

Book review: *The Machinery of Life* by David Goodsell

Up Close

After exploring the look of life for more than twenty years, a Scripps researcher and self-educated artist has again assembled an abundance of beautiful insights into the microscopic and submicroscopic world.

By miniaturising a submarine together with its crew and injecting it into the bloodstream of a human, film director Richard Fleischer presented one of humankind's oldest dreams: to experience physiological events up close without the assistance of a microscope. In Fleischer's 1966 science fiction film *Fantastic Voyage*, the protagonists are not only tossed around by cardiac turbulence and, at the end, nearly eaten by a huge white blood cell, but they have the unique possibility of admiring a living organism's breathtaking interior face-to-face.

Close-up without a microscope

Just Hollywood wishful thinking? Partially. To observe life at microscopic dimensions but without a microscope is feasible, thanks to David Goodsell, a molecular biologist and associate professor at Scripps Research Institute at La Jolla, California. Principally, Goodwell's lab researches drug resistance in HIV. With funding from the National Science Foundation, however, Goodsell also creates impressive and beautiful paintings of molecules and cells that are exhibited in galleries as well as pictured on the covers of all kinds of magazines. His illustrations show, "portions of living cells magnified so that one can see individual molecules".

As a result of his artistic avocation, Goodsell provides the monthly illustrations for a column on the RCSB Protein Data Bank (PDB), called "Molecule of the Month" (www.rcsb.org/pdb). In the last 20 years, Goodsell has also authored and/or illustrated several books on the molecular structure of living organisms that have been consistently praised by reviewers.

We lucky readers can now take a look at his latest release, *The Machinery of Life*, which is a new edition of Goodsell's 1993 book of the same name. Again, the author's full-colour illustrations are astonishing, forc-

ing the reader to dwell for minutes on every picture. They are based on data from scientific papers, electron microscopy and information about molecular structures that were obtained by X-ray crystallography. In his own words, Goodsell tries, "to make these illustrations as accurate as possible, [...] to get the proper number of molecules, in the proper place, and with the proper size and shape."

Goodsell is not only trying to do this. He does a good job.

Completely updated and extended

The 2nd edition of *The Machinery of Life* was completely revised. It includes a new cross-section of an *E. coli* cell, as well as Goodsell's ingenious panorama through a eukaryotic cell (see above) – starting from the cell membrane and ending in the nucleus. All updated with the latest scientific data. A new chapter covers over 17 pages life and death at molecular, cellular and whole organism levels, beginning with a cell that undergoes programmed cell death at 1,000,000-fold magnification (with a BID protein that forms a pore on a mitochondrial surface to release cytochrome c molecules into the cytoplasm). On the next page, we admire, now at 5,000,000-fold magnification, an obscure moribund protein that is marked with strings of ubiquitin to be cut down into pieces by a powerful proteasome. A few pages later, we watch the DNA repair process, performed by DNA photolyase; then the formation of reactive oxygen molecules by cytochrome c oxidase and the following battle of a lion-hearted vitamin c molecule against them and ... well, there are simply too many magnificent examples to mention.

Goodsell's technique is remarkable. He uses a combination of hand-drawing and computer graphics illustration. For him, "computer graphics is a perfect way to display the atomic details. Using experimental

coordinates determined by x-ray crystallography or other methods, [the reader] can see the position of every atom, and examine how they work together to catalyse a reaction or carry genetic information."

To show the, "millions of biomolecules working together to perform the daily tasks of life inside cells", Goodsell uses hand-drawn



David Goodsell giving a talk.

illustrations in ink and watercolour. Granted, in reality most biomolecules are colourless, of course, but colourless molecules are difficult to paint and nobody would understand their biological function if Goodsell didn't "stain" his cellular insights.

Want to buy a genuine Goodsell?

In the early 1990's, Goodsell's images rocked the scientific world by being stunning and spectacular. 15 years later, although his images aren't quite so shockingly spectacular, they are still stunning (and incorporate a lot of scientific advances that were made since the book's 1st edition).

By the way, if any *Lab Times* reader would like to buy an original Goodsell, go to www.flickr.com. Interested aficionados should have the necessary cash. A 15 x 20 cm "Cytochrome c in green and blue" costs \$250 and a 38 x 51 cm "Metastasis 1,000,000x" costs \$600. Both paintings once appeared in the journal *The Oncologist* and thus have collector's value. WEANÉE KIMBLEWOOD

David Goodsell, *The Machinery of Life*. 2nd edition, Copernicus/Springer, 2009. 167 pages, €26.75.

