Structural biology of viruses

Biophysical Chemistry 1, Fall 2010

Coat proteins

DNA/RNA packaging

Reading assignment: Chap. 15

Virus particles self-assemble from coat monomers

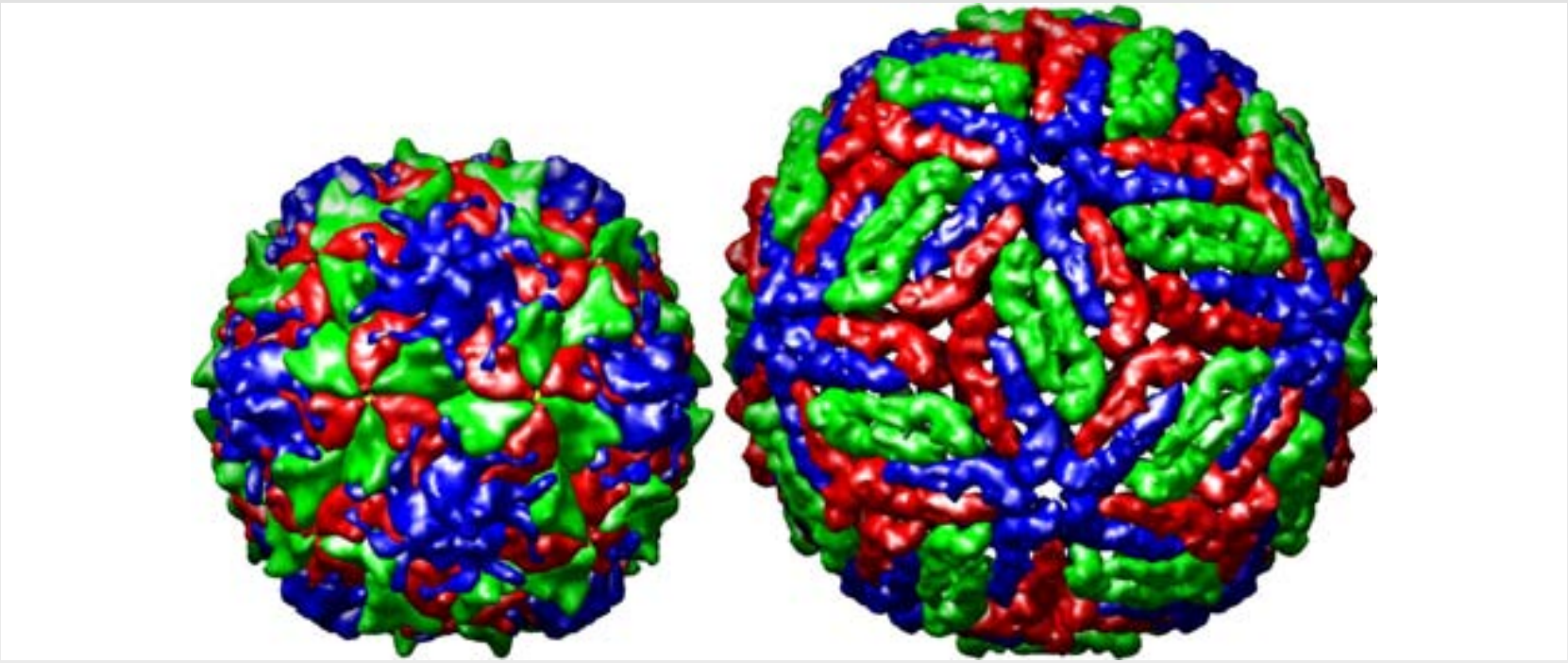


FIGURE 15.1 ■ Schematic drawings of virus particles. *Left*: Poliovirus, a simple icosahedral virus with a diameter of about 300 Å (based on a crystal structure). *Right*: Flavivirus, an enveloped virus with a crystal diameter of about 470 Å (based on a cryo-EM model with models of coat protein molecules from a crystal structure fitted into the cryo-EM density). The colors denote subunits in different environments as discussed below. From VIPER (http://viperdb.scripps.edu/).

