DISCOVERING BIOLOGY THROUGH CRYSTALLOGRAPHY

COLORING BOOK

This coloring book was produced by the RCSB PDB with support from the American Crystallographic Association (ACA) Outreach Task Force.

Request printed copies for scientific education and outreach at pdb101.rcsb.org/color

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RCSB PDB PROTEIN DATA BANK

rcsb.org

Access to biomolecular 3D data for research in molecular biology, structural biology, computational biology, and beyond

RCSB PDB-101

pdb101.rcsb.org

Educational resources that support molecular explorations through biology and medicine

The RCSB PDB is managed by the members of the Research Collaboratory for Structural Bioinformatics:

RUTGERS

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ACA

www.amercrystalassn.org

ACA is a non-profit, scientific organization that promotes interactions among scientists who study the structure of matter at atomic (or near atomic) resolution. These interactions will advance experimental and computational aspects of crystallography and diffraction.

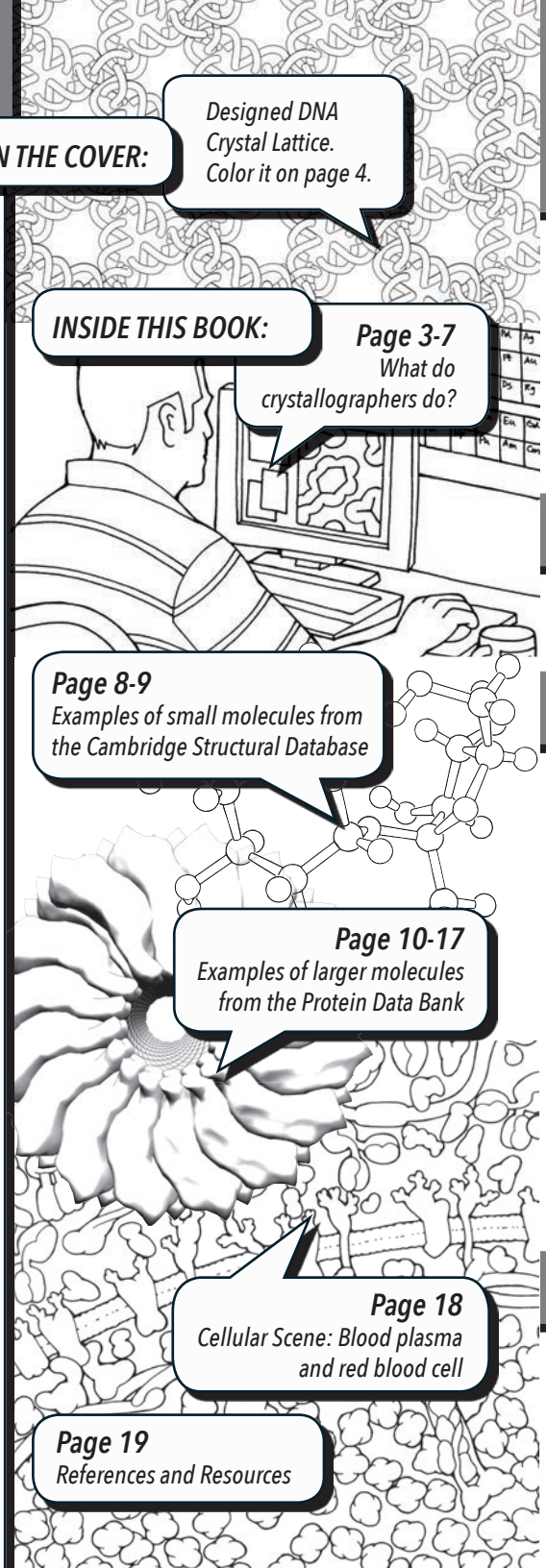
RCSB PDB-101 ACA

Discovering Biology Through Crystallography

Crystallography is the study of atomic and molecular structure. Crystallographers want to know how the atoms in a material are arranged in order to understand the relationship between atomic structure and properties of these materials. They work in many disciplines, including chemistry, geology, biology, materials science, metallurgy and physics. Crystallographers study diverse substances, from living cells to superconductors, from protein molecules to ceramics.

