Rhombic dodecahedral proteins

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Introduction

The work herein is an outgrowth of the discovery that the atomic elements are formed by the joining of identical regular octahedra. This is revealed by the octahedral periodicity of the atomic elements.[Ref #1] A region of the Tomato Bushy Stunt Virus subunit was found to have an arrangement of pleated sheets which define three faces of a rhombic dodecahedron at one of its threefold vertexes.[Ref #2] The name "beta annulus" suggested itself and it has been adopted herein. The author has not been able to find a way to link three chains so as to produce three sheets of three strands each in which each strand belongs to a different chain in the manner described in Reference 2. Other arrangements of peptides have produced similar outcomes and they are presented here.

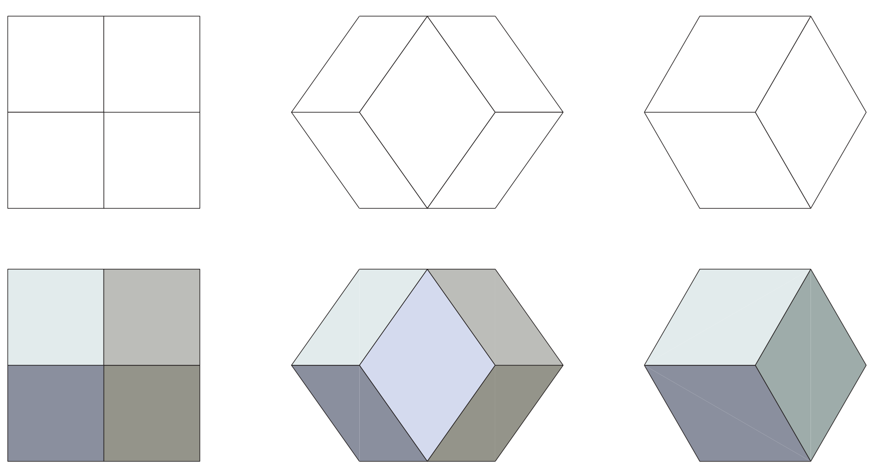
Beta annulus

The simplest beta annulus has three two-strand pleated sheets formed by three chains. Each chain is composed of two strands of beta180-chain with a 4helix-join. The plane of each sheet is parallel to a face of a rhombic dodecahedron. The three faces so formed meet at a threefold vertex. The first figure shows the rhombic dodecahedron in three views with the threefold-vertexial view being rightmost. The following figures show how beta annuluses can be joined in a rhombic dodecahedral assembly.

References

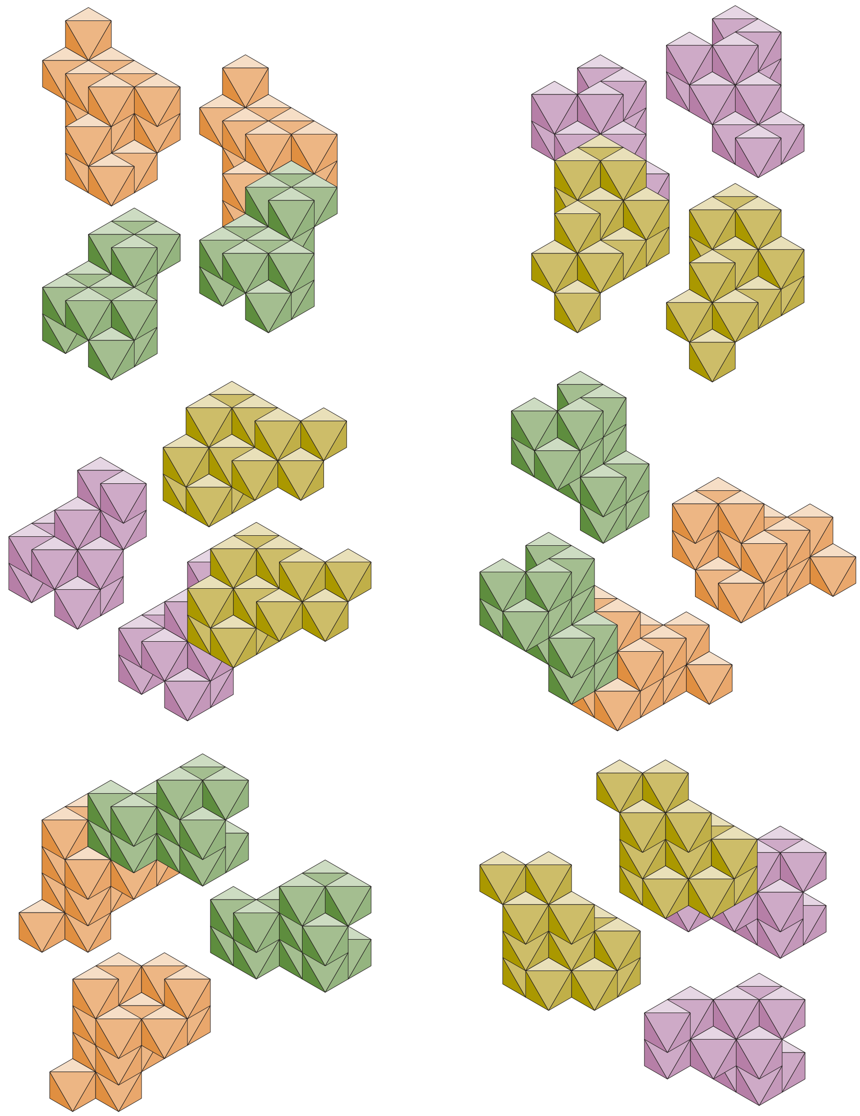
1. Robert William Whitby *Octahedron* 1st Ed., 2002 available online–
http://homepage.mac.com/whitby/.

2. S. C. Harrison, A.J. Olson, C. E. Schutt, F. K. Winkler, G. Briscogne, Tomato bushy stunt virus at 2.9 A resolution, *Nature* v. 276 23Nov78.