Icosahedral coats are the most common ones

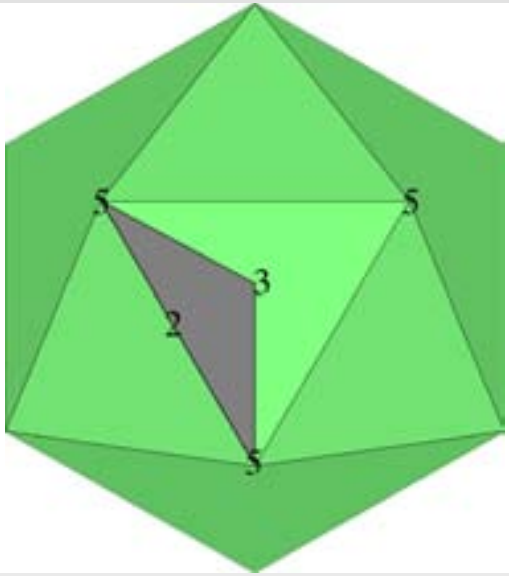
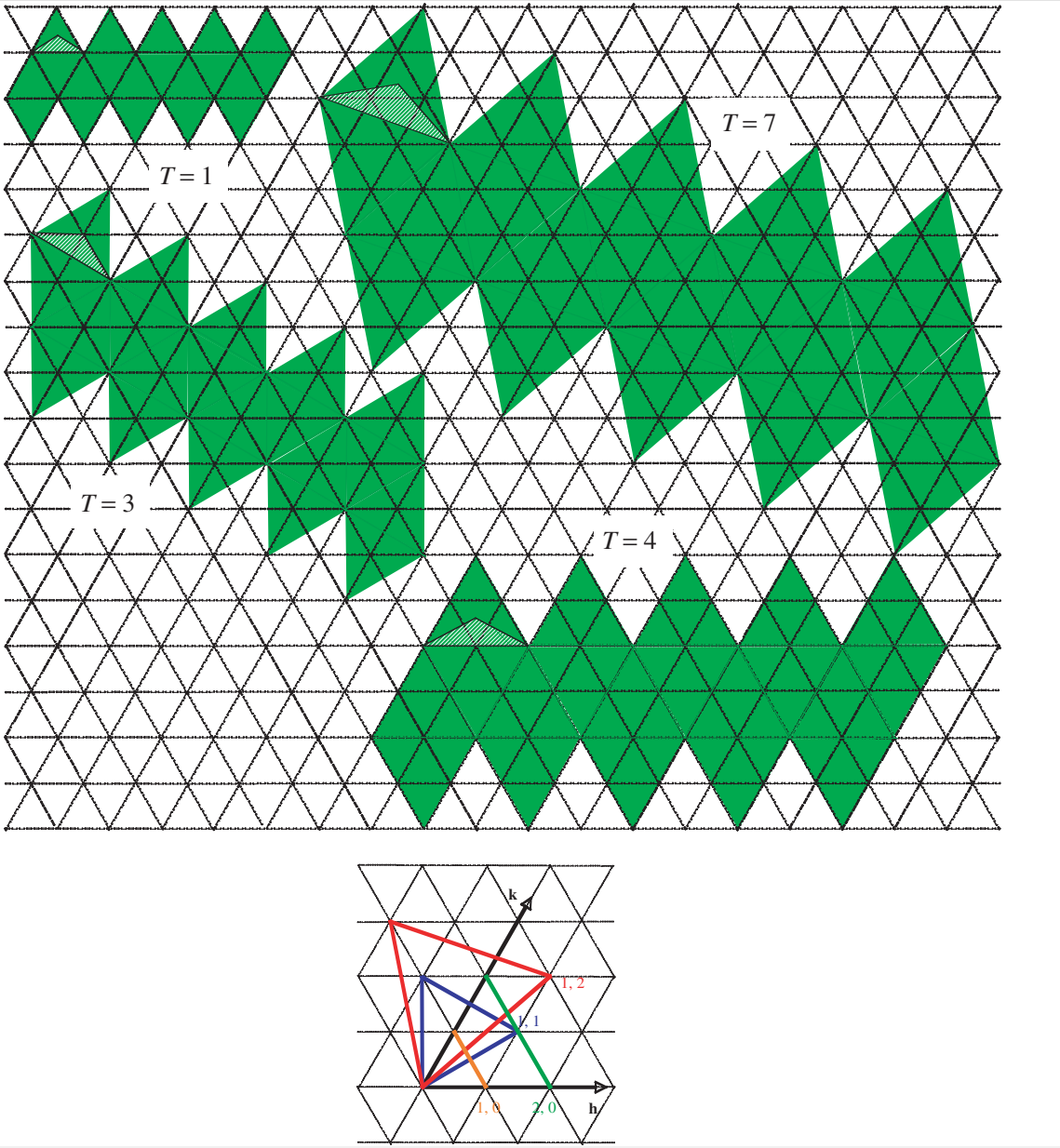


FIGURE 15.2 ■ An icosahedron showing the positions of the five-, three- and two-fold symmetry axes. The repeated unit is marked in gray. This is only one of many possible choices of the repeated unit.

