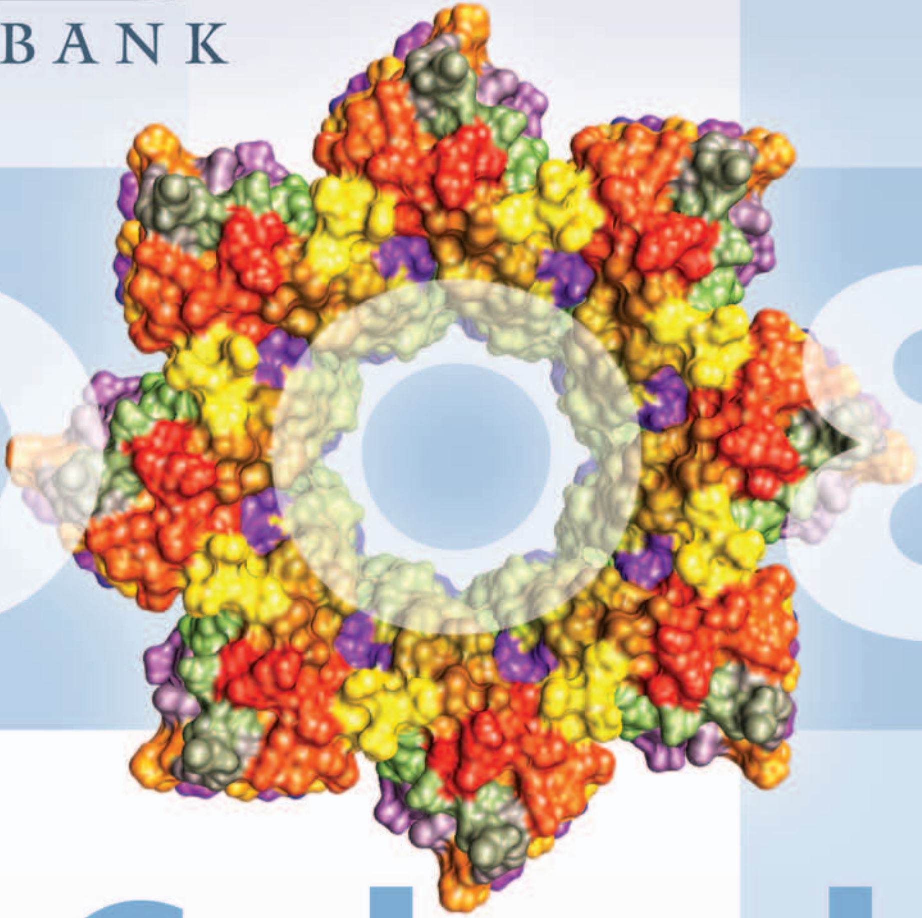
RCSB PDB

PROTEIN DATA BANK

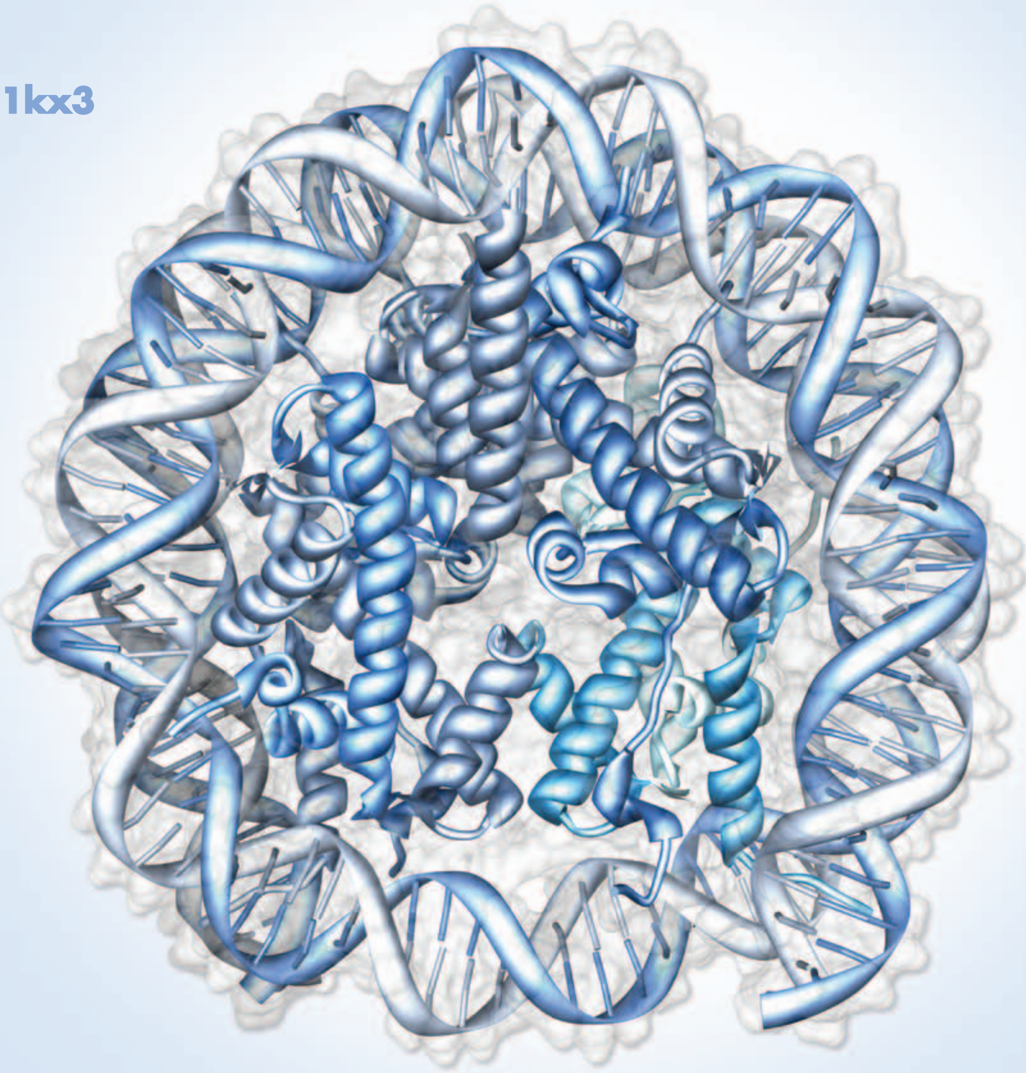


2008

Calendar

DNA

1kx3



DNA is one of the most familiar molecules. As the central icon of molecular biology, it is easily recognized by everyone. Information is stored in the way that the bases match one another on opposite sides of the double helix – adenine with thymine, guanine with cytosine – to form a set of complementary hydrogen bonds (1bna).

