Geometry: a secret weapon in the fight against viruses

Professor Reidun Twarock, a mathematical virologist, presents the first lecture of York Science Week: “Geometry: a secret weapon in the fight against viruses”. Part of our series on York Science Week

By Sam Wainwright, Science Editor (2014/15)
Monday 17 November 2014

Professor Reidun Twarock is a mathematician by training, but introduced herself to the audience of York Science Week’s first lecture with a great emphasis that interdisciplinarity is the key to her work - an idea that York Science Week seems keen to promote, alongside a real striving to achieve accessibility of science.

Viruses, she explained, are very efficient carriers of information – somewhere between a jar and a Trojan horse full of genetic information. The information they carry is called RNA, kind of like single-stranded DNA, which codes for all of the parts needed to harness a cell’s machinery in order to make more copies of the virus. When the virus invades a cell it harnesses the cell’s machinery to replicate itself, until the cell bursts.

One of the key parts of a virus is the capsid, which is the main ‘vessel’ that holds the RNA. Because it is favourable for a virus to be as efficient as possible, the capsid is made up of a repeating structure of proteins, which are coded by the RNA – the genetic information – it holds. Because the capsid has a repeating structure, it has rotational symmetry. A propeller with three blades, for example, has 3-fold rotational symmetry, and playing cards have 2-fold rotational symmetry.
Twarock talks about biology through a largely mathematical lens, comparing capsids to the geodesic domes created by Buckminster Fullerene: it is clear why she emphasises the multi-disciplinary aspect of her work.

The majority of virus capsids are icosahedrons, which have 60-fold symmetry – not because they are like a 60-blade propeller with one axis of rotation, but because they have more than one axis of rotational symmetry. The common cold and HPV are both caused by viruses of different sizes, but despite this have the same symmetry. These viruses both have an axis with 6-fold rotational symmetry. The type of viruses which Twarock and her group are interested in have 5-fold symmetry, which are much harder to determine the structure of.

Symmetry is key in finding the structure of a virus. Because viruses are too small to see under microscopes, their structure is determined by a technique called cryo-electron microscopy (cryo-EM), which uses a mathematical function to overlay the repeating symmetrical structure of the virus to amplify its structure. This is easy for viruses with a 6-fold symmetry axis, but for 5-fold it is much more difficult. Cryo-EM is a bit like unfolding the shape and laying it out flat. It is not exactly easy, but is possible to do this for structures with a 6-fold symmetry axis, but is impossible on structures with 5-fold symmetry axis. Twarock uses the analogy of trying to tile a bathroom floor: it is possible with hexagons but not with pentagons. This mathematical phenomenon means it is therefore necessary to know the overall symmetry of structures with 5-fold symmetries before their structure can be determined using cryo-EM.

Once the symmetry of the virus has been found, it is possible to see how the RNA fits inside the capsid. It turns out that the RNA is also ordered, and has the same symmetry as the capsid, interacting at certain nodes or “contacts” in the RNA. Identifying these contacts is one of the key breakthroughs of her work,
and is something that could not be solved using bioinformatics alone. It required a multi-disciplinary approach to solve the problem.

Viruses such as this are made up of multiple repeating protien “tiles”
Image: Phylogeny

Virus & football, spot the difference
Image: ilya

Her work and the work of a partner group in Leeds goes further to describe the process of virus assembly in the cell. They discovered that viruses actually rely on the cooperation of capsid proteins and RNA to form the capsid’s symmetrical dome shape. The contact points between the RNA and the inside face of the capsid are essential in the process of ‘building’ the capsid from its constituent parts, and so are potential drug targets, something Twarock has managed to do by working with industry. Drugs of this type slow the building of a capsids and can even cause it to be built incorrectly. These drugs, almost entirely a result of Twarock’s research, could be available “hopefully in under 10 years”, she says.

Twarock did a fantastic job of keeping the range of faces in the audience interested. Looking around the
room, no-one seemed out of their depth or bored. She perfectly catered to the mantra of York Science Week, promoting interdisciplinary science to the science students whilst making science accessible to those of a less scientific background.

Find out what else is on this week [here](http://nouse.co.uk/2014/11/17/geometry-a-secret-weapon-in-the-fight-against-viruses). Hopefully we’ll see you there!

---

**Most Read**

1. A closer look at Pot Noodles
2. The York flood fiasco: Where did all the water come from?
3. Fishing methods are devastating seas
4. Revolutionary biotech to combat deadly diseases
5. What is the environmental impact of print media?
6. World Penguin Day: Overfishing and climate change impacts penguin populations

---

**Write for Nouse Science**

Get in touch with the editors

Join the Facebook group

---

**More in Science**

- Revolutionary biotech to combat deadly diseases
- Could a snake have legs?
- Climate change is producing deadlier disasters
- Fishing methods are devastating seas
- Poaching is driving vulnerable species to the brink
- Microplastics: are they as bad as we feared?