This book focuses on the diverse 3D shapes and functions of biological molecules studied by crystallography. Crystallographers make their 3D structure data publicly available in online resources like the Protein Data Bank and the Cambridge Structural Database. This broad access helps researchers, educators, and students around the world better understand biology and medicine.

Crystallographers also work together in strong communities. The American Crystallographic Association (ACA) is a non-profit, scientific organization that promotes interactions among scientists who study the structure of matter at atomic (or near atomic) resolution.

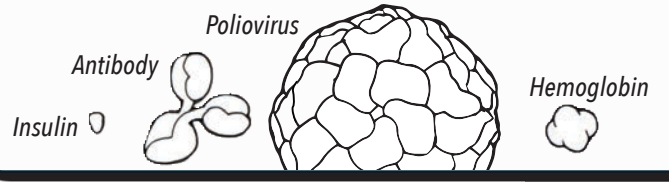


ON THE COVER: *Designed DNA Crystal Lattice. Color it on page 4.*

INSIDE THIS BOOK:

Structures studied by crystallography help us visualize cellular scenes

Blood plasma (top) and the red blood cell (bottom) shown at left include many molecules highlighted in this book:



Learn More

American Crystallographic Association: ***amercrystalassn.org***

PDB-101: ***pdb101.rcsb.org***

References

Access ***SMALL MOLECULES*** *at CCDC* ***ccdc.cam.ac.uk/structures*** *with these CSD refcodes:*

Sucrose: ***SUCROS08***
Caffeine: ***NUTPEZ***
Adenosine: ***ADENOS01***

Read Molecule of the Month *articles about each of these proteins at* ***pdb101.rcsb.org***

Access ***LARGER BIOMOLECULES*** *at RCSB PDB* ***rcsb.org*** *with these IDs:*

Designed DNA crystal: ***3gbi***
Myoglobin (only heme shown): ***1a6m***
DNA: ***1bna***
Insulin: ***4ins***
Hemoglobin: ***4hhb***
New Delhi Metallo-Beta-Lactamase: ***4eyl***
Rubisco: ***1rcx***
Tobacco Mosaic Virus: ***2tmv***
Poliovirus: ***1hxs***
Antibody: ***1igt***

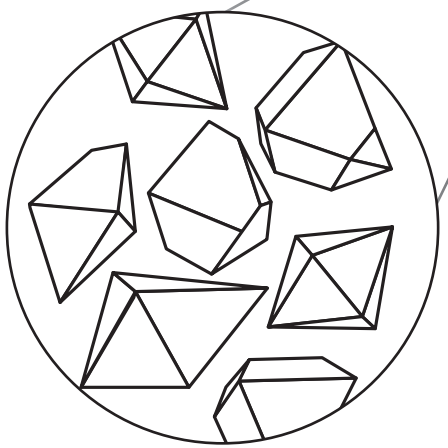
Credits

This book was created by RCSB PDB members David S. Goodsell, Brian Hudson, Maria Voigt, and Christine Zardecki

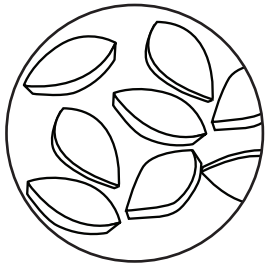
Molecular images created using UCSF Chimera, Ortep-3, and JSmol.

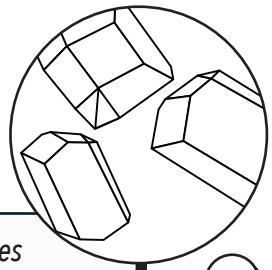
What do crystallographers do?

First, we grow crystals...



A molecule is purified and tiny crystals are grown. Usually, many attempts are made to form crystals.