Nucleosomes package DNA and also modify the activity of the genes that they store (1kx3). Each nucleosome is composed of eight "histone" proteins tightly bundled and encircled by two loops of DNA. The histone proteins have long tails (not shown), which extend outward from the compact nucleosome, reaching out to neighboring nucleosomes and binding them tightly together. The nucleus contains regulatory enzymes that chemically modify these tails to weaken their interactions. In this way, the cell makes particular genes more accessible to polymerases, which lets their particular information be copied and used to build new proteins.

1bna

January 2008

1bna: H.R. Drew, R.M. Wing, T. Takano, C. Broka, S. Tanaka, K. Itakura, R.E. Dickerson (1981) Structure of a B-DNA dodecamer: conformation and dynamics. *Proc.Natl.Acad.Sci.USA* **78**:2179-2183.

1kx3: C.A. Davey, D.F. Sargent, K. Luger, A.W. Maeder, T.J. Richmond (2002) Solvent mediated interactions in the structure of the nucleosome core particle at 1.9 Å resolution. *J.Mol.Biol.* **319**:1097-1113.

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
		1 New Year’s Day	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21 Martin Luther King Jr. Day	22	23	24	25	26
27	28	29	30	31		

DECEMBER 2007

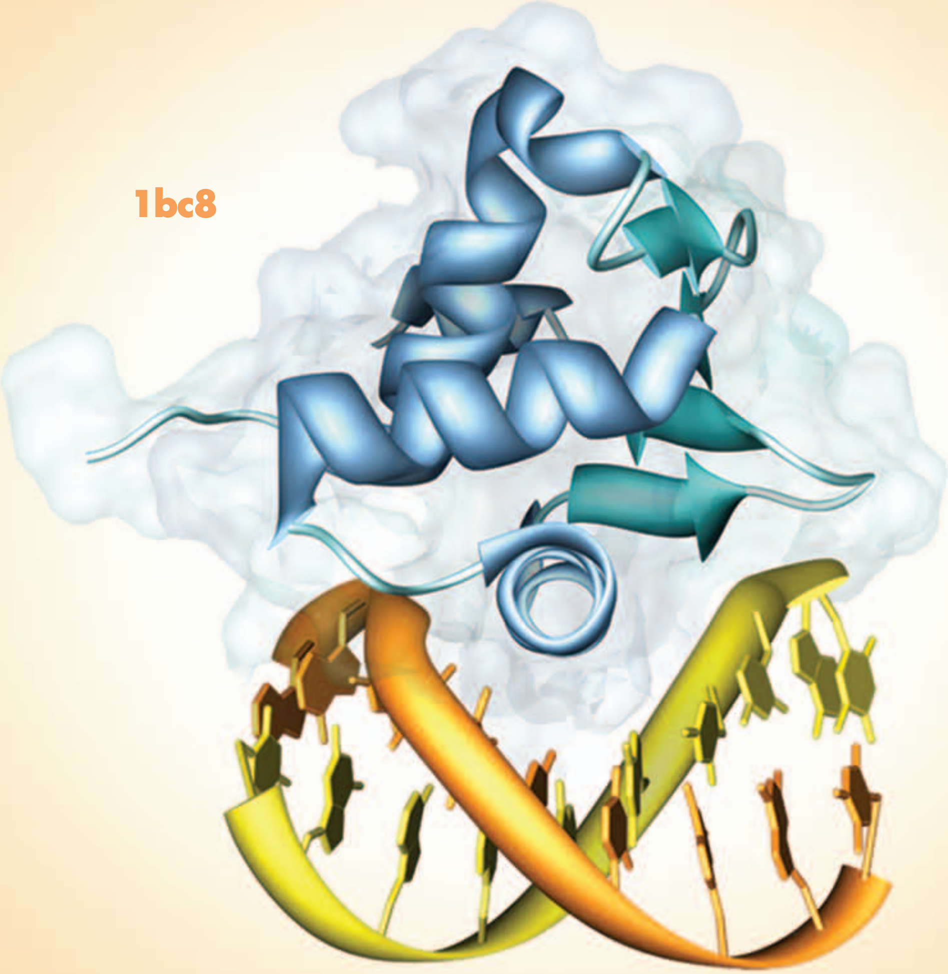
S	M	T	W	T	F	S
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30	31					

FEBRUARY

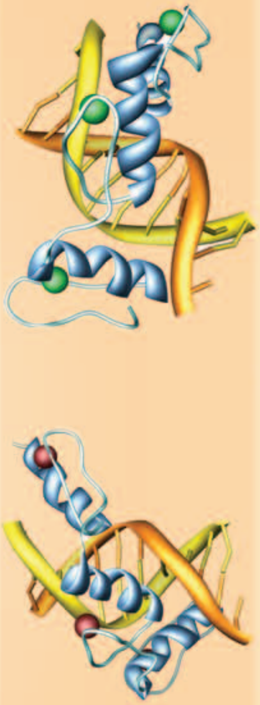
S	M	T	W	T	F	S
					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	

Transcription Factors

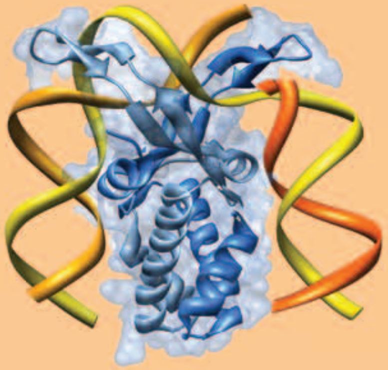
1bc8

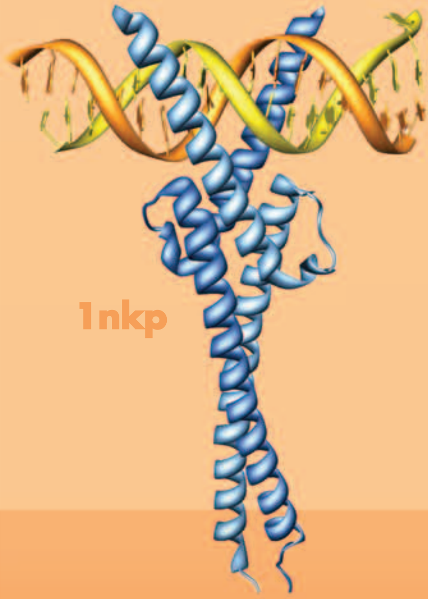


1a1h



1owf





1nkp

Transcription factors are proteins that regulate gene expression by binding to DNA regulatory sequences. Examples of four structurally distinct types of transcription factors are shown:

Zinc finger proteins have a relatively simple modular structure. They recognize a diverse set of DNA sequences with key contacts made by a few residues from each finger (1a1h).