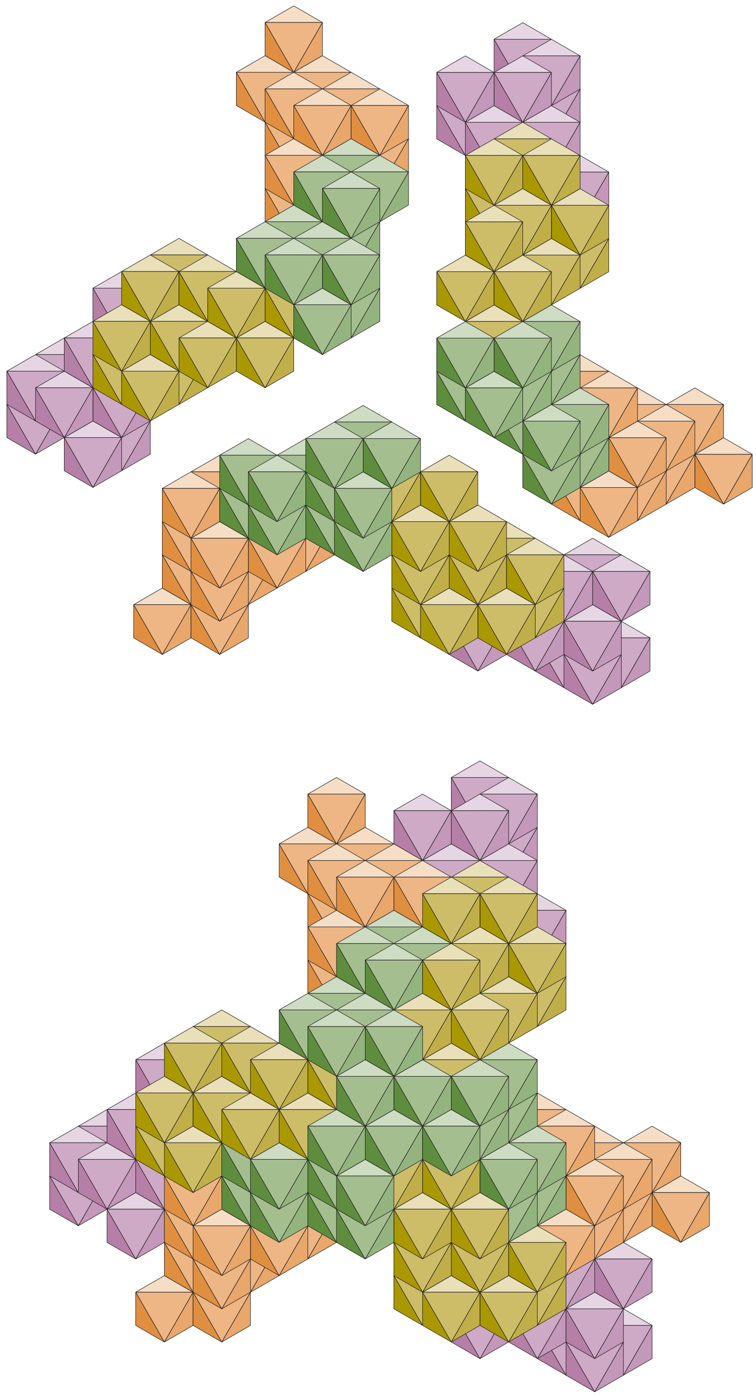
Rhombic dodecahedron

Three views of the rhombic dodecahedron–(left) along a fourfold vertexial diameter, (middle) along a facial diameter, (right) along threefold vertexial diameter.



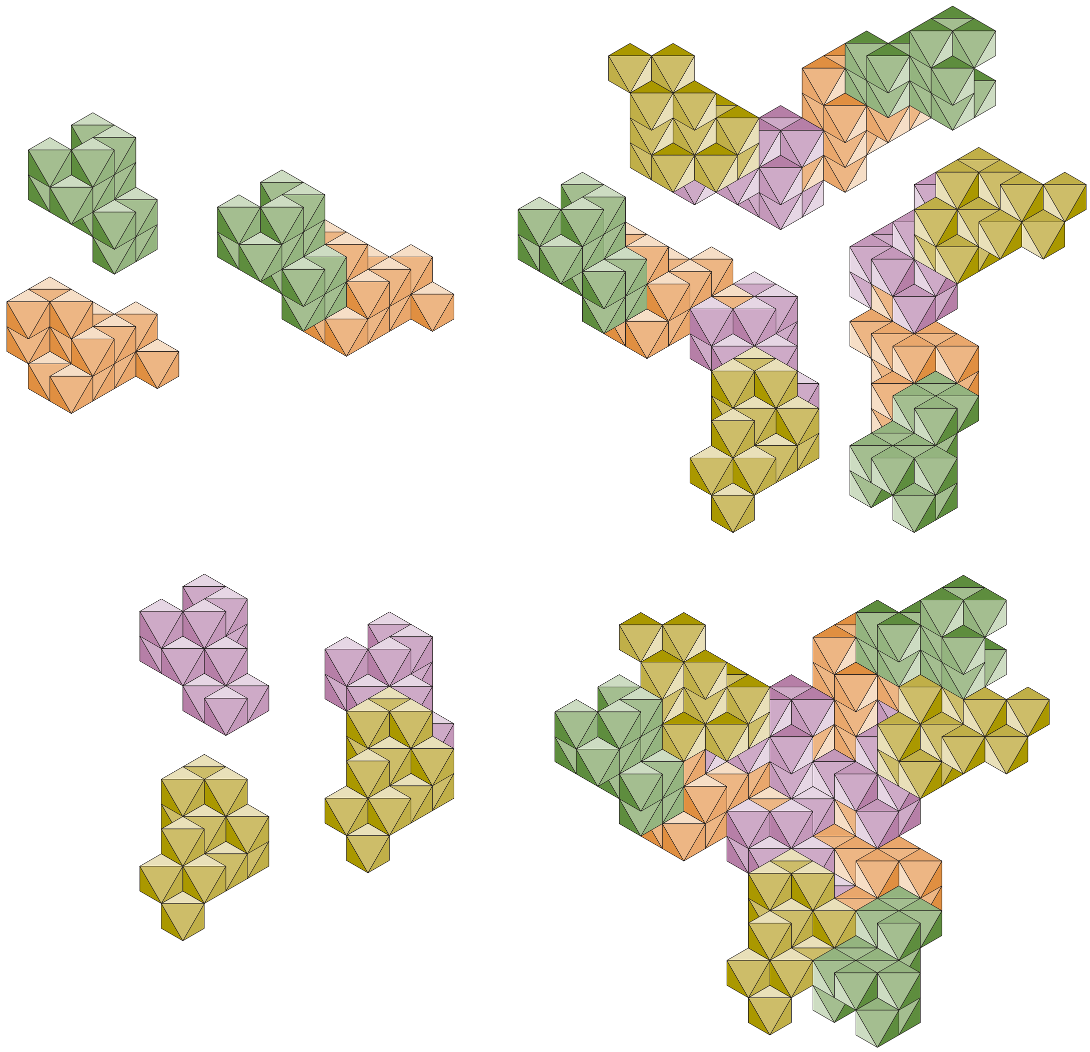
Beta annulus–sheet-forming residues

Residues of the same color have the same orientation or orientations which differ by a rotation of 1/3-revolution about an axis normal to the page. There are six groups of residues in the figure. Each group shows two unpaired residues adjacent to an assembled pair. The joins between pairs of residues is beta180 which permits strands made of these pairs to join as sheets.