Crystals adopt many different shapes

*Molecules are too small to be seen individually, but crystals contain **trillions** of copies arranged into a symmetrical, repeating lattice. Crystallographers use this repetition to help see the 3D shape of the structure.*

Designed DNA Crystal

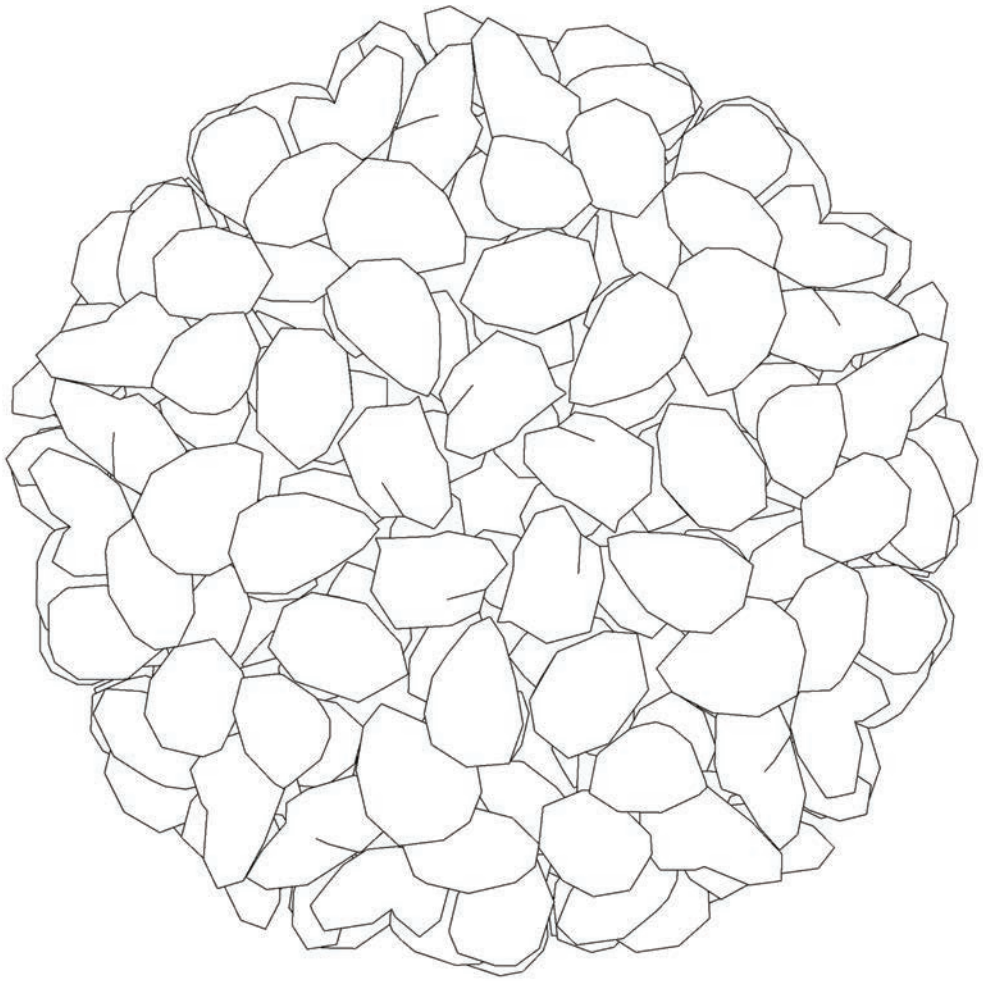
Small pieces of DNA have been engineered to form a nanoscale lattice

Antibodies

Antibodies search for foreign molecules like poliovirus in the blood. Polio vaccines tell cells of immune system to produce antibodies that prevent infection, and have been effective in limiting the spread of this disease.

