

Problem Solving Group

Playing with problems together.

Adibvafa Fallahpour - Biology Olympiad Questions

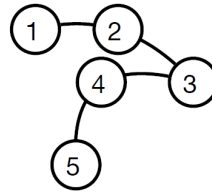
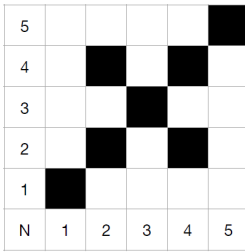
July 4, 2023

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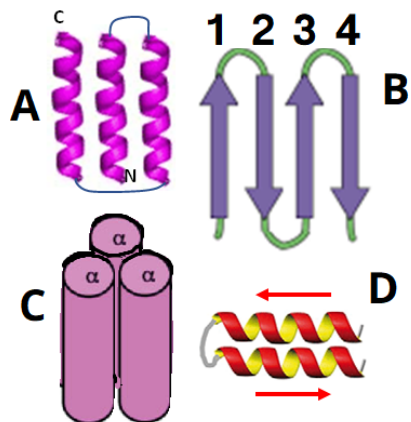
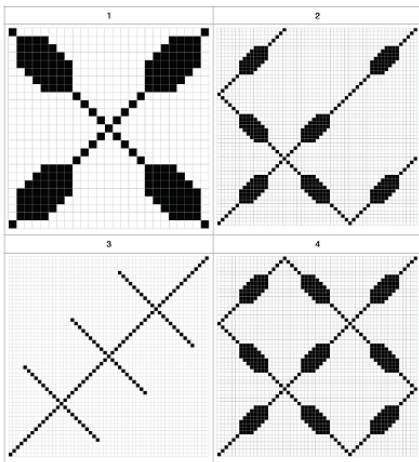
- On Protein Structure
- On Viruses
- On Neural Networks

1 On Protein Structure

Amino acids are building blocks of 3D protein structure. We can record the distance of two amino acids for all pairs of amino acids in the three-dimensional space after folding the protein. We draw the protein sequence from the first amino acid (N) to the last amino acid (C) on two perpendicular sides. So that the horizontal and vertical position of each matrix position represents a pair of amino acids in this sequence. If the distance calculated for a pair of amino acids is less than the threshold limit (they are spatially adjacent to each other), we mark the box corresponding to this pair of amino acids in the matrix with black color.



Question 1.1 (Biology Olympiad) Four distance matrices related to parts of different proteins along with 3D structures of several hypothetical proteins are shown. Which protein is related to which distance matrix?



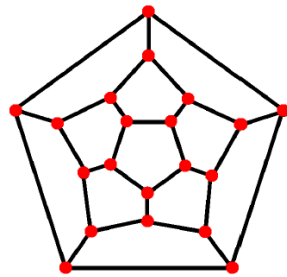
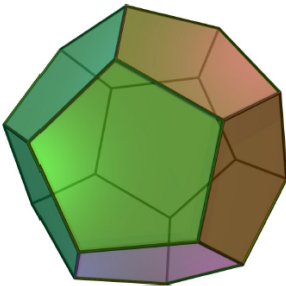
2 On Viruses

A new virus has been discovered that its shell (capsid) is a regular dodecahedron. This capsid is formed from twelve repetitions of a protein subunit, which is a regular pentagon. In the presence of a sufficient number of subunits, the capsid assembles spontaneously in such a way that:

1. Capsid construction starts with one subunit and other subunits (one after another) are attached to it.
2. At each stage, the next subunit that has the highest number of common sides with other subunits is connected.

Question 2.1 (Biology Olympiad) *How many distinct structures can be imagined in the stages of making this capsid (one subunit to twelve subunits or complete capsid)? Consider the structures that are transformed by rotation around the axes of symmetry as distinct.*

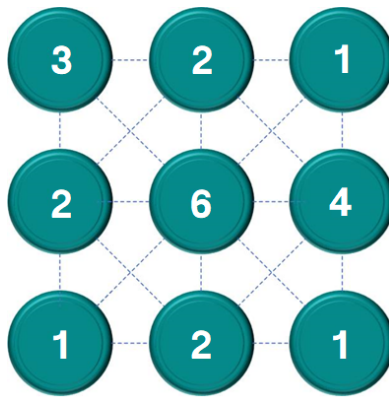
Guidance: If such structures are considered non-distinct, the number of possible structures would be 12.



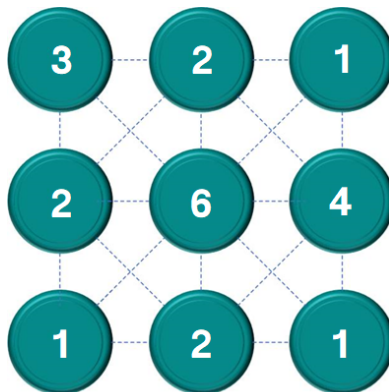
3 On Neural Networks

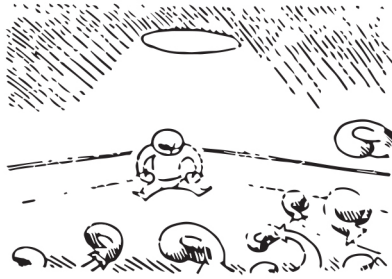
In the following network, 9 neurons are forming connections (called synapses) together. Each dotted line shows a possible synapses, with a maximum of 20 probable synapses. The number on each neuron (represented as a circle) shows their actual number of synapses.

Question 3.1 (Biology Olympiad) *Determine the actual number of synapses formed in this network.*



Another copy for use...





Problems worthy
of attack
prove their worth
by hitting back.

Piet Hein