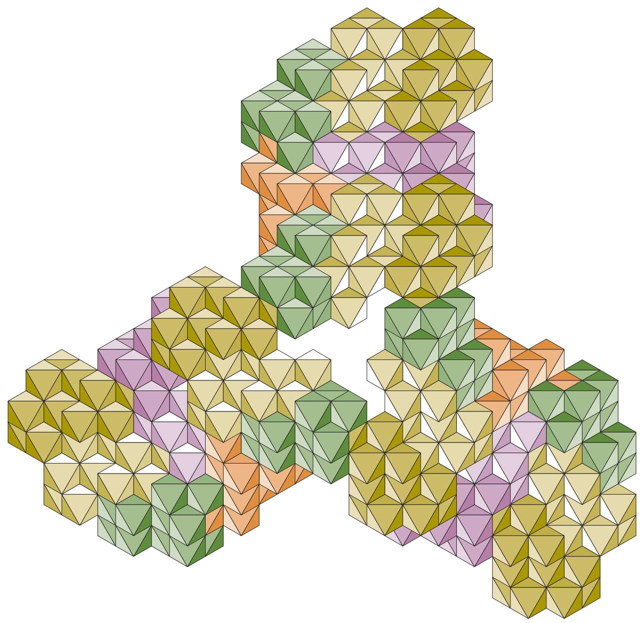
Beta annulus

Three chains form three sheets of two strands each. There are two residues per strand. The join between strands is 4helical. The chains shown here are identical except for a 1/3-turn rotation about of the threefold axis.



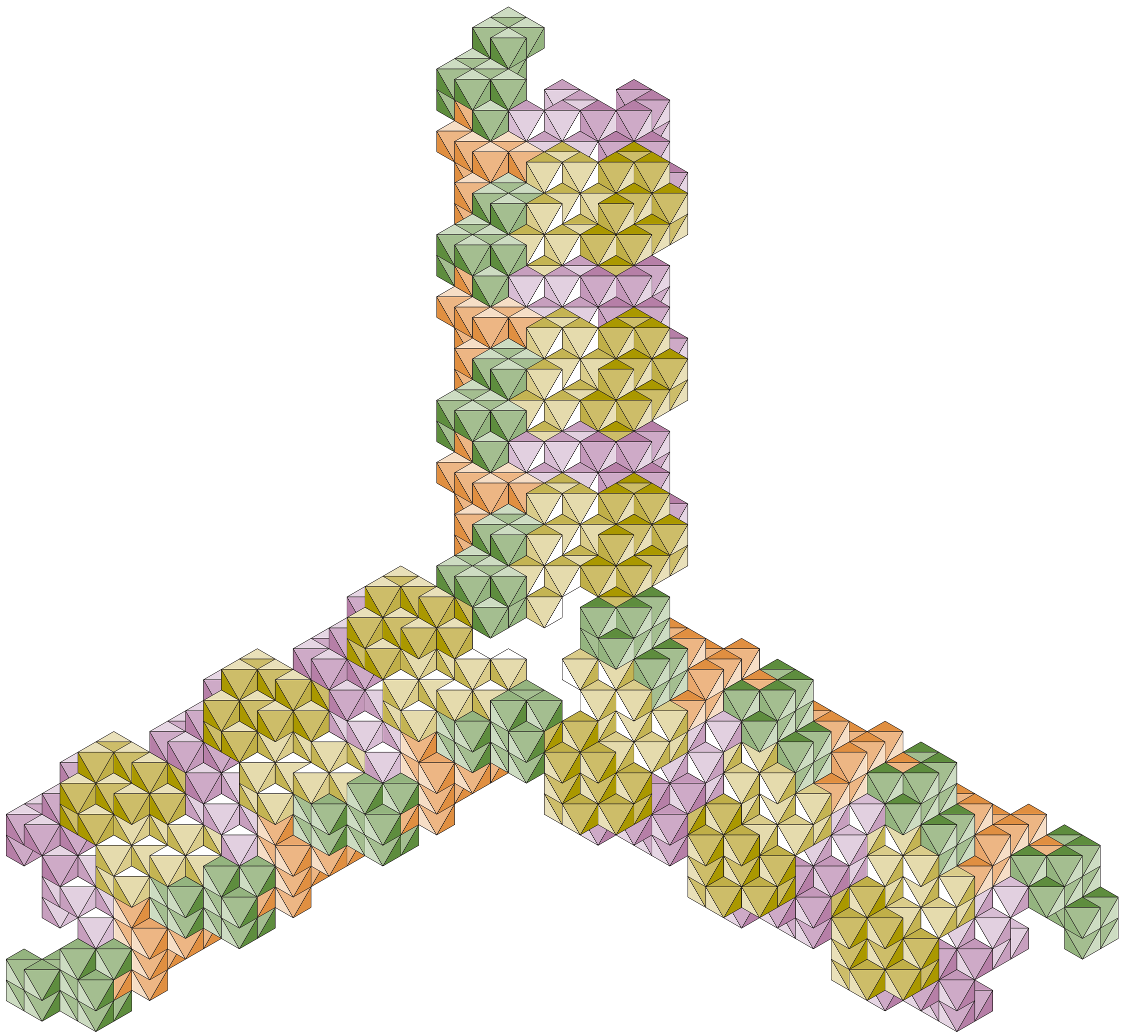
Beta annulus–obverse view

The figure shows the assembly of the beta annulus from a direction which is opposite to that of the previous figure. The steps in the assembly of just one chain are shown.



Beta annulus- each sheet is expanded by the insertion of a third strand

Each of the three sheets in the depicted beta annulus is composed of three strands of three residues each. The middle strand of each sheet has its male terminus near the axis of symmetry. It is parallel to the yellow-violet strand and anti-parallel to the green-orange strand. This is a step in the attempt to model the beta annulus described in Reference 2.