Helix-turn-helix motifs formed by two short connected helices are common in proteins regulating DNA transcription and replication. Shown is one variant, a "winged helix-turn-helix" (1bc8).

β–strands of "histone-like" integration host factor sharply bend DNA by opening up the minor groove (1owf).

Leucine zippers are dimeric motifs in which long helices are held by intertwined leucine residues. Both leucine zipper and helix-turn-helix motifs feature helices that fit snugly into the DNA major groove (1nkp).

February 2008

1owf: T.W. Lynch, E.K. Read, A.N. Mattis, J.F. Gardner, P.A. Rice (2003) Integration Host Factor: putting a twist on protein-DNA recognition. *J.Mol.Biol.* **330**:493-502.

1a1h: M. Elrod-Erickson, T.E. Benson, C.O. Pabo, (1998) High-resolution structures of variant Zif268-DNA complexes: implications for understanding zinc finger-DNA recognition. *Structure* **6**:451-464.

1bc8: Y. Mo, B. Vaessen, K. Johnston, R. Marmorstein, (1998) Structures of SAP-1 bound to DNA targets from the E74 and c-fos promoters: insights into DNA sequence discrimination by Ets proteins. *Mol. Cell* **2**:201-212.

1nkp: S.K. Nair, S.K. Burley, (2003) X-ray structures of Myc-Max and Mad-Max recognizing DNA: Molecular bases of regulation by proto-oncogenic transcription factors. *Cell* **112**:193-205.

JANUARY

S	M	T	W	T	F	S
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30	31		

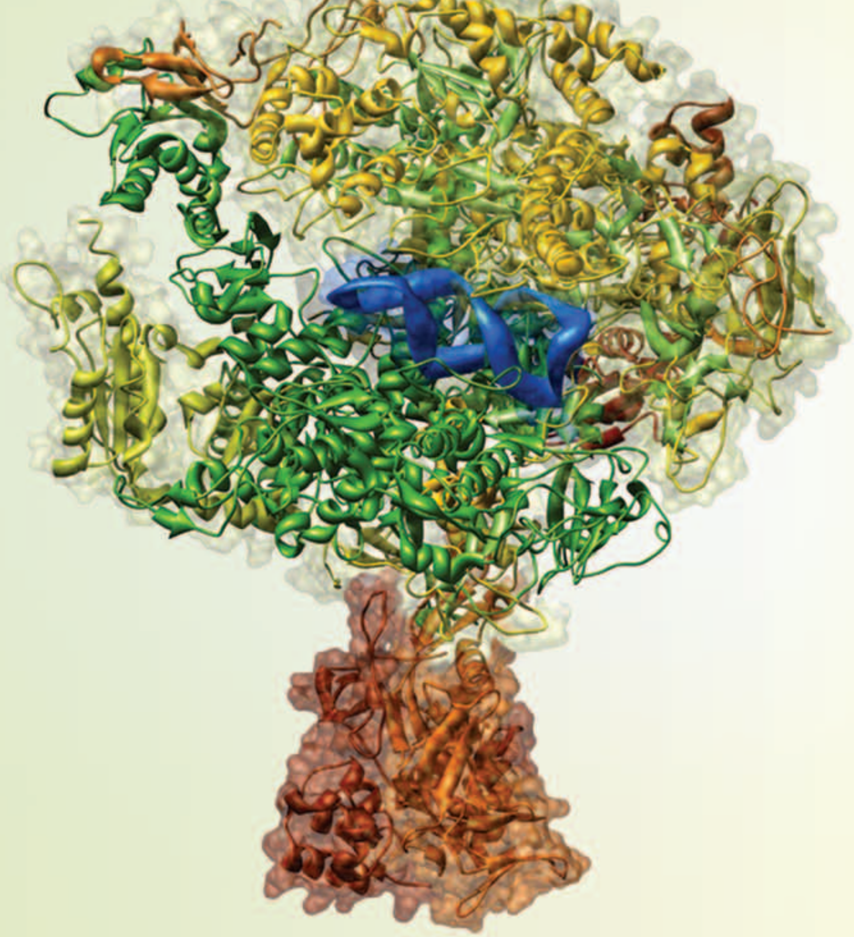
MARCH

S	M	T	W	T	F	S
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30	31					

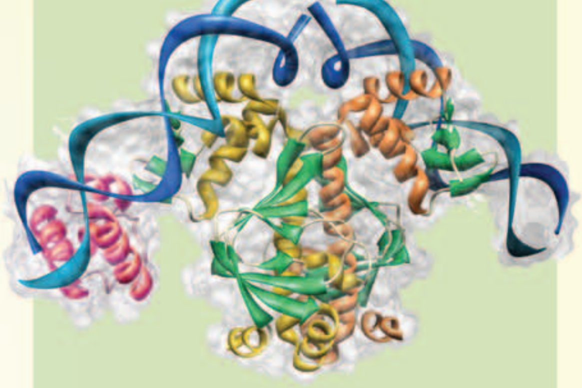
Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
					1	2
3	4	5	6	7 Chinese New Year	8	9
10	11	12	13	14 Valentine's Day	15	16
17	18 Presidents' Day	19	20	21	22	23
24	25	26	27	28	29	

RNA Polymerase

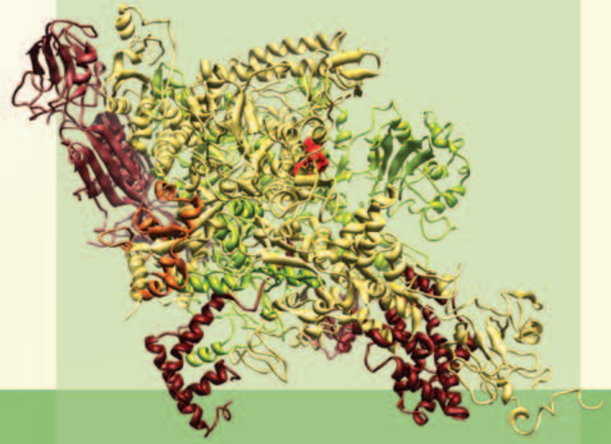
2b63



1lb2



1zyr



RNA polymerase is a complex and extremely precise nano-machine consisting of twelve different proteins. These proteins work in concert to unwind the DNA double helix, read the sequence from the anti-coding strand, and synthesize the messenger RNA.