Interactions can be viewed in two dimensions



Various triangulation numbers

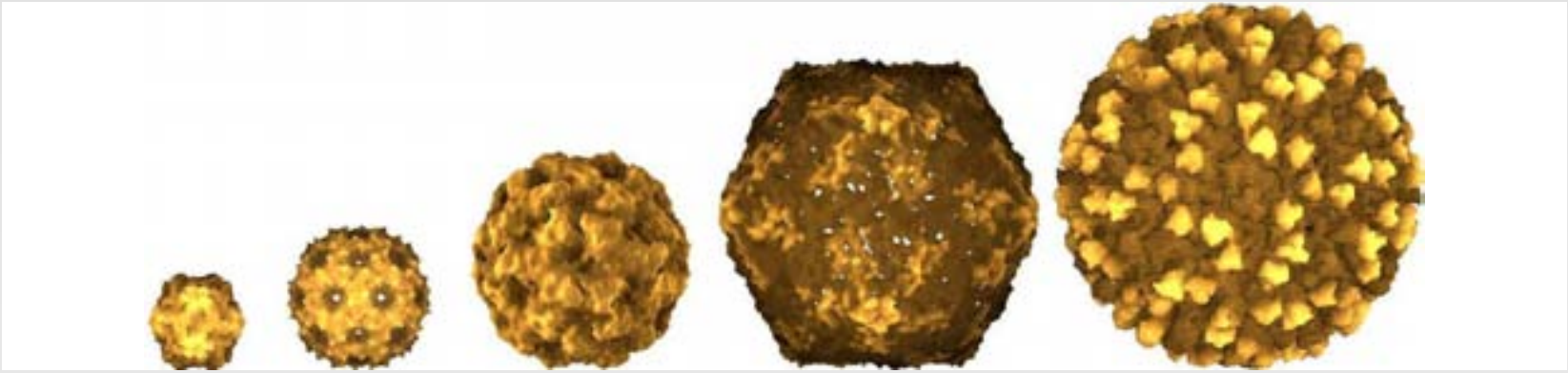


FIGURE 15.4 ■ Viruses with triangulation numbers 1, 3, 4, 7 and 13 showing their relative sizes. The surface of the virus particles is shaded according to its distance from the center, darker being closer. Some particles have an icosahedral shape, but the particles all have icosahedral symmetry. The drawings are based on the crystal structures (from *left* to *right*) of satellite tobacco necrosis virus, phage MS2, *Nudaurelia capensis* ω virus, phage HK97 and the bluetongue virus. From VIPER (http://viperdb.scripps.edu/).

Virus particles self-assemble from coat monomers

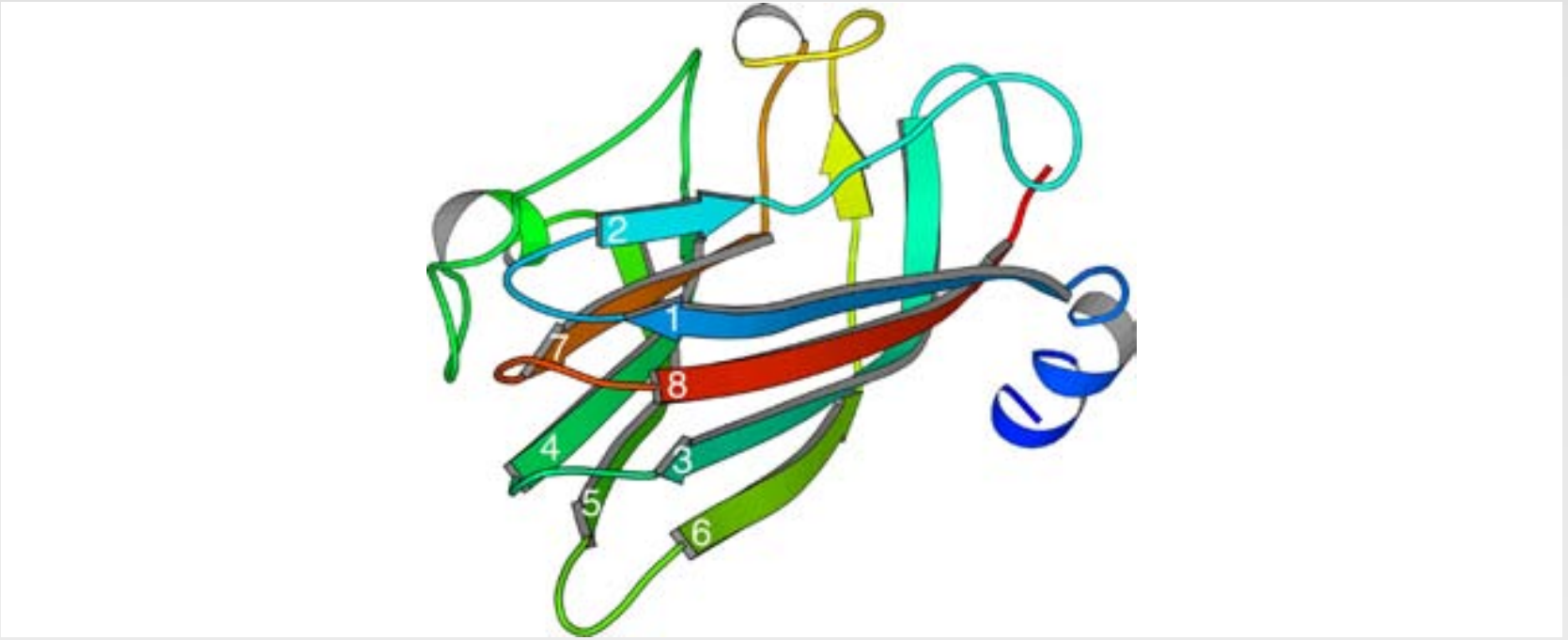


FIGURE 15.5 ■ The jellyroll fold in a viral coat protein subunit (satellite tobacco necrosis virus, PDB: 2BUK).