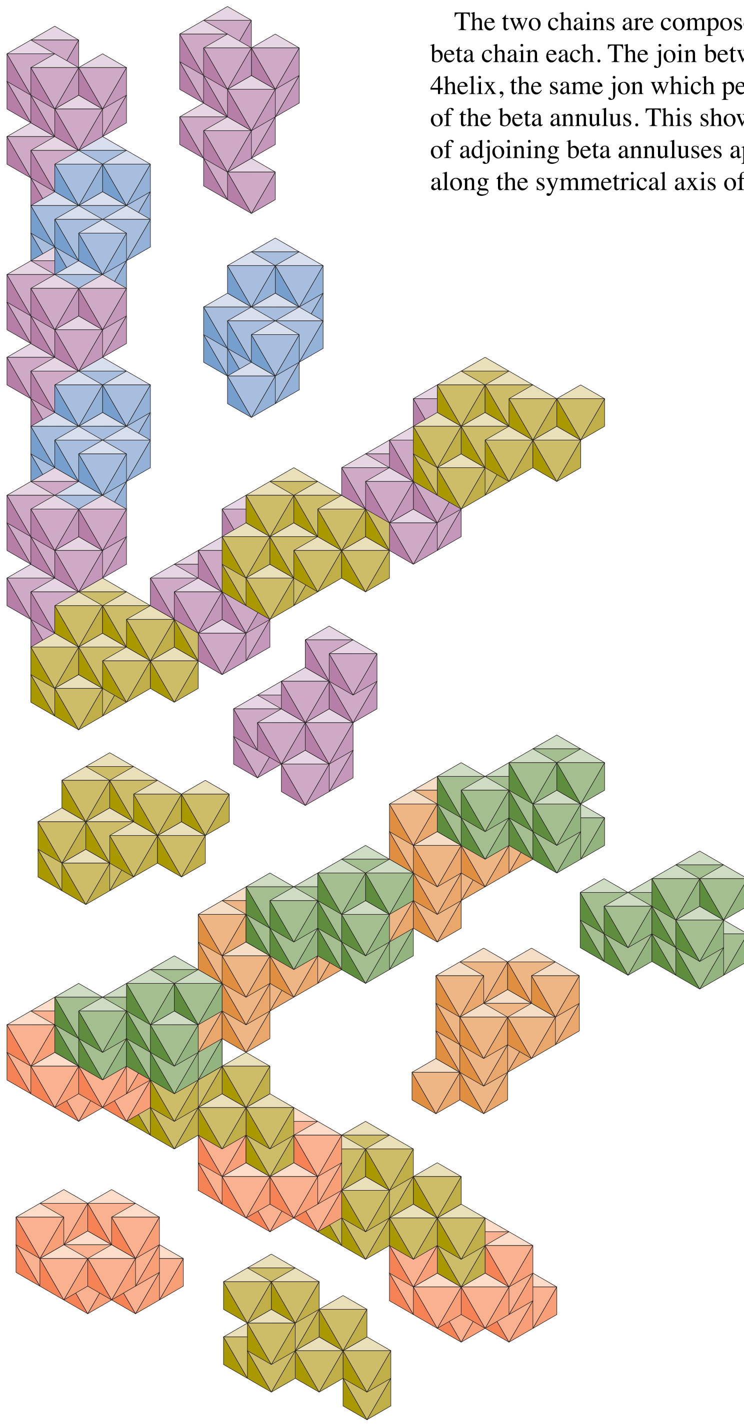


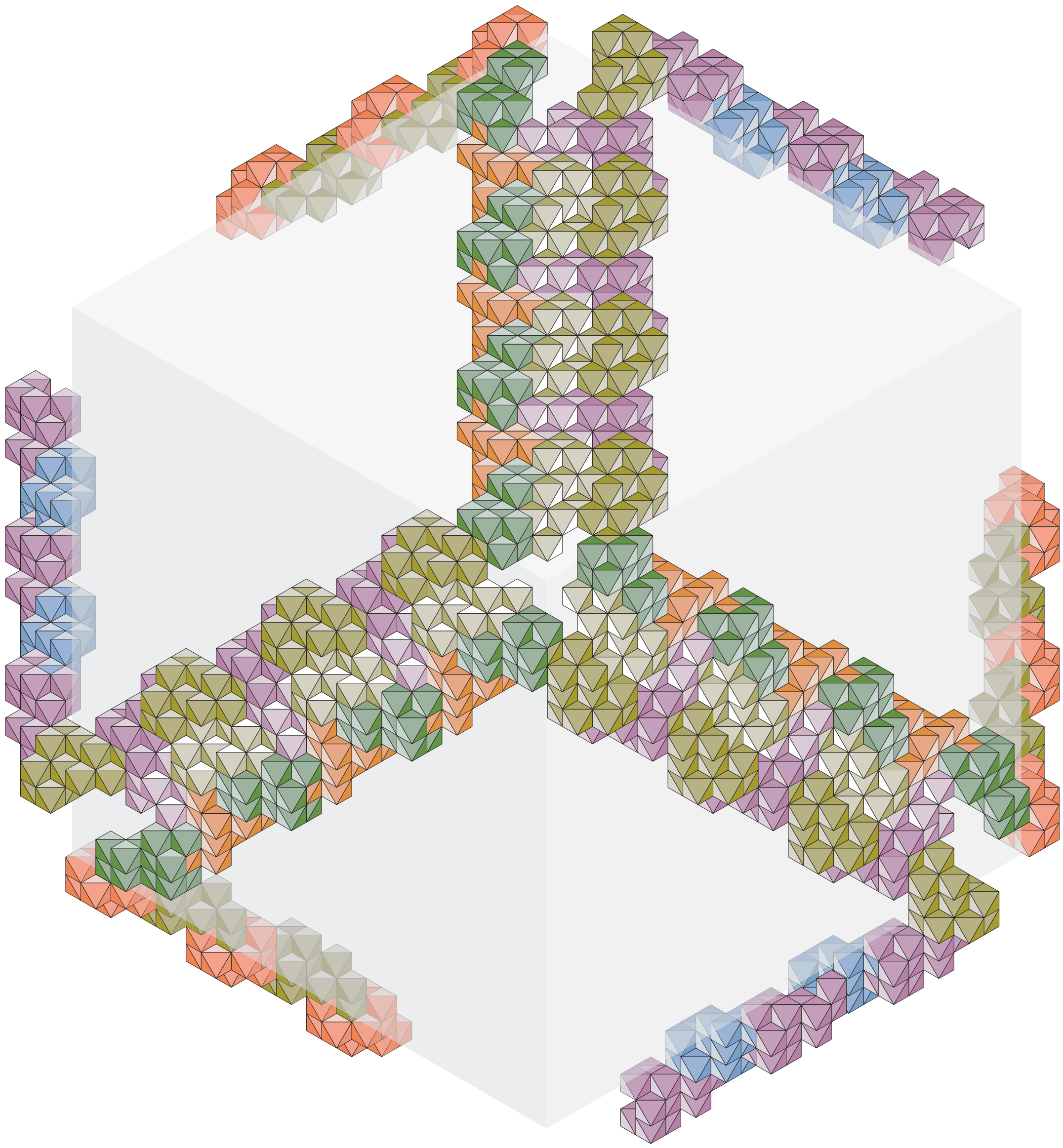
Beta annulus–three strand, six residues per strand

The beta annulus shown here has three sheets of three strands each. The violet and yellow strands have six residues each. The green and orange strand has seven residues, but only six are sheet joined.