Poliovirus

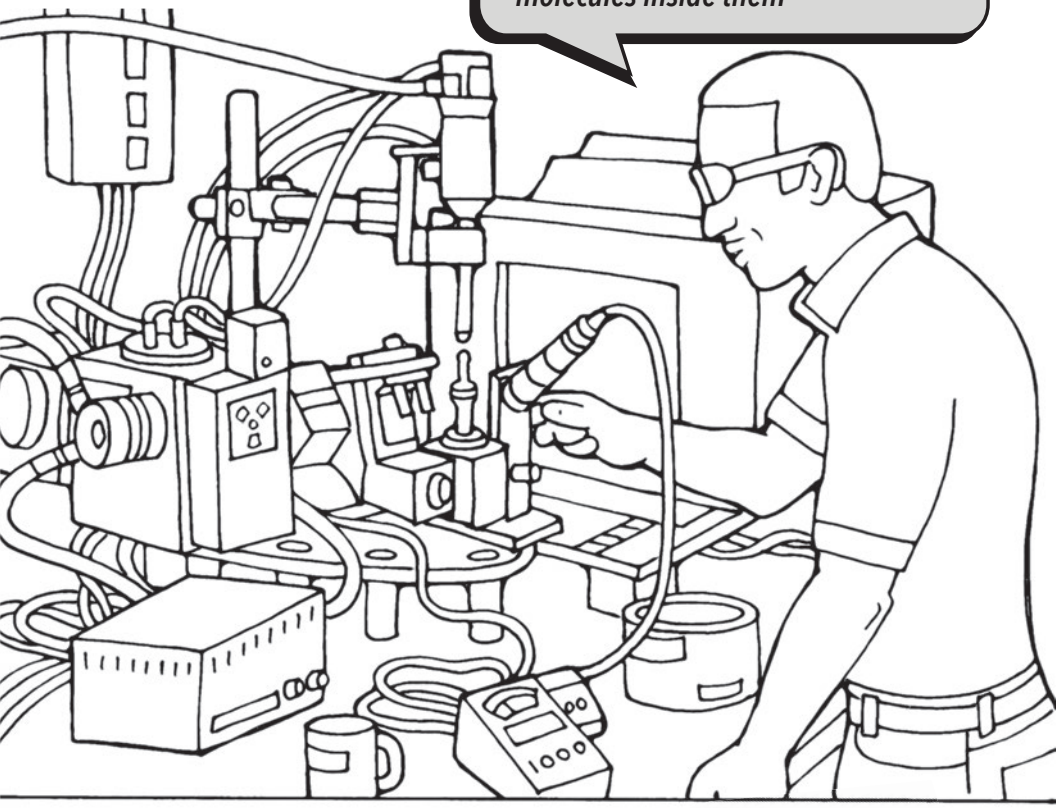
Poliovirus can spread to the nerve cells that control muscle motion, causing paralysis



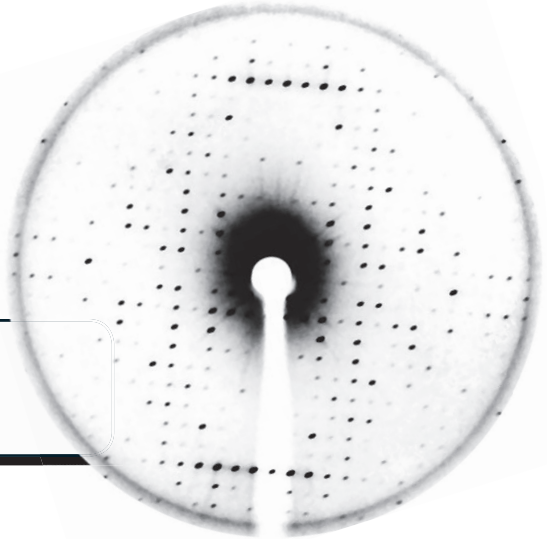
Thyroxine

Structures of small molecules, such as the thyroid hormone thyroxine, are also studied using X-ray crystallography

We use them to collect information about the arrangement of the molecules inside them