Interdigitation often stabilizes coats

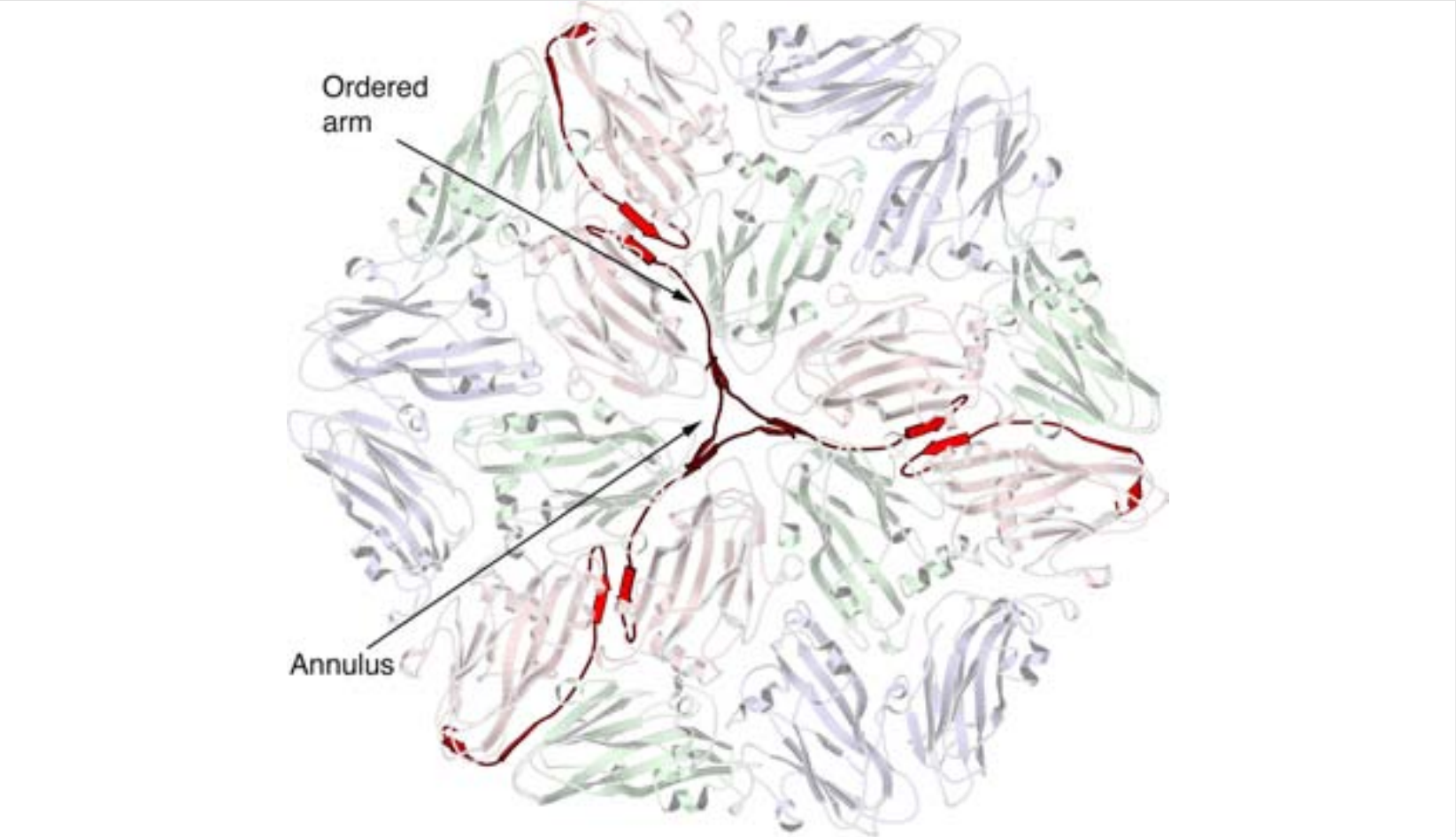
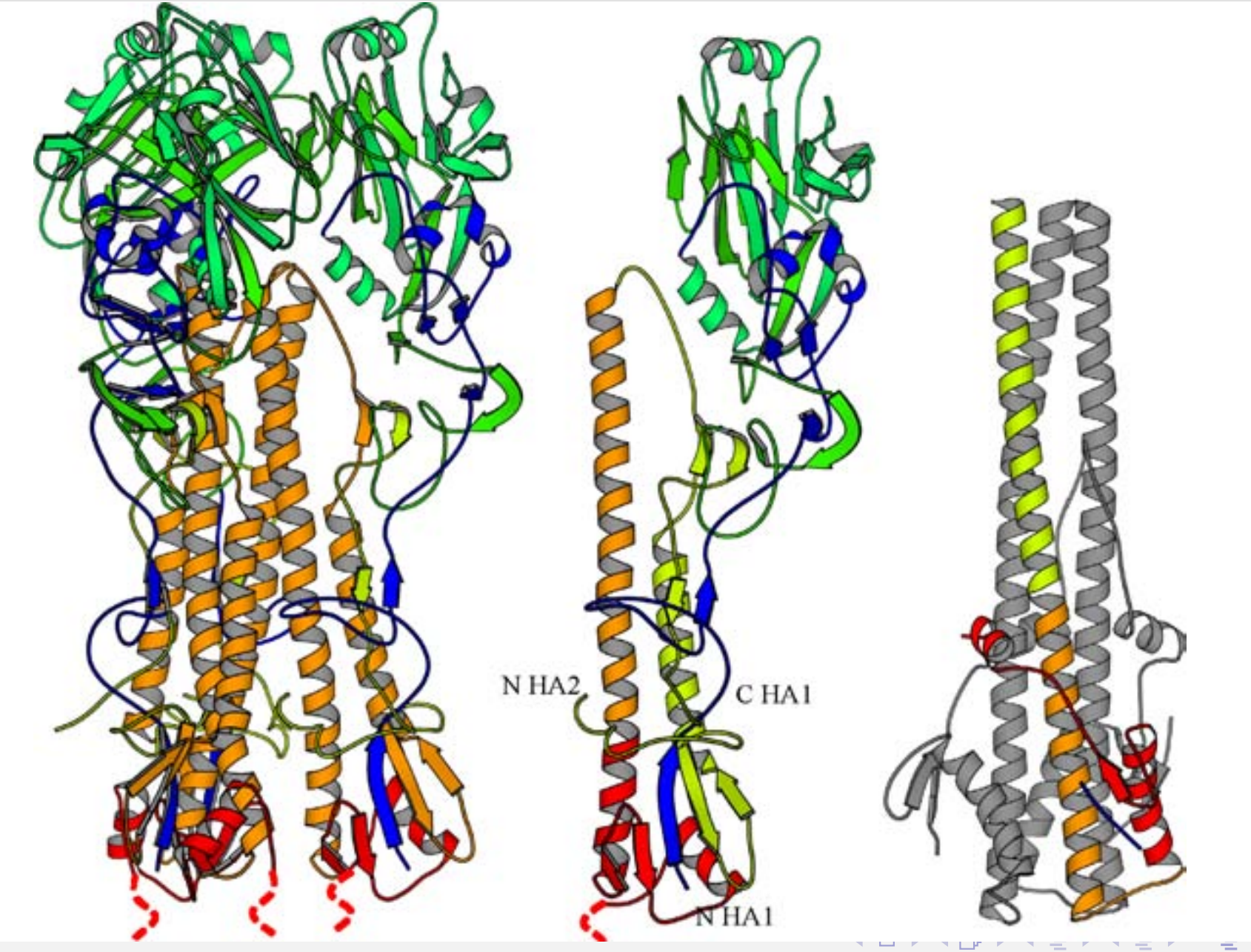