The structure shown in 2b63 reports all twelve proteins of the yeast polymerase II enzyme in complex with a stem-loop RNA aptamer (in blue) that inhibits DNA reading, but not RNA elongation, bound to the active center cleft. An example of an RNA polymerase found in bacteria is shown in 1zyr.

The complex shown in structure 1lb2 is the *E. coli* transcription factor catabolite activator protein interacting with one small piece of bacterial RNA polymerase to start transcription.

March 2008

1lb2: B. Benoff, H. Yang, C. L. Lawson, G. Parkinson, J. Liu, E. Blatter, Y.W. Ebright, H.M. Berman, R.H. Ebright (2002) Structural basis of transcription activation: the CAP-alpha CTD-DNA complex. *Science* **297:**1562-1566.

2b63: H. Kettenberger, A. Eisenfuehr, F. Brueckner, M. Theis, M. Famulok, P. Cramer (2006) Structure of an RNA polymerase II-RNA inhibitor complex elucidates transcription regulation by noncoding RNAs. *Nat.Struct.Mol.Biol.* **13**:44-48.

1zyr: S. Tuske, S.G. Sarafianos, X. Wang, B. Hudson, E. Sineva, J. Mukhopadhyay, J.J. Birktoft, O. Leroy, S. Ismail, A.D. Clark, C. Dharia, A. Napoli, O. Laptenko, J. Lee, S. Borukhov, R.H. Ebright, E. Arnold (2005) Inhibition of bacterial RNA polymerase by streptolydigin: stabilization of a straight-bridge-helix active-center conformation. *Cell* **122**:541-552.

FEBRUARY

S	M	T	W	T	F	S
					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	

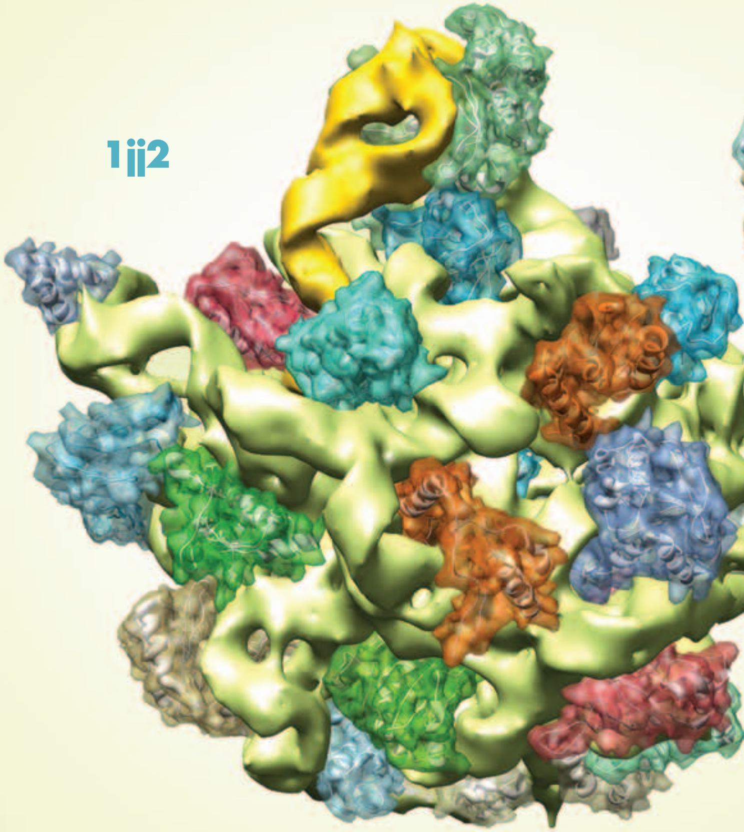
APRIL

S	M	T	W	T	F	S
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30			

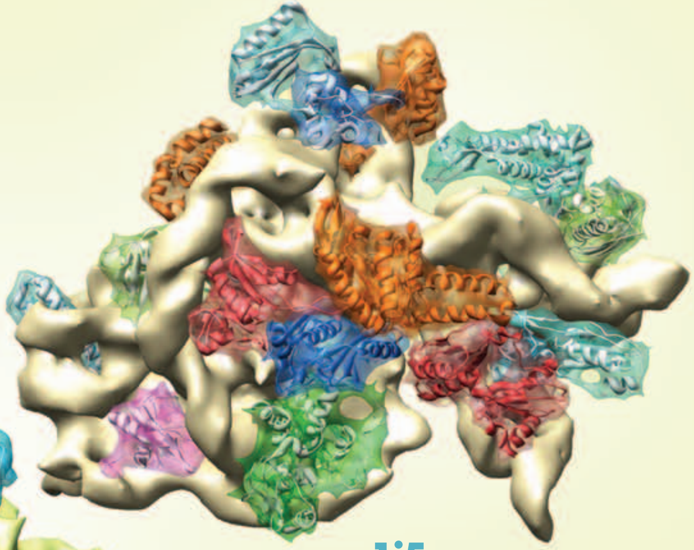
Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16 Palm Sunday	17 St. Patrick's Day	18	19	20 Spring begins	21 Good Friday	22
23 Easter 30	24 31	25	26	27	28	29