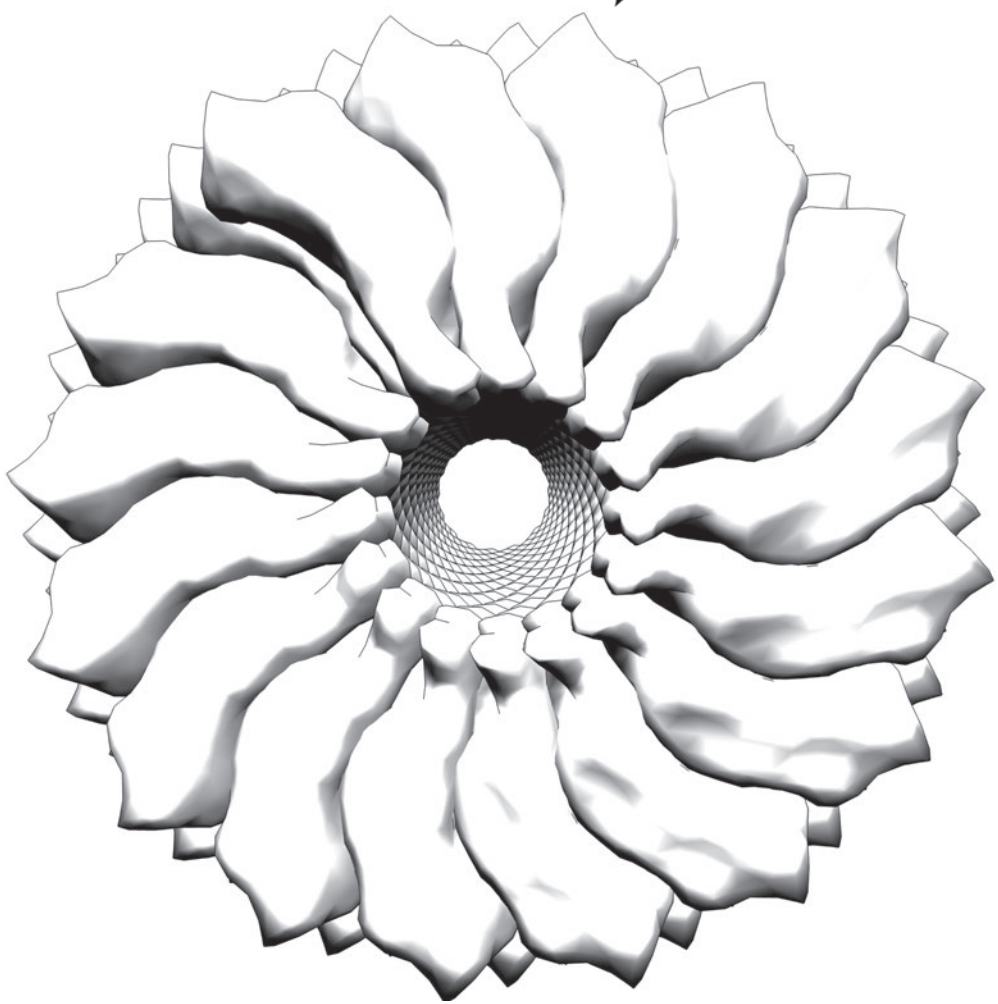
The crystals are placed in a beam of X-rays, which are diffracted by the molecules inside them into a characteristic pattern of spots



