

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 at a magnification of about 2,500,000 times, 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 1and 5. Pepsin 5ppp
- 2. Phospholipase 1aac 6. Trypsin 2ltp
- 3. Decarboxylase 28h 7. Carboxypeptidase 3cgp
- 4. Lysostein 1st1 8. Ribonuclease 5rua

Blood Plasma Proteins: transporting nutrients and defending against injury

- 9. Factor F 1a1a, 1a1d 11. Fibron 1em1, 2hd
- 10. Thrombin 1ppb 12. Serum Albumin 1a7i

Viruses and Antibodies: engaging in constant battle in the bloodstream

- 13. Antibody 1igt 14. HIVvirus 4duv

Hormones: carrying molecular messages through blood

- 15. Calciton 1pyn 17. Epidermal Growth Factor 1egf
- 16. Insulin 2hu

Channels, Pumps and Receptors: getting back and forth across the membrane

- 18. Gpcr 3pwn 1c1r
- 19. Beta2 Adrenergic Receptor/Gs Protein 2an5
- 20. Acetylcholine Receptor 2c9p
- 21. Epidermal Growth Factor Receptor 1em1, 2hm1, 2p0n
- 22. Rhodopsin 1l88
- 23. P-glycoprotein 4ac3
- 24. Potassium Channel 31at
- 25. Calcium Pump 1vsk
- 26. Glycerolipase 1gpk

Photosynthesis: harvesting energy from the sun

- 27. Photosystem II 1jii
- 28. Light-harvesting Complex 1mvt
- 29. Photosynthetic Reaction Center 1prc

Scale:
1nm 5nm 100nm

Energy Production: powering the processes of the cell

- 30. Cytochrome c Oxidase (Complex IV) 1oco
- 31. Cytochrome c 1c1r
- 32. Cytochrome b1 1b1
- 33. Succinate Dehydrogenase (Complex II) 1hd
- 34. NADH-Quinone Oxidoreductase (Complex I) 3m8, 3ku
- 35. ATP Synthase 1a7r, 1c17, 1d2p, 2a7v
- 36. Myoglobin 1mbd
- 37. Hemoglobin 4bbv
- 38. Ferritin 1hrs

Storage: containing nutrients for future consumption

Enzymes: cutting and joining the molecules of life

- 39. Farnesyl Synthase 2a6t, 2amc
- 40. Bcl2/Gs Ribonuclease Biophosphate Calcium/Calcium-dependent 1m1
- 41. Caspase Fluorenyl Protein 1gff
- 42. Luciferase 5d1s
- 43. Glucanase Synthase 2jpb
- 44. Alcohol Dehydrogenase 2zlu
- 45. Dihydrofolate Reductase 1dfl
- 46. Nitrogenase 1a2c
- 47. Lactate Dehydrogenase 1ldp
- 48. beta-Lactamase 4l8n
- 49. Catalase 1qpe
- 50. Thymidine Synthase 2bu
- 51. Stryphanon Synthase 1a9y
- 52. Arginase Carbonyltransferase 1a1t
- 53. Ribonuclease 1qgl
- 54. Phosphoglucose isomerase 1hxn
- 55. Phosphoenolpyruvate-kinase 4p8r
- 56. Aldolase 4a1d
- 57. Triosephosphate isomerase 2ipi
- 58. Glyceraldehyde-3-phosphate dehydrogenase 1gpd
- 59. Phosphoglycerate kinase 1gpk
- 60. Phosphoglycerate mutase 1gpm
- 61. Kinase 2en1
- 62. Pyruvate Kinase 1a1w
- 63. Acin 1mbg
- 64. Myosin 1mbj
- 65. Microtubule tub 1ub
- 66. Cadherin 1bku (in 4b)

Infrastructure: supporting and moving cells

- 67. Transfer RNA 4ba
- 68. Nucleosome 1nuc
- 69. Thymidylate Synthase 1q96
- 70. Galactamyl-ATP Synthase 1a9q
- 71. Indole-3-Pyruvate Synthase 1hy
- 72. Phenylalanyl-tRNA Synthetase 1ey
- 73. Arginyl-tRNA Synthetase 1arq
- 74. Ribosome 1ye, 1j2
- 75. Elongation Factor G/eIF4A 1m
- 76. Elongation Factor G 1dar
- 77. Elongation Factor T1 and T2 1e1u
- 78. Pre-60S 1ba
- 79. Chaperonin GroEL/ES 1aan
- 80. Protein chaperonin 2aa1
- 81. Heat Shock Protein Hsp90 2c9p
- 82. Proteasome 4b4t
- 83. Ubiquitin 1ubq
- 84. DNA 1bna
- 85. Bacteriophage Endonuclease EcoRI 1eri
- 86. DNA Polymerase 1aa
- 87. Topoisomerase 1a56
- 88. RNA Polymerase 2a2s
- 89. lac Repressor 1bba 1eda
- 90. Catalytic Gene Activator Protein 1gcp
- 91. DNA-binding Protein Transcription Factor IIB 1an
- 92. DNA Helicase 4evr
- 93. DNA Polymerase 1aa
- 94. Nucleosome 1aol
- 95. HU Protein 1p01
- 96. Single-stranded DNA-binding Protein Ssb1a

Protein Synthesis: building new molecular machines

DNA: storing and reading genetic information