www.pdb.org

Ribosomes

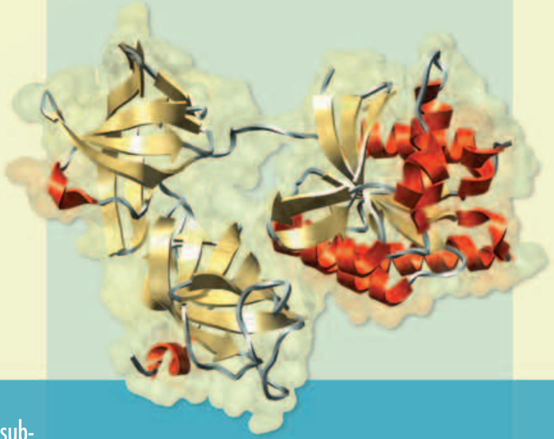


1jj2



1j5e

6tna



1d2e

Protein synthesis is a major task performed by living cells. The translation of the genetic information from messenger RNA into protein is performed by the ribosome, a large nucleoprotein complex comprising two subunits. The small subunit is denoted 30S in bacteria (1j5e) and the large subunit, 50S (1jj2). Both subunits are composed of long strands of RNA, shown in light yellow, and about fifty small proteins shown in bright colors. When synthesizing a new protein, the two subunits assemble into a full ribosome, with a messenger RNA trapped in the space between. The large ribosomal subunit catalyzes peptide bond formation and binds initiation, termination, and elongation factors (such as the mitochondrial elongation factor Tu (EF-Tu) in 1d2e). The ribosome reads the messenger RNA in steps of three nucleotides, since each nucleotide triplet codes for one amino acid. Amino acid building blocks are carried to the ribosomal machine bound to transfer RNA (6tna).

April 2008

1j5e: B.T. Wimberly, D.E. Brodersen, W.M. Clemons Jr., R.J. Morgan-Warren, A.P. Carter, C. Vonrhein, T. Hartsch, V. Ramakrishnan (2000) Structure of the 30S ribosomal subunit. *Nature* **407**:327-339.

1jj2: D.J.Klein, T.M.Schmeing, P.B. Moore, T.A. Steitz (2001) The kink-turn: a new RNA secondary structure motif. EMBO J. 20:4214-4221; N. Ban, P. Nissen, J. Hansen, P.B. Moore, T.A. Steitz (2000) The complete atomic structure of the large ribosomal subunit at 2.4 Å resolution. *Science* **289**:905-920.

6tna: J.L. Sussman, S.R. Holbrook, R.W. Warrant, G.M. Church, S.H. Kim (1978) Crystal structure of yeast phenylalanine transfer RNA. I. Crystallographic refinement. *J.Mol.Biol.* **123**:607-630.

1d2e: G.R. Andersen, S. Thirup, L.L. Spremulli, J. Nyborg (2000) High resolution crystal structure of bovine mitochondrial EF-Tu in complex with GDP. *J.Mol.Biol.* **297**:421-436.

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20 Passover begins at sundown	21 Passover	22 Earth Day	23	24	25 DNA Day	26
27	28	29	30			

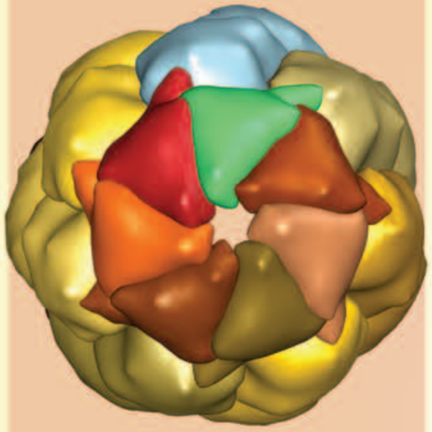
MARCH

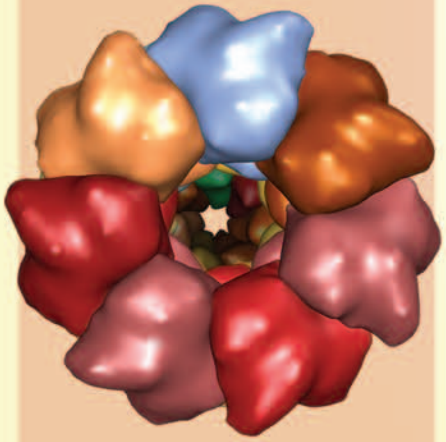
S	M	T	W	T	F	S
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30	31					

MAY

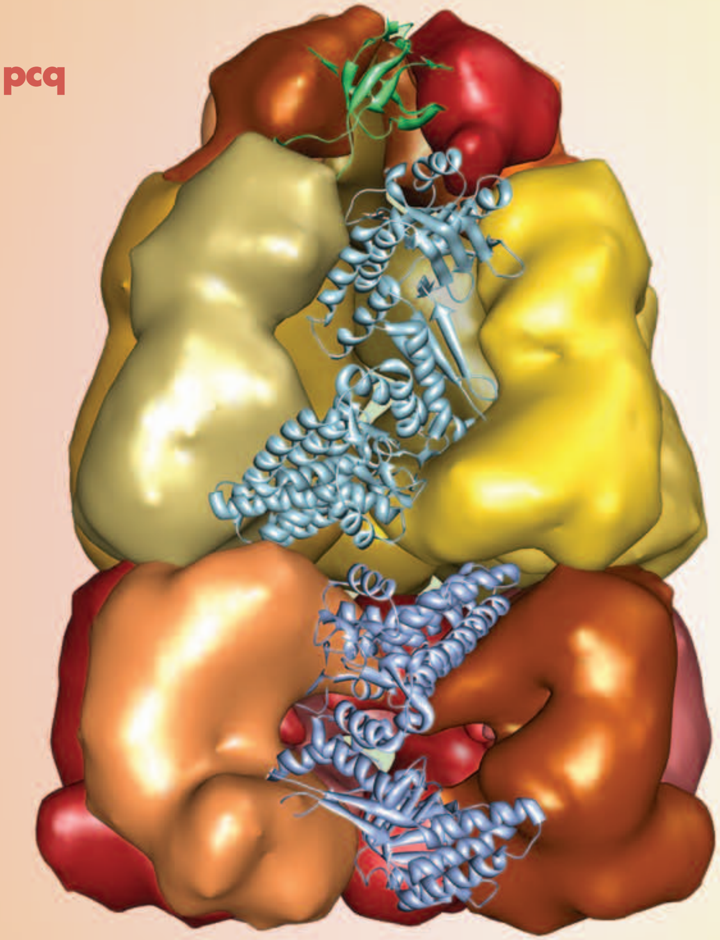
S	M	T	W	T	F	S
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	31