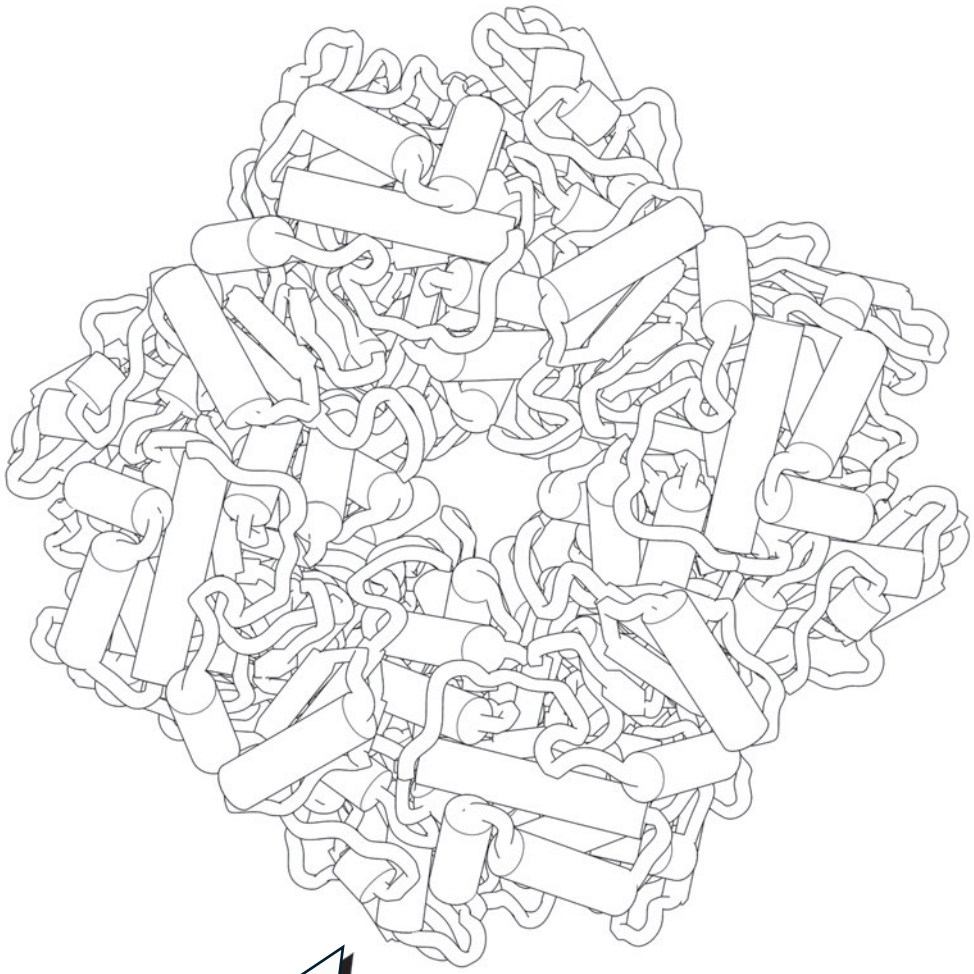
X-ray diffraction pattern of a DNA crystal

Tobacco Mosaic Virus

A cylindrical arrangement of proteins protects a long strand of RNA in TMV



Crystallography provides an important look into the biology of all living things, including plants



Rubisco

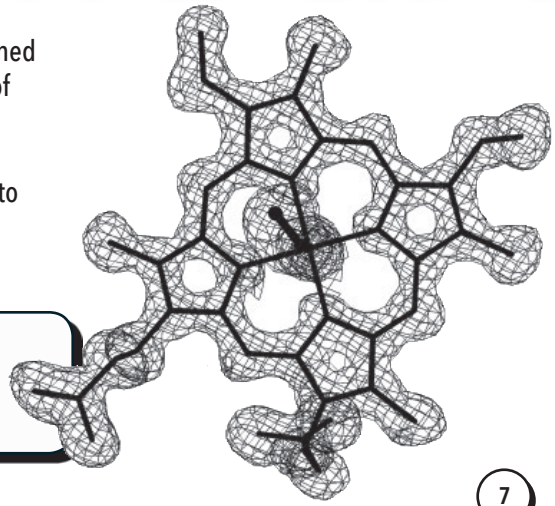
Rubisco fixes atmospheric carbon dioxide into bioavailable sugar molecules

What happens next?

The diffraction pattern is analyzed to determine the three dimensional atomic structure of molecules