Inter beta annular chains

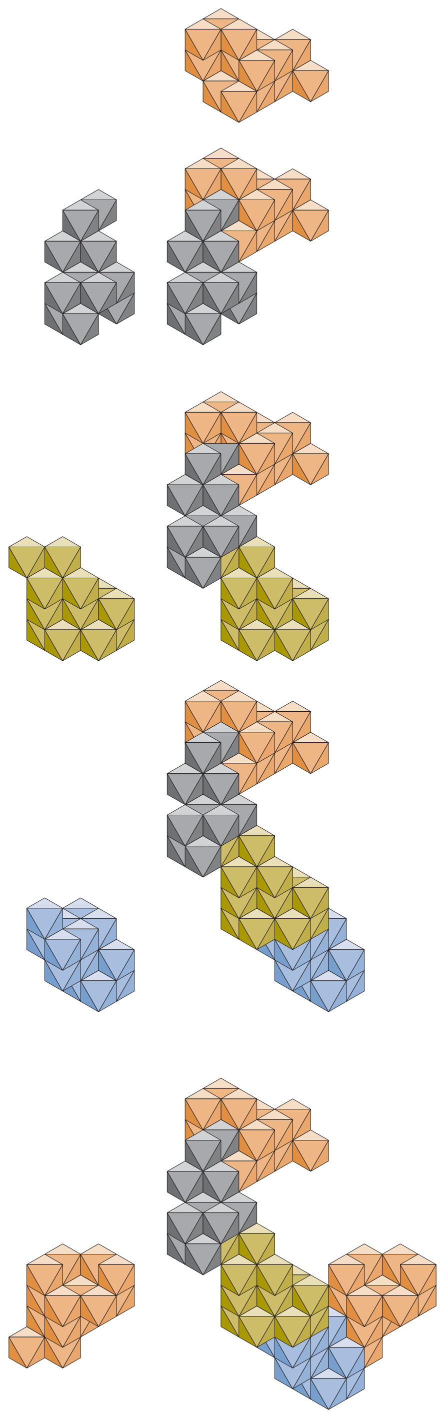
The two chains are composed of two strands of beta chain each. The join between the strands is 4helix, the same jon which permits the formation of the beta annulus. This shows how the strands of adjoining beta annuluses appear when viewed along the symmetrical axis of another.

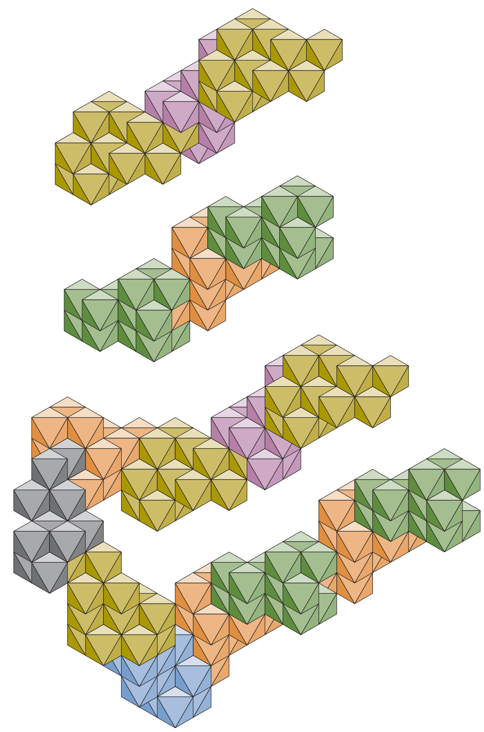




Beta annulus–relationship to rhombic dodecahedron

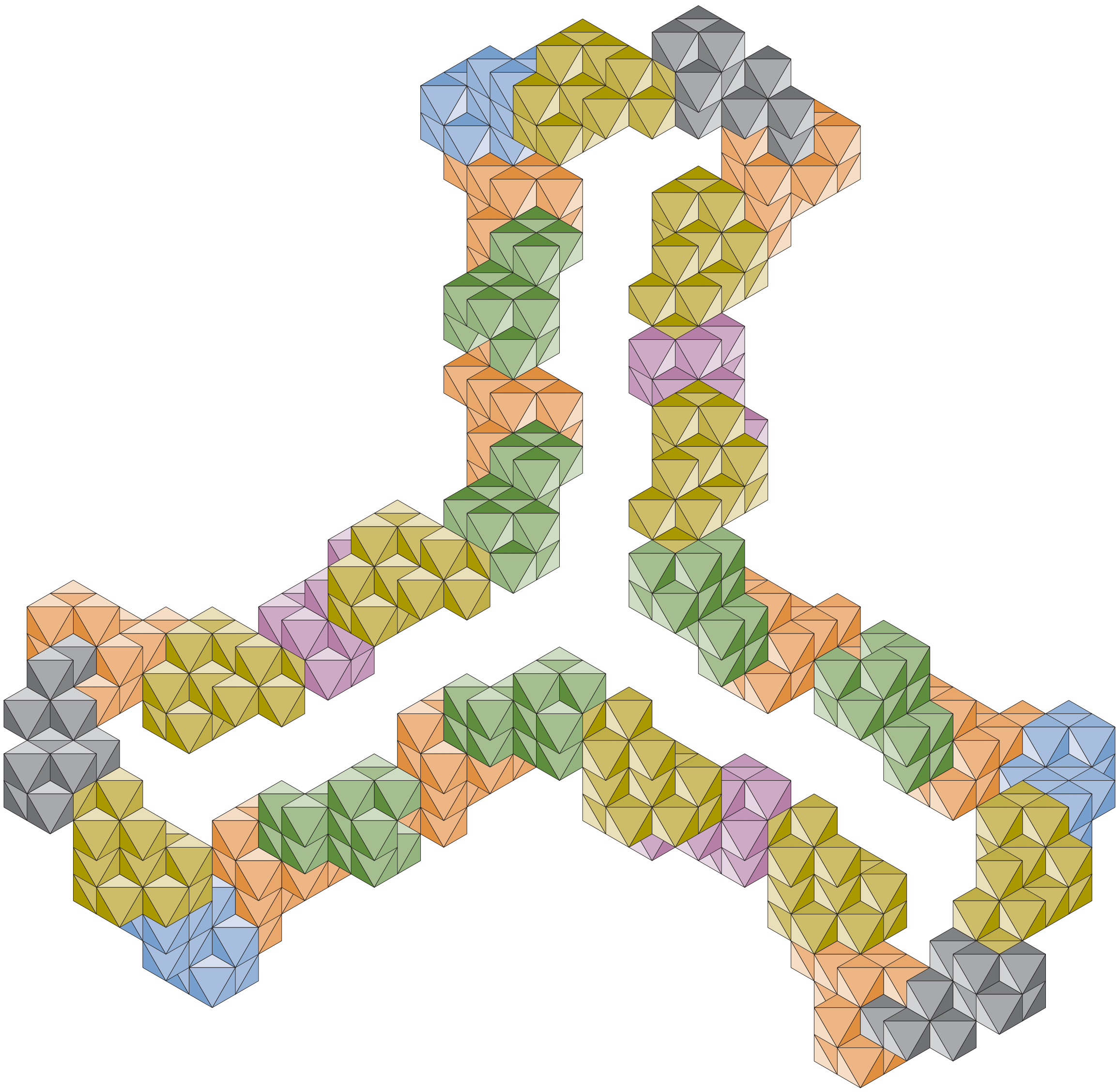
The assembly is superimposed upon the projected image of a rhombic dodecahedron to show the relation between the planes of its sheets and the faces of the dodecahedron. Each of the three pairs of outer strands could belong to sheets on adjoining faces. The sheets of the annulus and those of the six adjoining faces define nine of the twelve faces of a rhombic dodecahedron. Because the joins between the strands of the chains are ***helical***, the ends of the outer strands ***cannot*** meet directly. The axis of each strand of each sheet is parallel to the minor diameter of the dodecahedral face defined by the sheet.