Chaperones

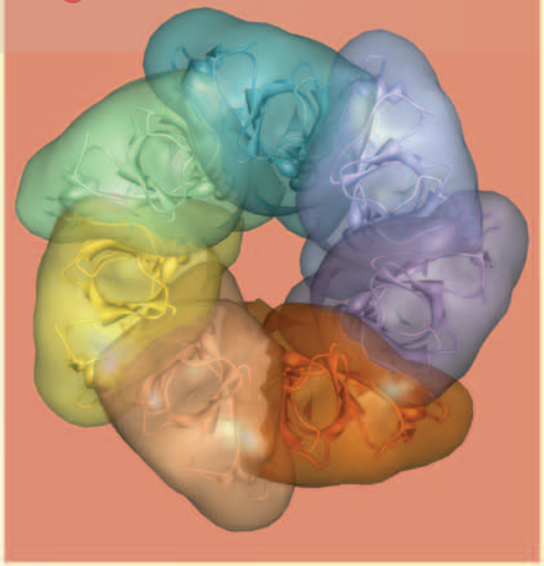




1pcq



1g31



Proteins are synthesized as formless chains and need to be folded into precise three-dimensional structures. Correct folding is critical for protein function. Chaperones are multimeric machines that help proteins fold correctly. Misfolded or unfolded proteins can lead to disease; Alzheimer's disease, for example, is caused by the unnatural aggregation of proteins into cell-clogging fibrils.

The GroEL/GroES chaperone complex helps to fold proteins by isolating them in a cage, away from other molecules present in the cytosol environment. GroEL/GroES is composed of two stacked cylinders of GroEL proteins and a cap of GroES (1pcq, in red). The GroEL proteins form a hollow cylinder with a protein-sized cavity inside. Unfolded proteins enter this cavity and fold up inside. The heptamer of the Gp31 protein from bacteriophage T4 functionally substitutes for the bacterial co-chaperonin GroES in assisted protein folding reactions and effectively increases the size and the hydrophilicity of the folding cavity of native bacterial GroEL/GroES complex (1g31).

May 2008

1g31: J.F. Hunt, S.M. van der Vies, L. Henry, J. Deisenhofer (1997) Structural adaptations in the specialized bacteriophage T4 co-chaperonin Gp31 expand the size of the Anfinsen cage. *Cell* **90**:361-371.

1pcq: C. Chaudhry, G.W. Farr, M. Todd, H.S. Rye, A.T. Brunger, P.D. Adams, A.L. Horwich, P.B. Sigler (2003) Role of the gamma-phosphate of ATP in triggering protein folding by GroEL-GroES: function, structure and energetics. *EMBO J.* **22**:4877-4887.

APRIL

S	M	T	W	T	F	S
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30			

JUNE

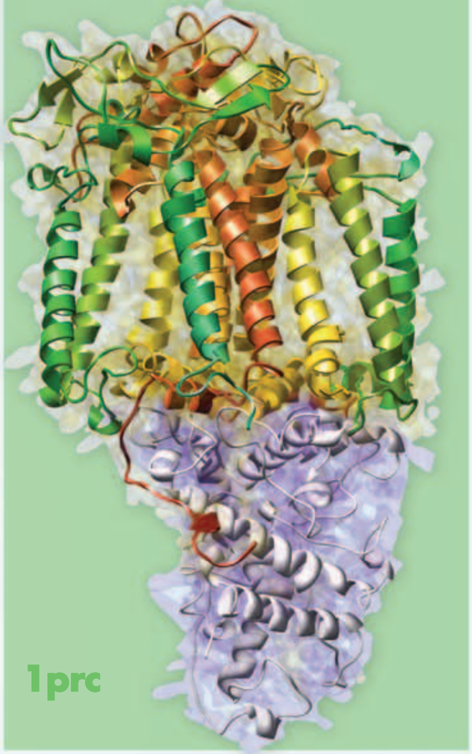
S	M	T	W	T	F	S
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30					

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
				1	2	3
4	5	6	7	8	9	10
11 Mother's Day	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26 Memorial Day	27	28	29	30	31

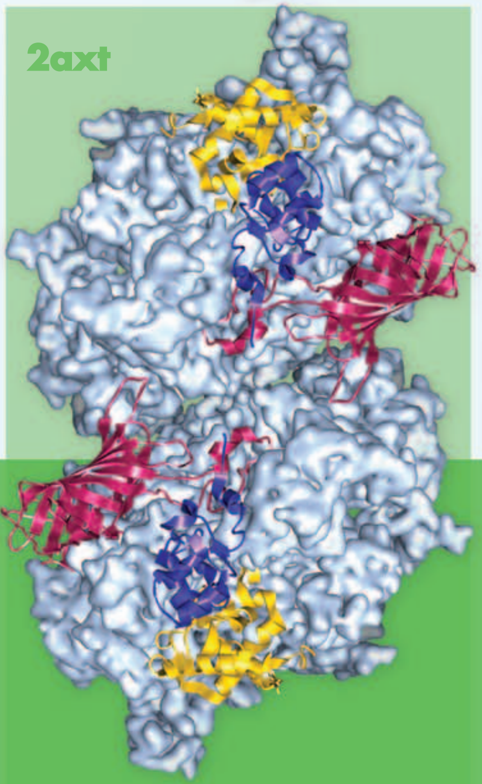
Photosynthesis

1jb0

1prc



2axt



The dominant energy source for living systems is sunlight. Photosynthesis turns sunlight into chemical energy. The photosynthetic proteins that perform this task form molecular complexes composed of more than a dozen proteins, tens of organic molecules ("cofactors"), and many metal cations. Photons from visible light excite electrons in green chlorophylls. The electrons are transferred to a series of other cofactors and finally reduce a carrier molecule, $NADP^+$ to NADPH, which delivers them to enzymes that build sugar from water and carbon dioxide.

Photosystem II (2axt) and the photosynthetic reaction centre (1prc) capture photons and use their energy to extract electrons from water molecules. The electrons from Photosystem II are passed down a chain of electron-carrying proteins, getting an additional boost from Photosystem I (1jb0). As these electrons flow down the chain, they are used to pump hydrogen ions across the thylakoid membrane, providing power for ATP synthesis.

June 2008

1prc: J. Deisenhofer, O. Epp, I. Sinning, H. Michel (1995) Crystallographic refinement at 2.3 Å resolution and refined model of the photosynthetic reaction centre from *Rhodopseudomonas viridis*. *J.Mol.Biol.* **246**:429-457.

