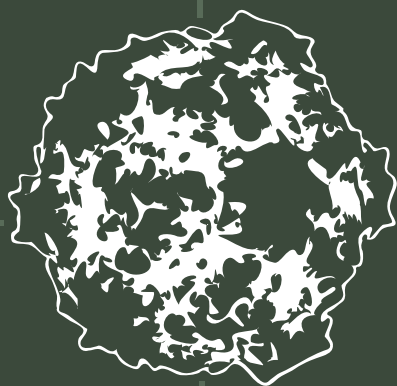


Geometry of icosahedral viruses

Viruses are macromolecular complexes made of DNA or RNA molecule (genome) inside a protein shell (capsid). Some viruses are in addition enveloped in a cellular membrane. Simplest viruses appear spherical or polyhedral and their symmetry is icosahedral.

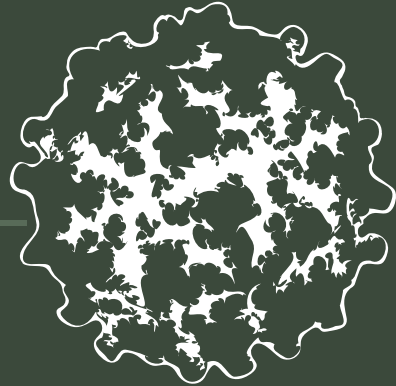
There is a great variety in viral proteins and apparent shapes of the viruses, yet most icosahedral viruses can be easily geometrically idealized.