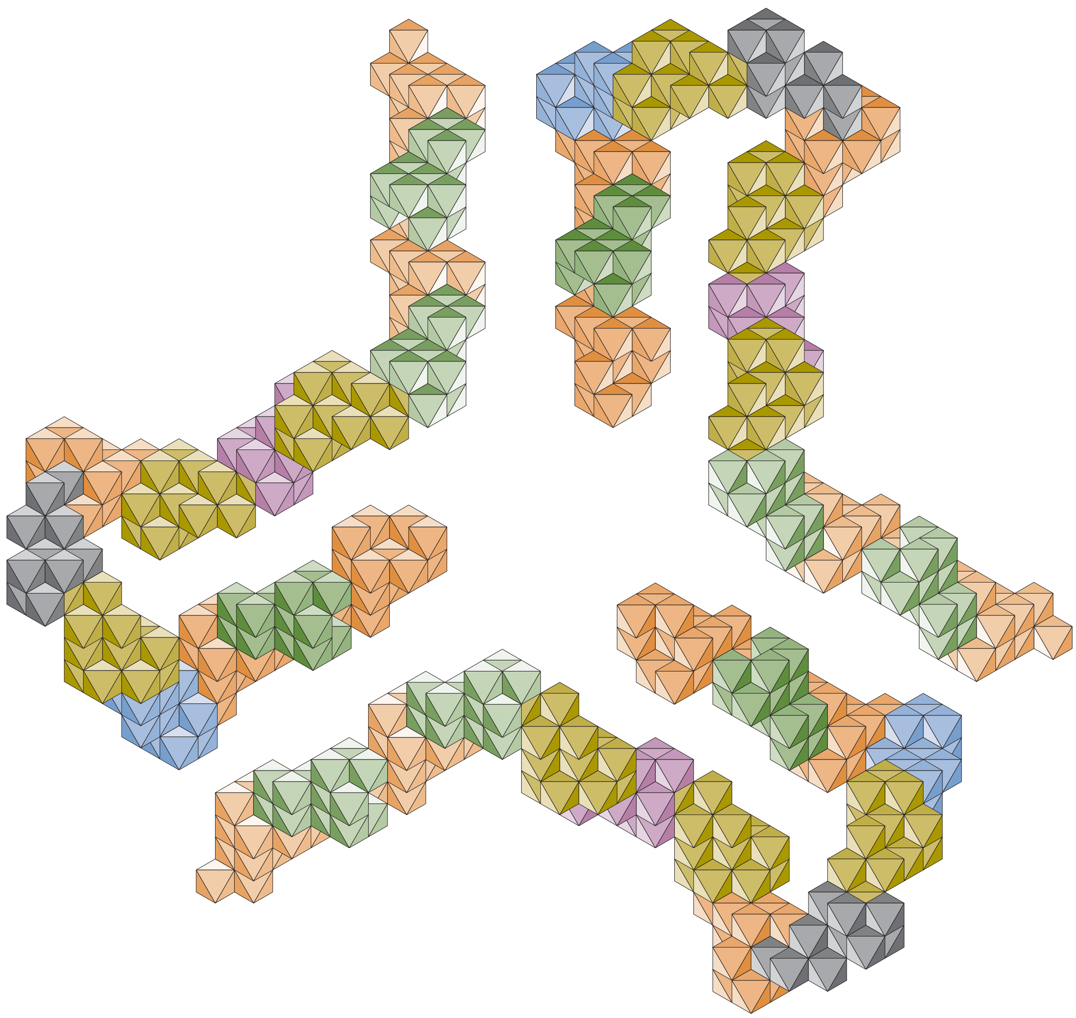


Sheet loop assembly

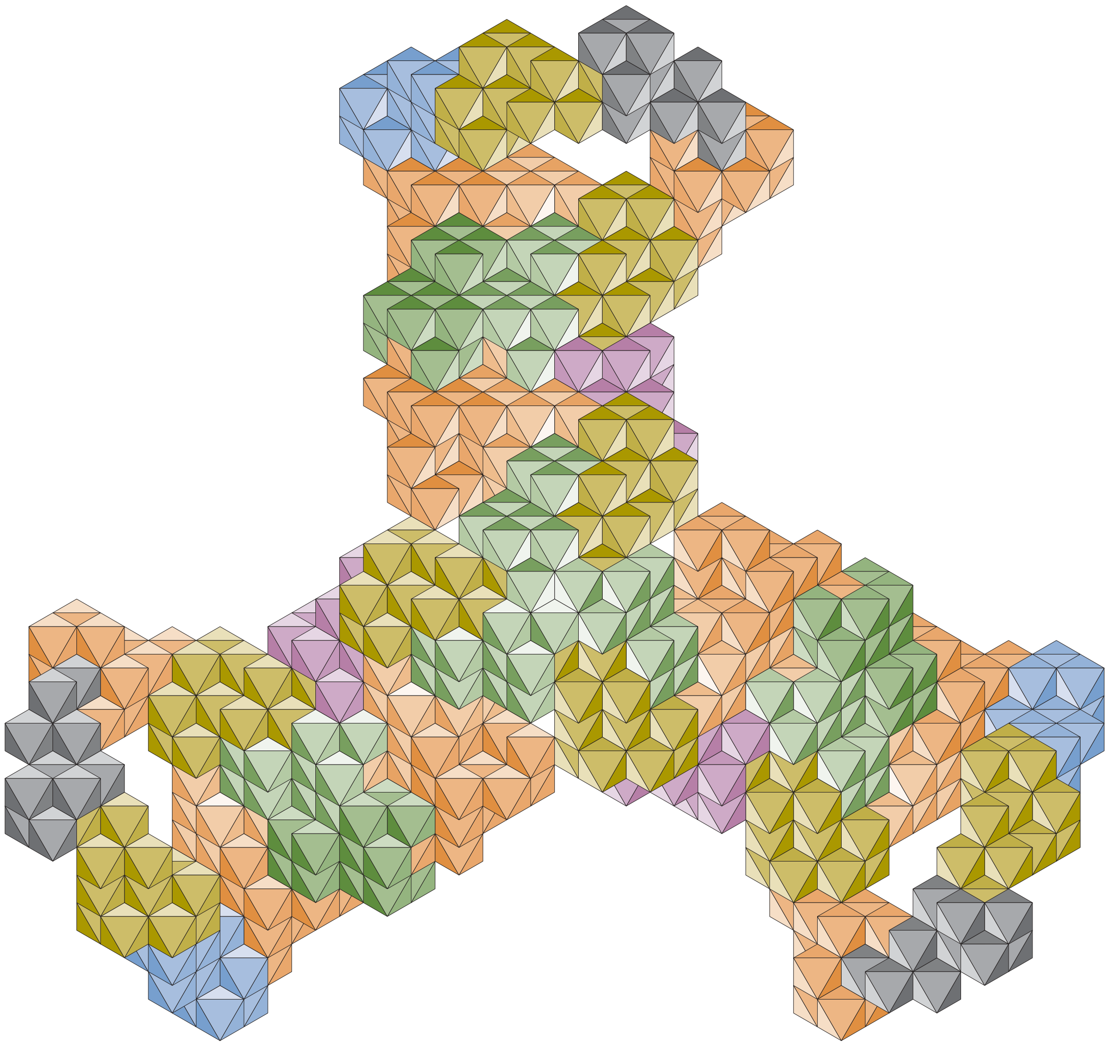
On the left, the figure shows the assembly of a sheet loop. It begins with the joining of the orange and black residues at the top and finishes with the addition of a second orange residue at the bottom. On the right, the sheet loop is joined to two three-residue strands of beta180 chain. The spacing of the chains in this assembly is one strand width.