1jb0: P. Jordan, P. Fromme, H.T. Witt, O. Klukas, W. Saenger, N. Krauss (2001) Three-dimensional structure of cyanobacterial photosystem I at 2.5 Å resolution. *Nature* **411**:909-917.

2axt: B. Loll, J. Kern, W. Saenger, A. Zouni, J. Biesiadka (2005) Towards complete cofactor arrangement in the 3.0 Å resolution structure of photosystem II. *Nature* **438**:1040-1044.

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15 Father's Day	16	17	18	19	20	21 Summer begins
22	23	24	25	26	27	28
29	30				MAY	JULY

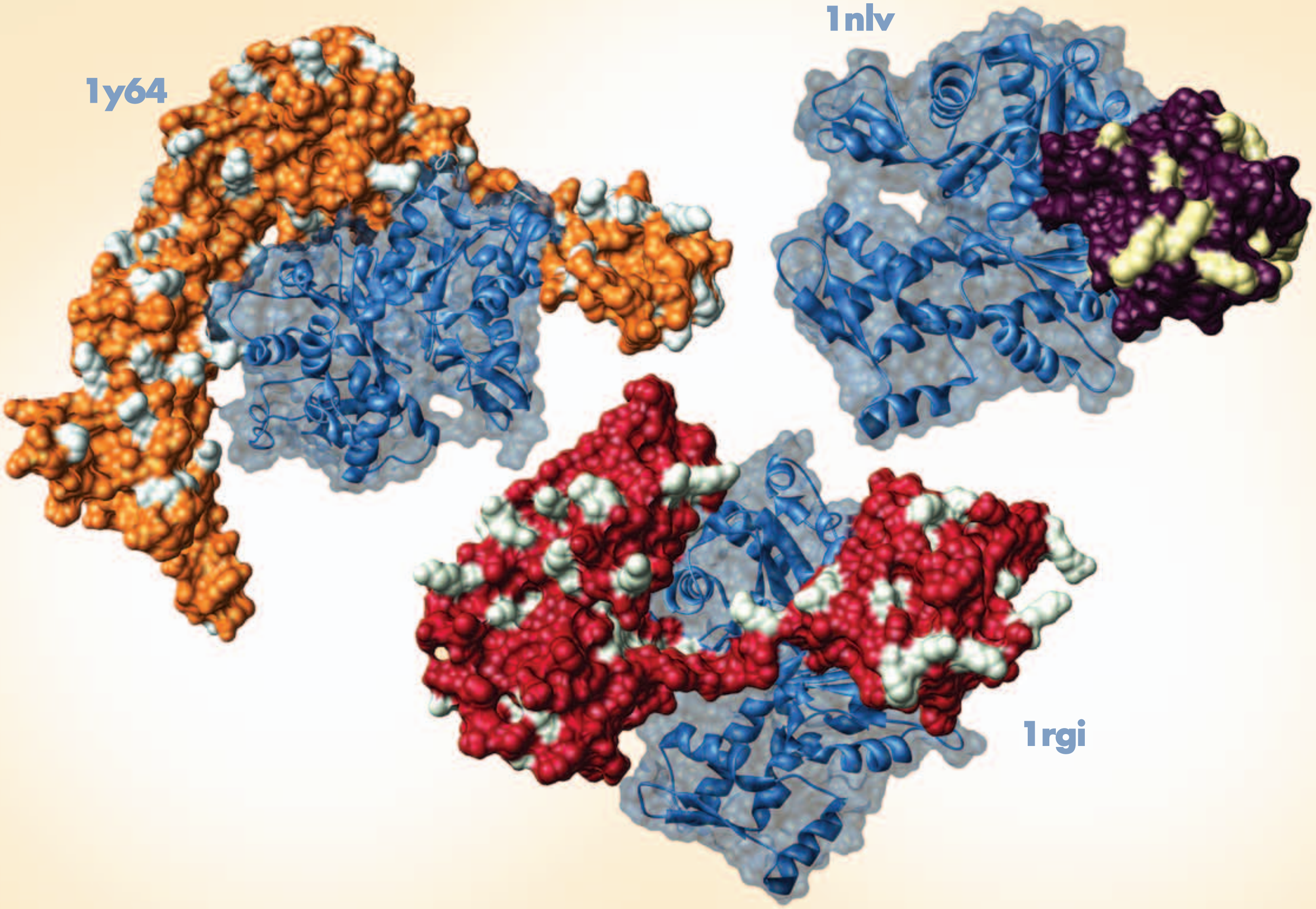
MAY

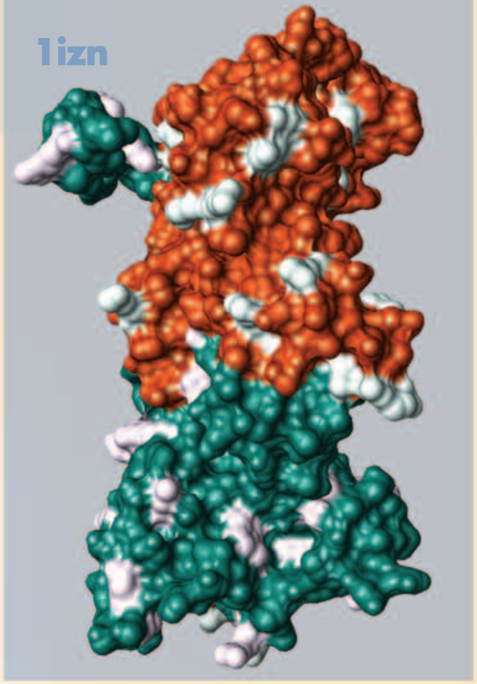
S	M	T	W	T	F	S
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	31

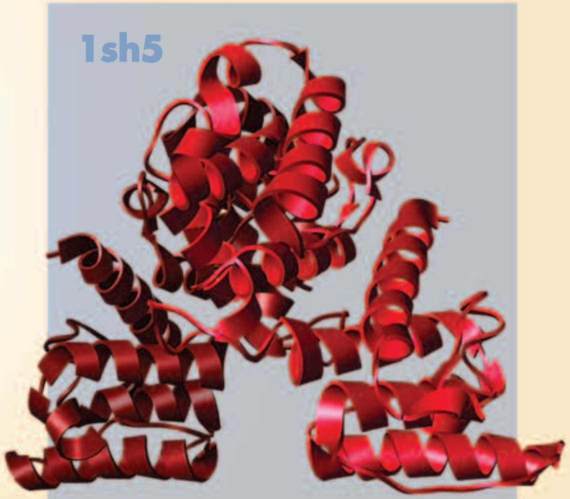
JULY

S	M	T	W	T	F	S
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30	31		

Actin







The cytoskeleton is an intracellular maze of filaments that supports and shapes the cell. The most plentiful type of filament is composed of actin, shown here in blue. The cytoskeleton, however, is not a static structure, since it must respond to the changing needs of the cell.