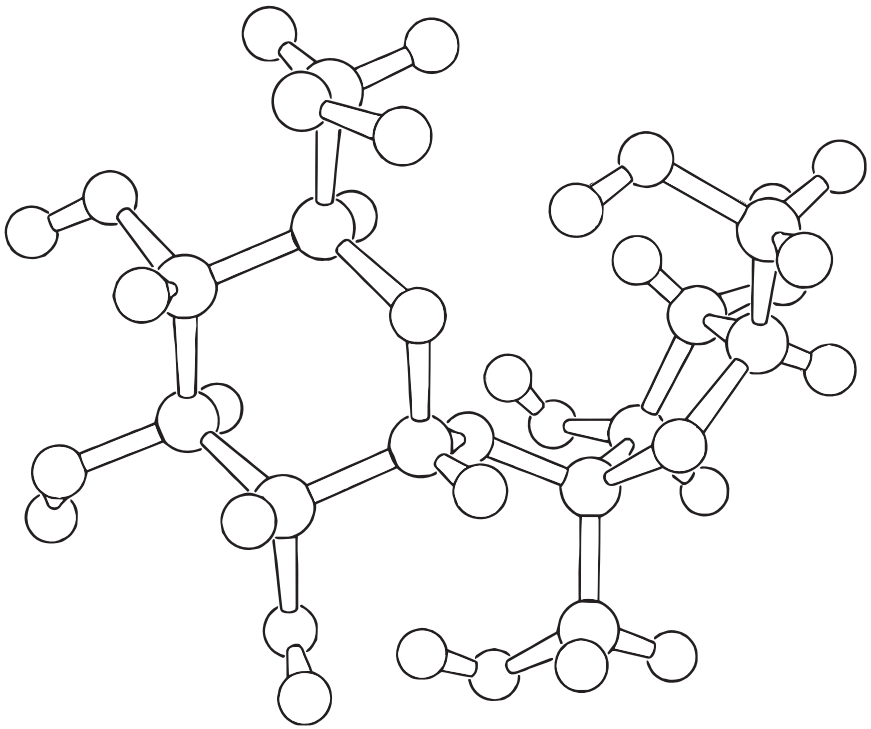
The X-ray diffraction pattern is transformed in the computer to reveal the location of electrons in the protein.

This electron density map is then used to determine the location of each atom.



Electron density map of a heme from myoglobin

Small molecule crystal structures like these are available in the Cambridge Structural Database (CSD). Learn more at ***ccdc.cam.ac.uk***



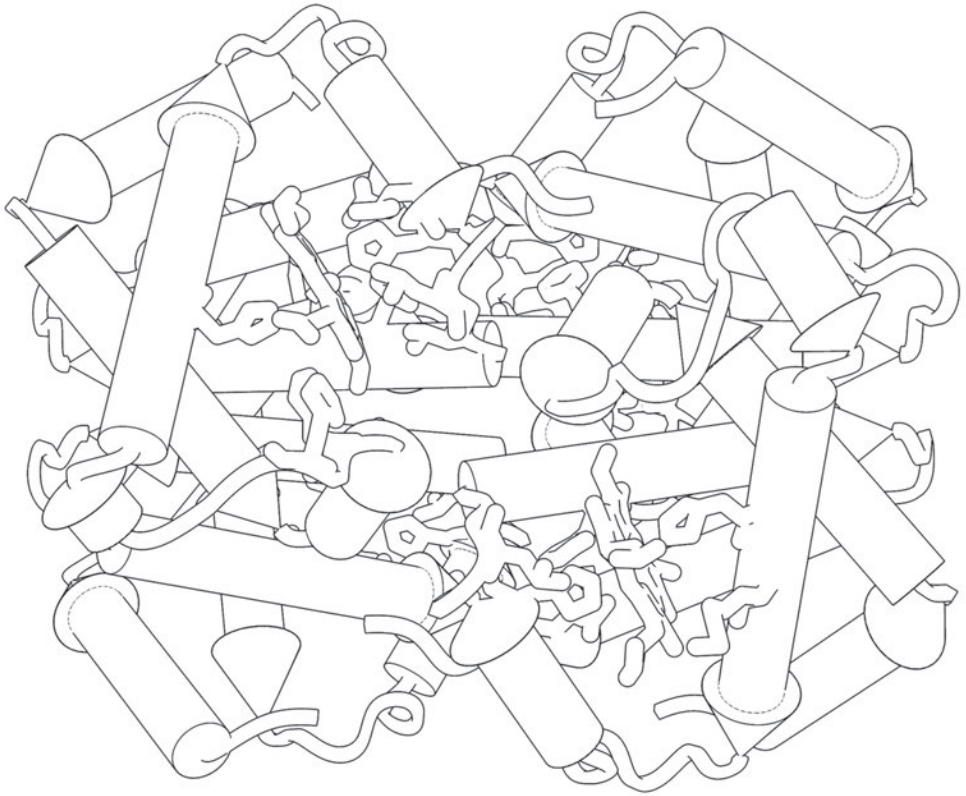
Sucrose

Sucrose is the sweet molecule in table sugar, composed of glucose (left half) attached to fructose (right half)

New Delhi Metallo-Beta-Lactamase

This enzyme is found in some superbugs that inactivate a wide range of penicillin-like antibiotics