FIGURE 15.7 ■ The arrangement of 18 subunits around the three-fold (quasi-six-fold) axis in the southern cowpea mosaic virus. The partially ordered arm in one of the subunits (marked in red) interacts with arms from symmetry-related subunits at the three-fold axis (beta annulus, indicated with an arrow). In this virus, the N-terminal 23 amino acids are disordered in all subunits. This region contains several positively charged residues and probably interacts with the viral RNA, which is asymmetric.

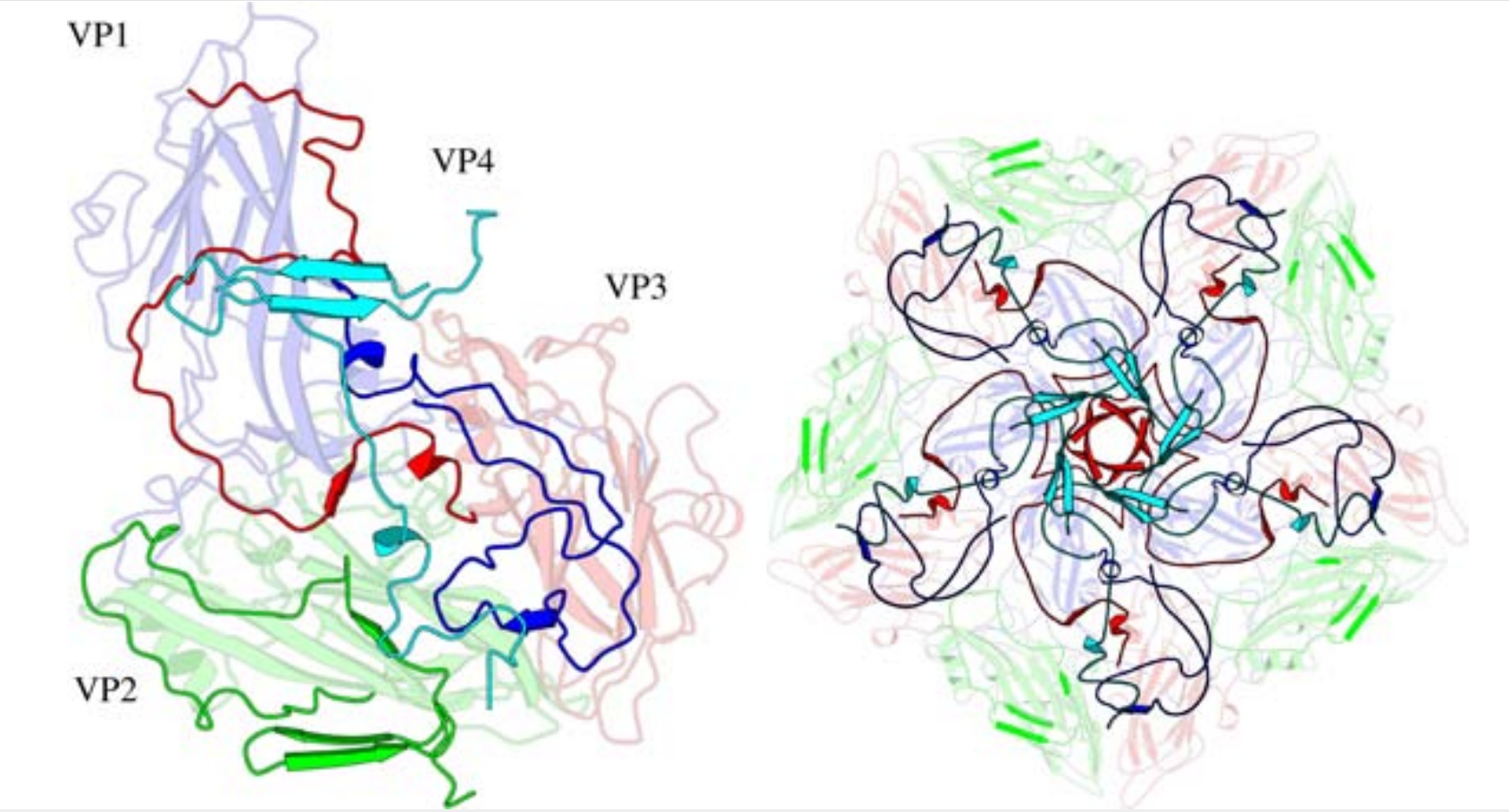
Cell entry: hemagglutinins



Cell entry: simple viruses

FIGURE 15.9 ■ The E1 protein from the Semliki Forest virus, an alphavirus (PDB: 1I9W). The coloring is from N-terminal (blue) to C-terminal (red). The fusion peptide is the loop at the extreme right of the molecule and is hidden through contacts to another protein in a homodimer. The anchor to the viral membrane is at the C-terminus of the protein, but this part of the protein was removed before crystallization and is therefore not seen here.

