**Molecular Machinery: A Tour of the Protein Data Bank**

**Educational Standards**

1. Common Core
   1. Integration of Knowledge and Ideas
      1. RST.11-12.7
      2. RST.11-12.8
      3. RST.11-12.9
2. Next Generation Science Standards
   1. Practices
      1. 2. Developing and using models
      2. 4. Analyzing and interpreting data
      3. 6. Constructing explanations
   2. Crosscutting Concepts
      1. 1. Patterns
      2. 6. Structure and function
   3. Disciplinary Core Ideas
      1. LS1: From molecules to organisms: Structures and processes
3. Advanced Placement Biology - Essential Knowledge (EK), Learning Objectives (LO), Science Practices (SP)
   1. EK 4.A.1
      1. LO 4.2, SP 1.3
      2. LO 4.3, SP 6.1, 6.4
   2. EK 4.B.1
      1. LO 4.17, SP 5.1

**Teaching Notes**

The Molecular Machinery Poster (<http://mm.rcsb.org/>) presents a range of molecular structures from the PDB showing different shapes and sizes of biological molecules and their complexes. Illustrations of 96 structures from the archive are drawn to scale, depicted relative to the cellular membrane, and organized in categories related to function. A scale bar provides a sense of molecular size in nanometers.

The interactive view of Molecular Machinery lets users select a structure, access the entry coordinates and visualize it in 3D using Protein Viewer (PV; requires WebGL enabled). Explore these structures by reading a brief summary of the molecule's biological role, and accessing the corresponding PDB entry and Molecule of the Month column.

Users can highlight structures in the Molecular Machinery viewer based on functional category. For instance, selecting "Blood Plasma" from the right menu highlights the structures shown that are involved with transporting nutrients and defending against injury.

The "Auto Mode" option will automatically launch a tour of the structures, highlighting the different categories of structures and the individual examples. The 3D view uses PV to rotate the molecule, use different depiction styles, and zoom in/out of the molecule. This mode can be used as a screensaver on a computer.

Some key points to highlight and discuss with your students:

1. All proteins have specific shapes that are best suited for their function(s)
2. Strategic locations of amino acid residues, with different physical and chemical properties (side-chains), enable proteins to perform a variety of different functions in the cell.
3. Small globular proteins (made of one single polymer chain) present in the cytoplasm or secreted by the cell, have their hydrophobic amino acid residues tucked in the core of the protein.
4. Larger protein complexes (formed from multiple copies of the same or different proteins) may have protein chains with interfaces that have hydrophobic amino acids. These proteins chains seek out and bind to partner proteins with complimentary interfaces and form functional assemblies.
5. In proteins that are composed of multiple domains, connected with flexible linker regions, scientists often selectively study regions or domains of the protein that are structurally stable and functionally important. The PDB archive may have multiple structures of one or more domains of the protein. To get a sense of how all these parts (domains) may work together, some of the domains of specific proteins have been shown next to each other in the Molecular Machinery interactive to represent the complete molecule. However, the actual structure of the complete protein may be slightly different from these composite presentations.

**Key**

* **Big and Small – Proteins Do Them All.**

Protein molecules seen here are involved in various big and small tasks within and outside the cell. Look at all the structures in this collection – note that some of these structures are big, while some are small. Each protein or nucleic acid molecules in these structures are colored in a different color or shades of a color.

* + Examine the small and large protein structures shown in the “Digestive Enzymes” and “Viruses and Antibodies” respectively. What do the colors of these proteins tell you about the composition of these molecules? (Level: Basic)

The small structures are mostly made of a single protein molecule while the larger structures are composed of two or more protein chains (or other biological molecules, e.g. nucleic acids, sugars, lipids etc.).

* + If you were to examine the surfaces of each protein chain that make the big and small proteins, do you think that the surfaces of these molecules will have similar properties? (Hint: think about the polarity, charges etc. of these surfaces). (Level: Advanced)

Small proteins have polar or charged surfaces and are soluble in aqueous environments. Component proteins molecules in larger structures interact with each other via complementary surfaces – i.e. the interacting surfaces may have one or more of hydrophobic, polar, or oppositely charged groups interacting with each other to stabilize the interface.

* **The Protein Factory.**

Look at the collection of molecules grouped under the heading “Protein Synthesis”. In this collection the red colored regions represent RNA.

* + What is the role of RNA in Protein Synthesis? Explain with reference to one or more structures seen here. (Level: Advanced)

Ribosomal RNA plays a structural role and interacts with various proteins in the ribosome structure. Transfer RNA acts as a translator of the messenger RNA (transcript) to the language of proteins. The structures of tRNA seen here show the overall shape of the molecule and its various complexes to enzymes that charge (covalently link) it with specific amino acids. One of the structures also shows tRNA bound to an elongation factor.