The Worldwide PDB (wwPDB) organization manages the PDB archive and ensures that the PDB is freely and publicly available to the global community

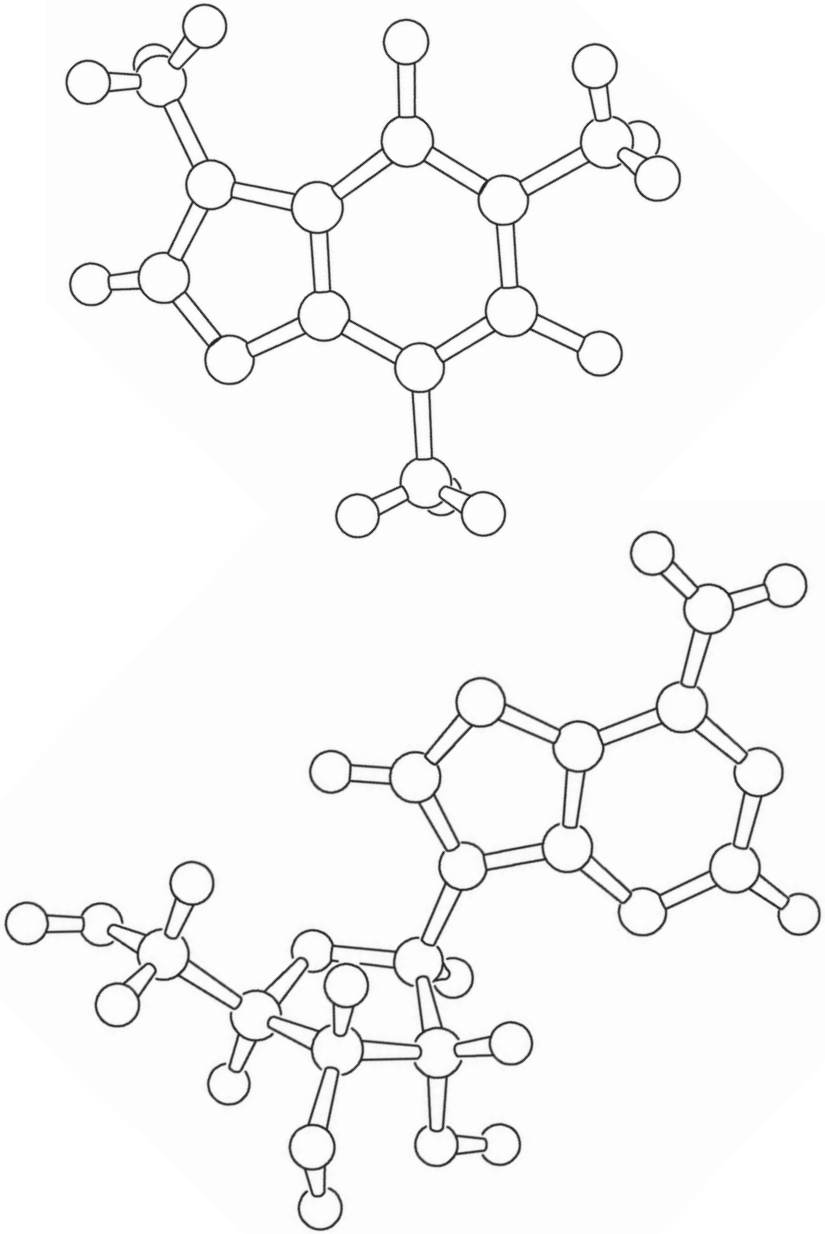


Hemoglobin

Hemoglobin carries oxygen from the lungs to the body's tissues

Caffeine and Adenosine

Caffeine (top) mimics the shape of adenosine (bottom), blocking receptors for adenosine in the brain that are involved in drowsiness



Since 1971, the Protein Data Bank archive (PDB) has served as the single repository of information about the 3D structures of proteins, nucleic acids, and complex assemblies

DNA

Atomic structures reveal how the iconic double helix encodes genetic information

Insulin

The hormone insulin helps control the level of glucose in the blood