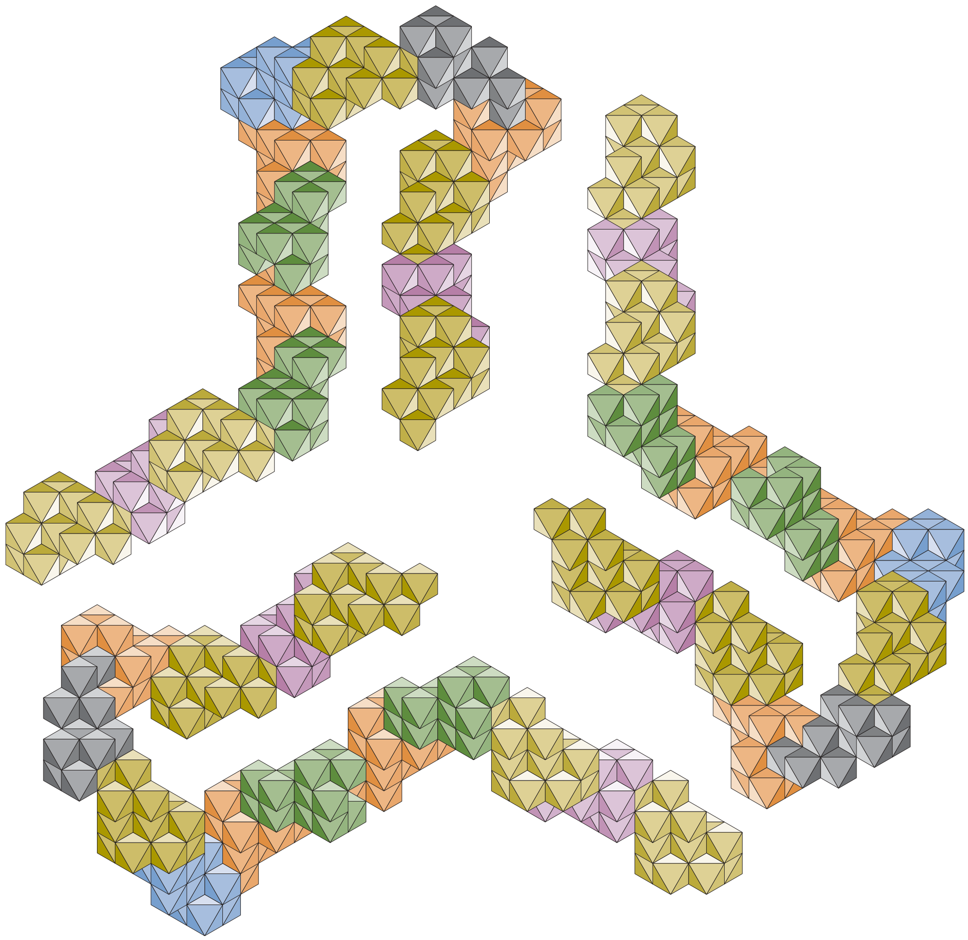
Cyclic peptide formed of three sheet loops.
Three sheet loops identical to the one assembled in the previous figure have been joined to form the cyclic peptide of thirty-three residues shown here.



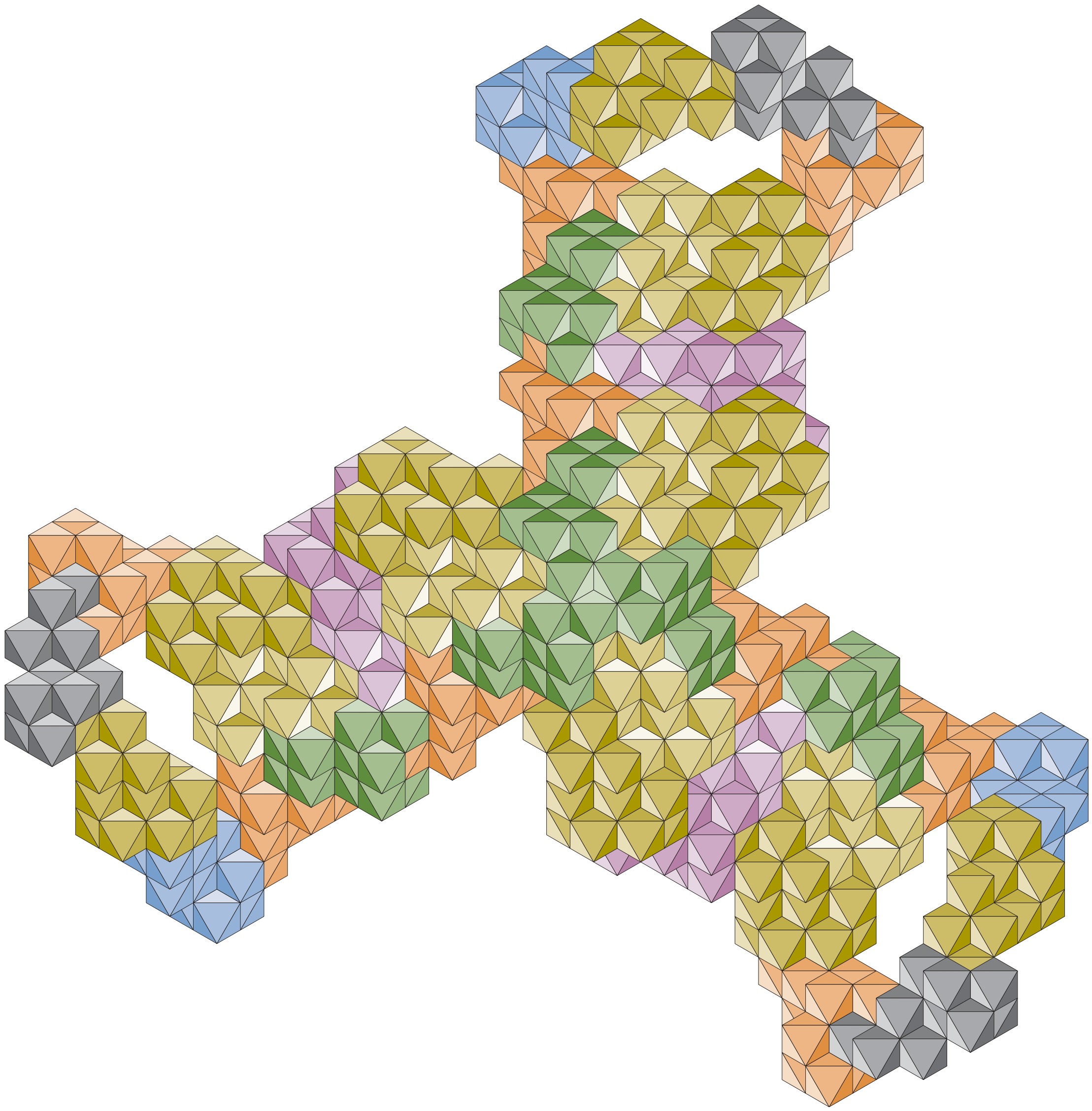
Three sheet loops each with a four residue beta180-chain extension on its male end



