Overall Student Learning Objective: Cells are packed full of thousands of proteins, each trying to do their singular job amidst the chaos and jostling of all the others.

- Proteins are not uniformly distributed in cells. Instead, location, location, location! A particular protein will be found in a specific place/compartment, where it interacts with other like-minded proteins to perform a specific function.
- Some proteins are soluble in the watery environment of the cell’s cytoplasm. Others are insoluble in water, and are therefore embedded in the cell’s hydrophobic membranes.
- While most proteins fold up into compact globular 3D structures, some proteins exist as long, flexible chains.
- Many proteins function as multi-protein complexes (machines), rather than as single, solitary proteins.
- These landscape images represent biology at the mesoscale – spanning that dimension between the *molecular world* as revealed by crystallography and *cellular world* as revealed by microscopy.

⭐️ We suggest that the use of a landscape is highly synergistic with a physical model of a protein. While the physical model focuses attention on the molecular details of a protein’s structure, the landscape emphasizes the cellular context in which the protein acts.

**Key point 1**

Patterns, Scale and Mechanism/Explanation are three *cross-cutting concepts* described in the framework upon which the Next Gen Science Standards were created. These cellular landscapes can be used to call your students’ attention to each of these concepts. The close examination of these landscapes requires (1) attention to detail as patterns in the distribution of different proteins are noted, (2) an explicit comparison of the relative scale of a protein, an organelle and a cell, and (3) the explanation (a story) of the molecular basis of some cellular process/mechanism.
Key Point 2

These images provide students with “a model” for how the inside of a cell might look – at the mesoscale. Each student is challenged to reconcile their own mental image of what the inside of a cell looks like with the model provided by David Goodsell.

Key Point 3

Every shape included in these landscapes represents a specific protein – illustrated at its appropriate size / shape / and the best current estimate of its concentration in the cell.

What can you teach with these landscapes?

With **A Tour of the Human Cell**, you can teach “your flu shot in action”, as you trace the production of an antibody protein from (1) the transcription of its gene in the nucleus, to (2) the translation of the mRNA in the cytoplasm by ribosomes docked onto the endoplasmic reticulum, to (3) the folding of the protein in the endoplasmic reticulum, to (4) its path through the Golgi, to (5) vesicles loaded with mature antibody proteins being walked toward the cell membrane by kinesin motor proteins, to (6) the fusion of the vesicle with the cell membrane to release the antibody into the circulation.

By comparing the **E. coli** and the **Mitochondria** landscape, you can teach the endosymbiotic theory of mitochondria, as students compare the similarities and differences between these two structures. Especially telling is the extreme expansion of the inner membrane of the mitochondria, with its many copies of the electron transport chain proteins and ATP synthase.

With the **Synapse** landscape, you can teach the basic concept of neurotransmission, as vesicles containing acetylcholine fuse with the pre-synaptic cell’s membrane to release the neurotransmitter into the synapse, where it diffuses across the synapse to bind to the acetylcholine receptor proteins found on the membrane of the post-synaptic muscle cell.

These Cellular Landscapes are created by artist/scientist/author David Goodsell, Ph.D. We highly recommend that you read David’s book entitled “**The Machinery of Life**”, from which the art featured in these posters is taken. David is also the author of the Molecule of the Month, a regular feature of the Protein Data Bank website at [www.pdb.org](http://www.pdb.org).

⭐ For more detailed lesson plans and activities, please visit [http://www.3dmoleculardesigns.com/Education-Products/Tour-of-Human-Cell.htm](http://www.3dmoleculardesigns.com/Education-Products/Tour-of-Human-Cell.htm)

**Molecular Landscapes** can be purchased from 3D Molecular Designs ([www.3dmoleculardesigns.com](http://www.3dmoleculardesigns.com)).