Molecular Machinery: A Tour of the Protein Data Bank

Cells build many complex molecular machines that perform the biological jobs needed for life. Some of these machines are molecular scissors that cut food into digestible pieces. Others then use these pieces to build new molecules when cells grow or tissues need to be repaired. Some molecular machines form sturdy beams that support cells, and others are motors that use energy to crawl along these beams. Some recognize attackers and mobilize defenses against infection.

Researchers around the world are studying these molecules at the atomic level. These 3D structures are freely available at the Protein Data Bank (PDB), the central storehouse of biomolecular structures. A few examples from the ~100,000 structures held in the PDB are shown here, with each atom represented as a small sphere. The enormous range of molecular sizes is illustrated here, from the water molecule (H₂O) with only three atoms (shown at the left) to the ribosomal subunits with hundreds of thousands of atoms.

**Digestive Enzymes**: breaking food into small nutrient molecules
1. Amylase 1hmd
2. Phospholipase 1poc
3. Dextranase 2dnj
4. Lysozyme 1egf
5. Neutrophilic Elastase 2ptc
6. Trypsin 2pzt
7. Carboxypeptidase 1szr
8. Ribonuclease 1smw

**Blood Plasma Proteins**: transporting nutrients and defending against injury
9. Factor X 1xa, 1hid
10. Thrombin 1ppb
11. Fibrin 1m1j, 2baf
12. Serum Albumin 1gcn
13. Antibody 1vij
14. Rhodopsin 2kva
15. Guanosine 1pwc
16. Insulin 2hu
17. Epidermal Growth Factor 1egf
18. Ras Protein 1p2f
19. Betaxa-Antiadvirulucorceptor 1saw
20. Methyltransferase 2ptc
21. Epidermal Growth Factor Receptor 1k1f, 2gna, 2ptc
22. Rhodopsin 1h6a
23. Phospholipid 3g4t
24. Potassium Channel 3g61
25. Cytosol 1poc
26. Calcium Channel 1s1l
27. Photosystem II 1s1l
28. Light-harvesting Complex 1tnt
29. Photosynthetic Reaction Center 1poc
30. Cyanobacterium 1poc
31. Synechococcus 1poc

**Viruses and Antibodies**: engaging in constant battle in the bloodstream
13. Antibody 1vij
14. Rhodopsin 2kva
15. Guanosine 1pwc
16. Insulin 2hu
17. Epidermal Growth Factor 1egf
18. Ras Protein 1p2f
19. Betaxa-Antiadvirulucorceptor 1saw
20. Methyltransferase 2ptc
21. Epidermal Growth Factor Receptor 1k1f, 2gna, 2ptc
22. Rhodopsin 1h6a
23. Phospholipid 3g4t
24. Potassium Channel 3g61
25. Cytosol 1poc
26. Calcium Channel 1s1l
27. Photosystem II 1s1l
28. Light-harvesting Complex 1tnt
29. Photosynthetic Reaction Center 1poc
30. Cyanobacterium 1poc
31. Synechococcus 1poc
32. Synechococcus 1poc
33. Synechococcus 1poc
34. Synechococcus 1poc
35. Synechococcus 1poc
36. Synechococcus 1poc
37. Synechococcus 1poc
38. Synechococcus 1poc
39. Synechococcus 1poc
40. Synechococcus 1poc
41. Synechococcus 1poc
42. Synechococcus 1poc
43. Synechococcus 1poc
44. Synechococcus 1poc
45. Synechococcus 1poc
46. Synechococcus 1poc
47. Synechococcus 1poc
48. Synechococcus 1poc
49. Synechococcus 1poc
50. Synechococcus 1poc
51. Synechococcus 1poc
52. Synechococcus 1poc
53. Synechococcus 1poc
54. Synechococcus 1poc
55. Synechococcus 1poc
56. Synechococcus 1poc
57. Synechococcus 1poc
58. Synechococcus 1poc
59. Synechococcus 1poc
60. Synechococcus 1poc

**Energy Production**: powering the processes of the cell
31. Cytochrome c Oxidase (Complex IV) 1ocs
32. Cytochrome c Oxidase (Complex III) 1r4f
33. Succinate Dehydrogenase (Complex II) 1r4f
34. NADH-Qutone Oxidoreductase (Complex I) 1r4f
35. ATP Synthase 1e79, 1e7t, 1llp, 2a7u
36. Myoglobin 1mbd
37. Hemoglobin 4bhb

**Storage**: containing nutrients for future consumption
38. Ferritin 1hrs

**Enzymes**: cutting and joining the molecules of life
39. Fatty Acid Synthase 2nnb, 2nnc
40. Rubisco: Ribulose Bisphosphate Carboxylase/Oxygenase 1rca
41. Green Fluorescent Protein 1gfp
42. Luciferase 1gfp
43. Glutamine Synthetase 2g9k
44. Alcohol Dehydrogenase 2dka
45. Dihydrofolate Reductase 1dfr
46. Nitrogenase 1nc2
47. Lactate Dehydrogenase 1lmp
48. Beta-Lactamase 4bhm
49. Catalase 1dop
50. Thymidylate Synthase 2nu
51. Tryptophan Synthase 1tnsw
52. Aspartate Carbamoyltransferase 4at1
53. Hexokinase 1dph
54. Phosphoglucomutase 1tom
55. Phosphofructokinase 1pfr
56. Aldolase 4af6
57. Triosephosphate Isomerase 2ppt
58. Glyceraldehyde-3-phosphate Dehydrogenase 3gpd
59. Phosphoglycerate Kinase 3gpk
60. Phosphofructokinase 3gpm
61. Eukaryote 1a3w

Infrastructure: supporting and moving cells

Protein Synthesis: building new molecular machines
67. Transfer RNA 4dna
68. Valyl-tRNA Synthetase 1gax
69. Thrreyl-tRNA Synthetase 1q69
70. Glutamyl-tRNA Synthetase 1euq
71. Isoleucyl-tRNA Synthetase 1ffy
72. Phenylalanyl-tRNA Synthetase 1qf6
73. Aspartyl-tRNA Synthetase 1asy
74. Ribosome 1j5e, 1jj2
75. Elongation Factor Tu/tRNA 1ttt
76. Elongation Factor G 1dar
77. Elongation Factor Ts and Tu 1efu
78. Prefoldin 1fxk
79. Chaperonin GroEL/ES 1aon
80. Proline cis/trans Isomerase 2cpl
81. Heat Shock Proteins Hsp90 2cg9
82. Proteasome 4b4t
83. Ubiquitin 1ubq

DNA: storing and reading genetic information
84. DNA 1bna
85. Restriction Endonuclease EcoRI 1eri
86. DNA Photolyase 1tez
87. Topoisomerase 1a36
88. RNA Polymerase 2e2i
89. lac Repressor 1lbh
90. Catabolite Gene Activator Protein 1cgp
91. TATA-binding Protein/Transcription Factor IIB 1ais
92. DNA Helicase 4esv
93. DNA Polymerase 1atu
94. Nucleosome 1aoi
95. HU Protein 1p51
96. Single-stranded DNA-binding Protein 3a5u

Intracellular Proteins: Nucleus
Intracellular Proteins: Cytosol