Cell entry: poliovirus architecture



Getting the right RNA back into the virus

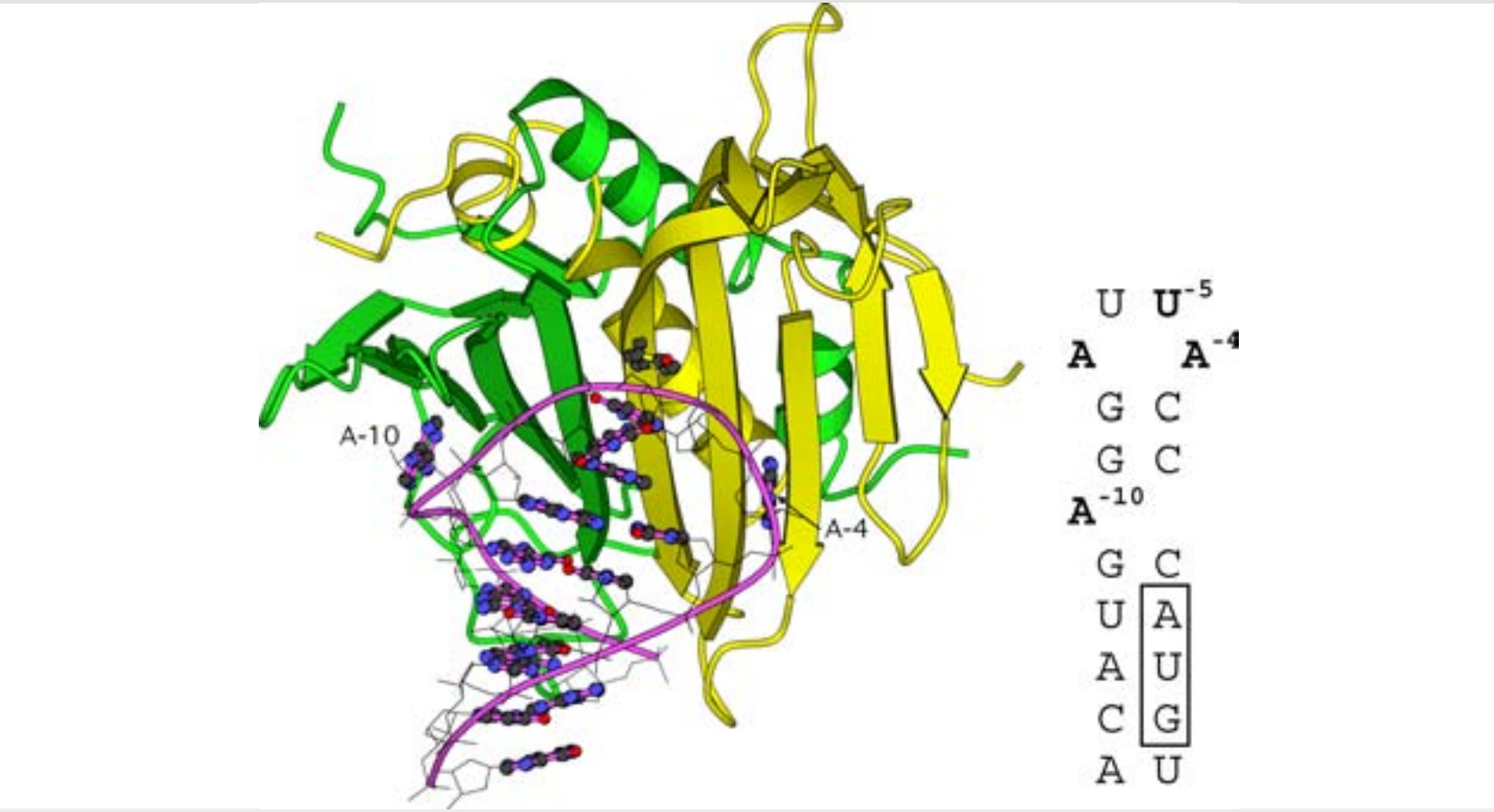
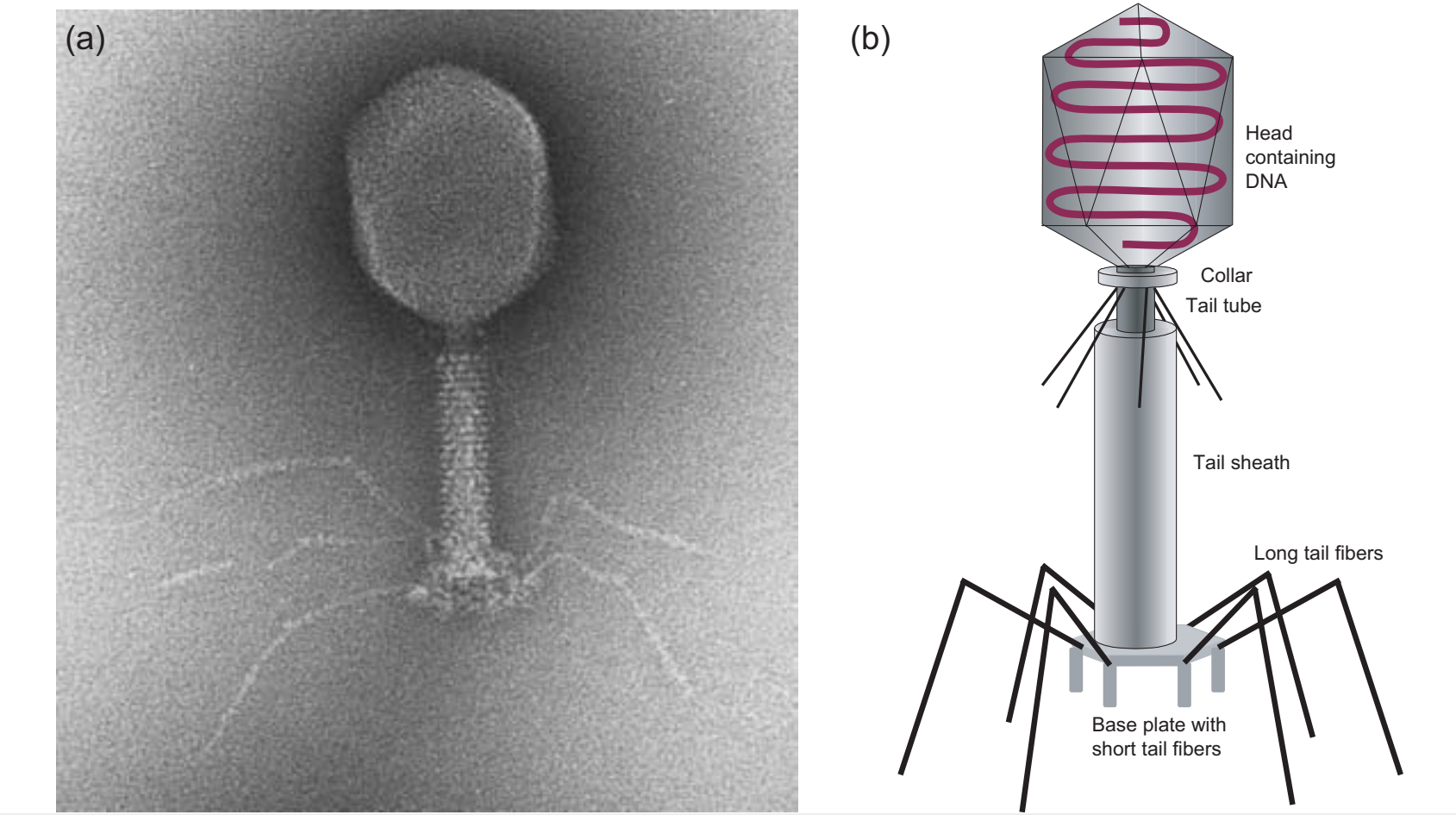


FIGURE 15.12 ■ The binding of the RNA hairpin by the MS2 dimer (PDB: 1ZDI). Adenine bases –10 and –4 are bound in corresponding pockets in the two monomers of the dimer, and uracil base –5 is stacked to a tyrosine sidechain in one of the subunits. To the *right*, the secondary structure of the hairpin is shown. The initiation codon of the replicase subunit is boxed.

