

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 1amd
2. Phospholipase 1pse
3. Decarboxylase 2d8
4. Lycopodium 1c1
5. Pepsin 5pnp
6. Trypsin 2trp
7. Carboxypeptidase 3cpa
8. Ribonuclease 5rua

Blood Plasma Proteins: transporting nutrients and defending against injury

9. Factor F 1kfa, 1kfd
10. Thrombin 1p9b
11. Fibron 1m1, 2hd
12. Serum Albumin 1a7i

Viruses and Antibodies: engaging in constant battle in the bloodstream

13. Antibody 1igt
14. HIV virus 4hdv

Hormones: carrying molecular messages through blood

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

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

18. Gpcr 3trp, 1c1
19. Beta2 Adrenergic Receptor/Gs Protein 2an5
20. Acetylcholine Receptor 2d9p
21. Epidermal Growth Factor Receptor 1egp, 2jms, 2jps
22. Rhodopsin 1rh8
23. P-glycoprotein 4ac3
24. Potassium Channel 3kaf
25. Calcium Pump 1ca4
26. Glycerol-gate 1gk1

Photosynthesis: harvesting energy from the sun

27. Photosystem II 1ps2
28. Light-harvesting Complex 1lvt
29. Photosynthetic Reaction Center 1prc

Enzymes: cutting and joining the molecules of life

30. Fatty Acid Synthase 2a8b, 2a8c
31. Bacteriophage T4 1bph
32. Gamma Fluorocyclin Protein 1gfl
33. Luciferase 1luc
34. Glucanase Synthase 2gls
35. Alcohol Dehydrogenase 1ahd
36. Nitrogenase 1n2d
37. Laccase 1lcc, 1lcp
38. beta-Lactamase 4lbt
39. Catalase 1cat
40. Thymidine Synthase 2thc
41. Strychnine Synthase 1sry
42. Arginine Carbonyltransferase 1act

Energy Production: powering the processes of the cell

39. Cytochrome c Oxidase (Complex IV) 1cco
40. Cytochrome c 1c1
41. Cytochrome b1 1cb1
42. Succinate Dehydrogenase (Complex II) 1hd2
43. NADH-Quinone Oxidoreductase (Complex I) 2nrx, 2nru
44. ATP Synthase 1atp, 1atf, 1atp, 2atp
45. Myoglobin 1mbd
46. Hemoglobin 4hba

Storage: containing nutrients for future consumption

47. Ferritin 1ftr

Infrastructure: supporting and moving cells

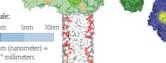
48. Actin 1akg
49. Myosin 1myo
50. Microtubule tub 1mt
51. Cadherin 1cdu
52. E-cadherin 1ecad

Protein Synthesis: building new molecular machines

67. Transfer RNA 4tta
68. 60S Ribosomal Subunit 1gpe
69. Threonyl-tRNA Synthetase 1g86
70. Glutamyl-tRNA Synthetase 1g8q
71. Histidyl-tRNA Synthetase 1h8y
72. Phenylalanyl-tRNA Synthetase 1ey1
73. Arginyl-tRNA Synthetase 1arg
74. Ribosome 1rye, 1r2
75. Elongation Factor 2/eEF2A 1m1
76. Elongation Factor G 1idat
77. Elongation Factor 1i and Tu 1etu
78. Pre-60S 1b6
79. Chaperonin GroEL/ES 1tan
80. Protein chaperonin 2cpn
81. Heat Shock Protein Hsp90 2g9p
82. Proteasome 4baf
83. Ubiquitin 1ubq

DNA: storing and reading genetic information

84. DNA 1dna
85. Bacteriophage Endonuclease EcoRI 1eri
86. DNA Polymerase 1dna
87. Topoisomerase 1tse
88. RNA Polymerase 2rpo
89. Ice Nucleation Protein 1inb
90. Catalytic Gene Activator Protein 1gap
91. DNA-binding Protein Transcription Factor IIB 1ab
92. DNA Helicase 4evr
93. DNA Polymerase 1dna
94. Nucleosome 1nuc
95. HU Protein 1pud
96. Single-strand DNA-binding Protein 1sdbp



Scale: 1nm 10nm 100nm 1micrometer 10micrometers

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