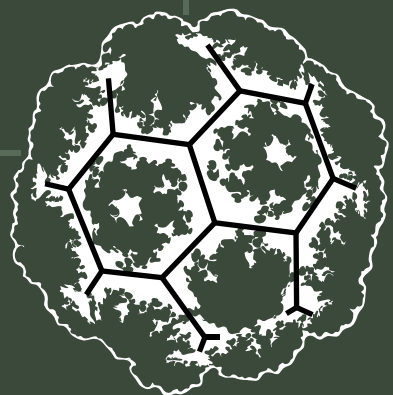
ringspot tobacco



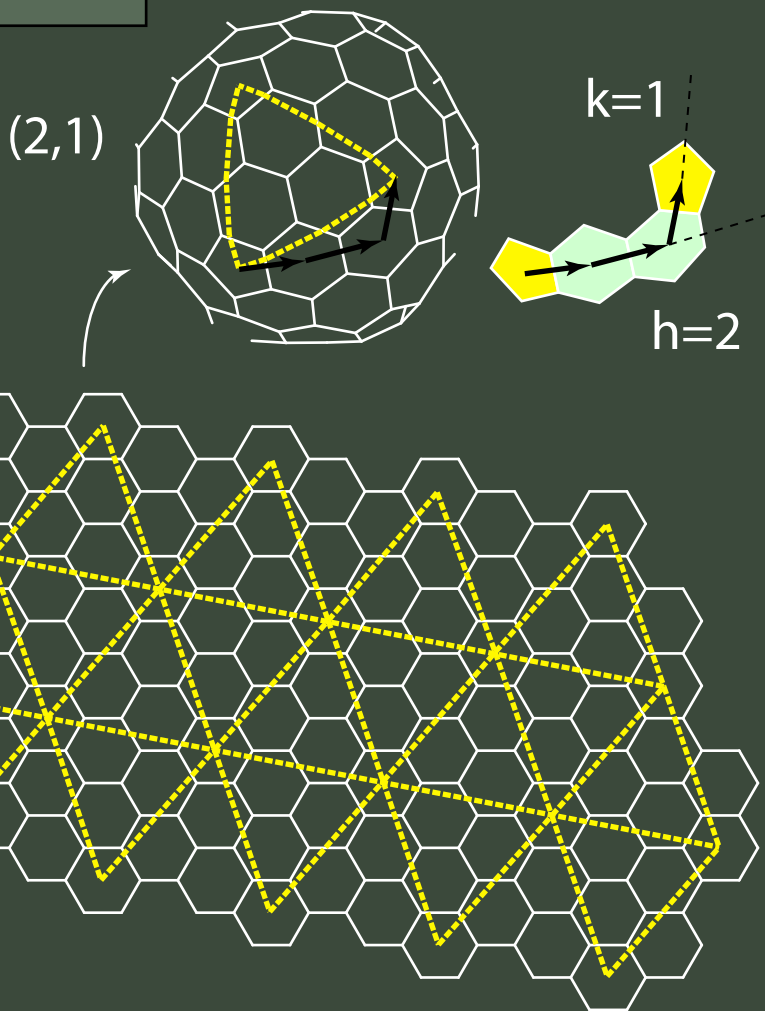
bromo mosaic



nodamura



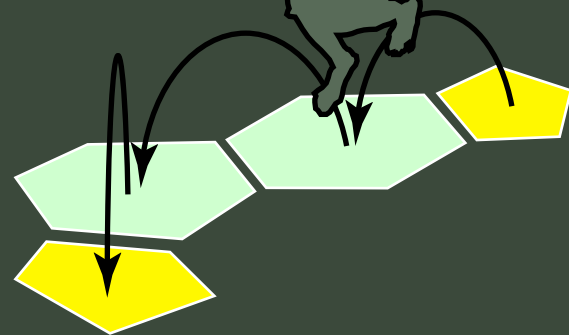
turnip yellow mosaic



1. Start from a pentagon.
2. Pick a direction, i.e. a neighboring hexagon.
3. Jump h times in that direction. You will land on h hexagons.
4. Turn left by about 60 degrees.
5. Jump k times to reach another pentagon.

(h,k)

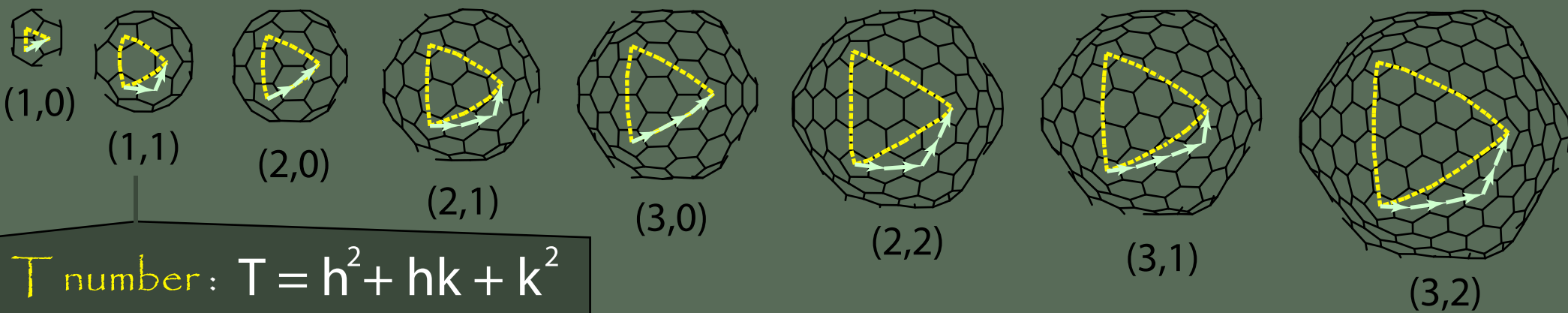
$(2,1)$



A "virus" can be cut out of the hexagonal network and "glued" into an icosahedral shape.

In viruses, pentagons (hexagons) are made of five (six) proteins and are called **pentamers** (hexamers). All regular (or Caspar-Klug) icosahedral viruses, have exactly 12 pentamers.

T=1 T=3 T=4 T=7 T=9 T=12 T=13 T=19



T number: $T = h^2 + hk + k^2$