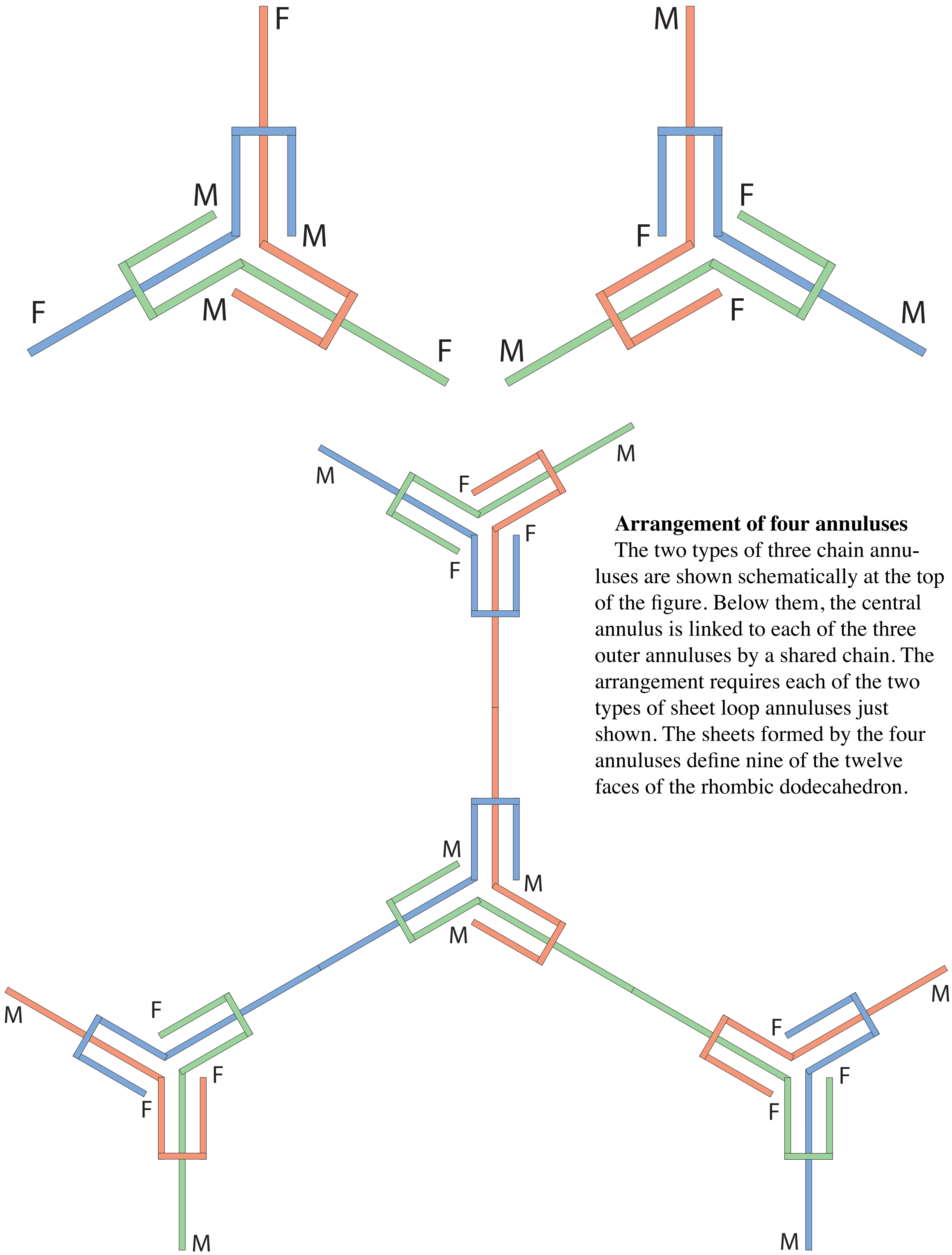
Beta annulus formed of three sheet loops with male end extensions



Three sheet loops with extensions on female ends

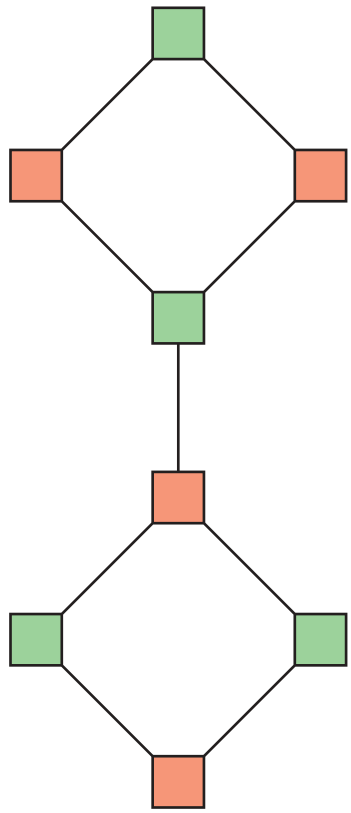


Beta annulus formed by three sheet loops with extensions on their female ends



Arrangement of four annuluses

The two types of three chain annuluses are shown schematically at the top of the figure. Below them, the central annulus is linked to each of the three outer annuluses by a shared chain. The arrangement requires each of the two types of sheet loop annuluses just shown. The sheets formed by the four annuluses define nine of the twelve faces of the rhombic dodecahedron.



Rhombic dodecahedral assembly of beta annuluses

The figure shows the distribution of beta annuluses within a rhombic dodecahedral protein. Each filled square represents a beta annulus. The colors mark the two different types–male end extension or female end extension. The lines joining the colored squares represent only ***possible*** beta180-chain links because the join between the stands of the chains is ***helical***.