Genome packaging in bacteriophage



Some details of the packing apparatus

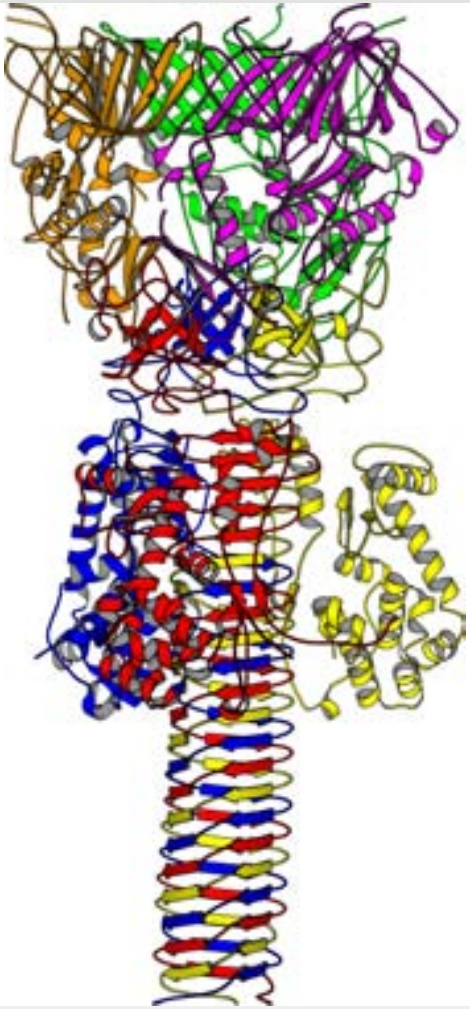


FIGURE 15.14 ■ The trimeric gp5-gp27 complex. The three monomers of gp5 are in red, blue and yellow, and the monomers of gp27 in green, brown and purple. The lysozyme domain of gp5 is at the upper part of the triple beta helix that forms the stalk of the molecule.

The T4 “baseplate”

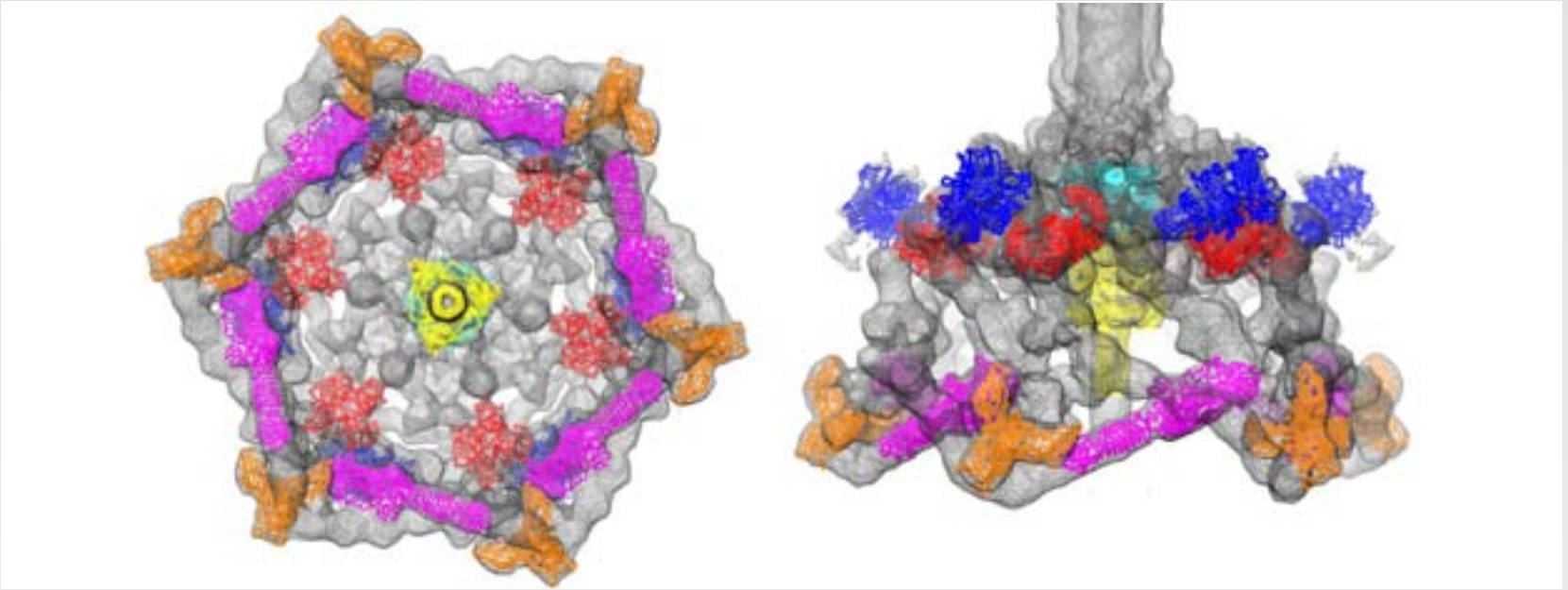


FIGURE 15.15 ■ Fitting of several proteins from the T4 baseplate into a cryo-EM map. The gp5-gp27 complex is at the center of this model. gp5 is in yellow and gp27 (barely visible) in turquoise. The other proteins that are modeled are gp9 (blue), gp8 (red), gp11 (orange), and gp12 (purple). (Courtesy of Thomas Goddard, University of San Francisco.)