The proteins shown here help to reshape the cytoskeleton by assembling or disassembling actin filaments as necessary. A molecule of ATP, which is bound inside each actin molecule, is important in this process. When it is hydrolyzed to ADP, the filament becomes unstable and falls apart.

Gelsolin breaks down actin filaments by assisting the hydrolysis of ATP and blocking the sites of interaction with other actin proteins. Two different fragments of gelsolin are shown in 1nlv and 1rgi bound to actin.

The protein CapZ forms a cap on the actin filaments shown in 1izn, which limits assembly.

The protein formin assists the assembly of actin by aligning two actin proteins in the proper orientation which starts the process of filament growth. One domain of formin is shown bound to actin in 1y64.

Plectin links neighboring actin filaments into higher order structures. The actin-binding domain is shown in 1sh5.

July 2008

1nlv: S.M.Vorobiev, B. Strokopytov, D.G. Drubin, C. Frieden, S. Ono, J. Condeelis, P.A. Rubenstein, S.C. Almo. The structure of non-vertebrate actin: Implications for the ATP hydrolytic mechanism (2003) *Proc.Natl.Acad.Sci. USA* **100**:5760-5765.

1rgi: L.D.Burtnick, D. Urosev, E. Irobi, K. Narayan, R.C. Robinson (2004) Structure of the N-terminal half of gelsolin bound to actin: roles in severing, apoptosis and FAF *EMBO J.* **23**:2713-2722.

1izn: A.Yamashita, K. Maeda, Y. Maeda (2003) Crystal structure of CapZ: structural basis for actin filament barbed end capping *EMBO J.* **22**:1529-1538.

1sh5: J. Sevcik, L. Urbanikova, J. Kostan, L. Janda, G. Wiche (2004) Actin-binding domain of mouse plectin: crystal structure and binding to vimentin *Eur.J.Biochem.* **271**:873-1884.

1y64: T. Otomo, D.R. Tomchick, C.Otomo, S.C. Panchal, M. Machius, M.K. Rosen (2005) Structural basis of actin filament nucleation and processive capping by a formin homology 2 domain. *Nature* **433**:488-494.

JUNE

S	M	T	W	T	F	S
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30					

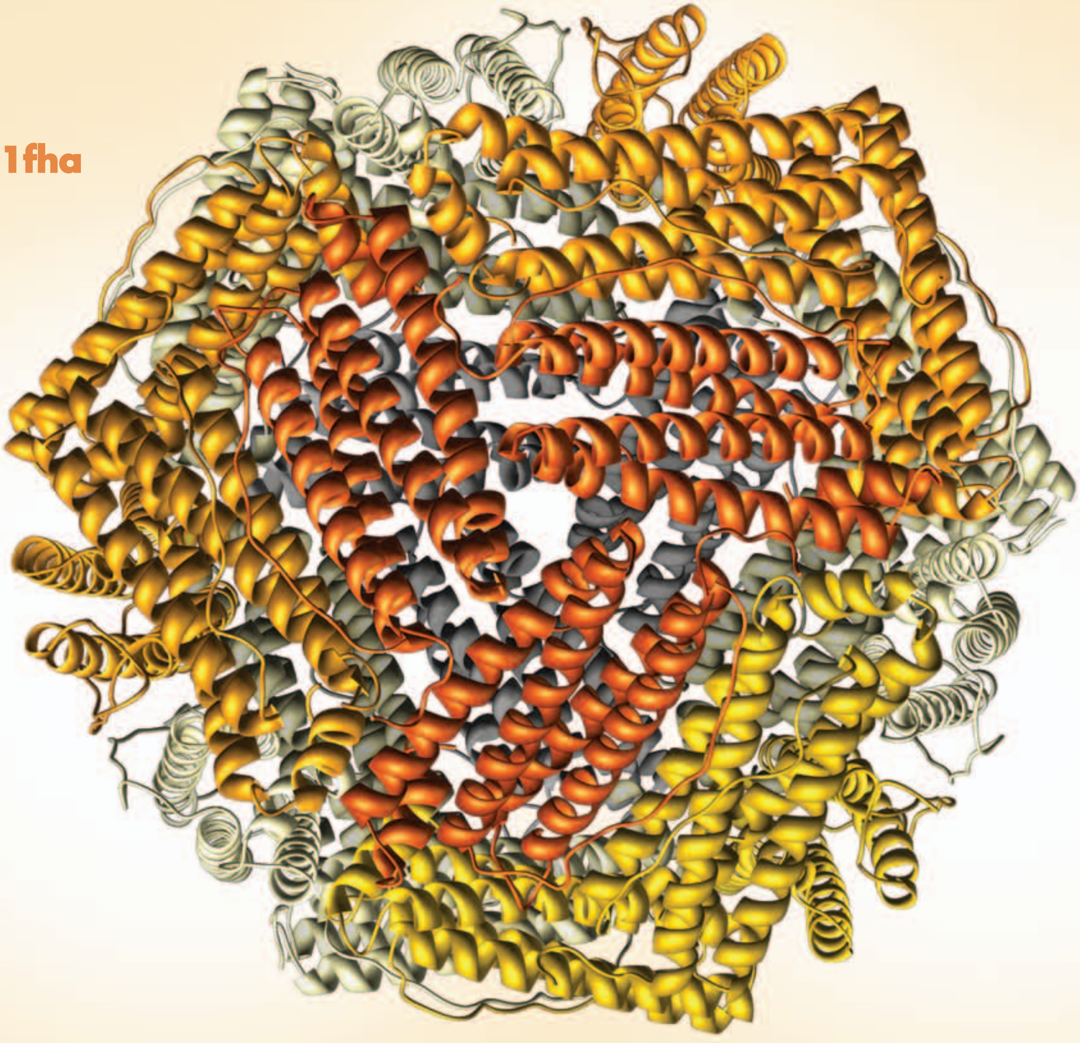
AUGUST

S	M	T	W	T	F	S
					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30
31						

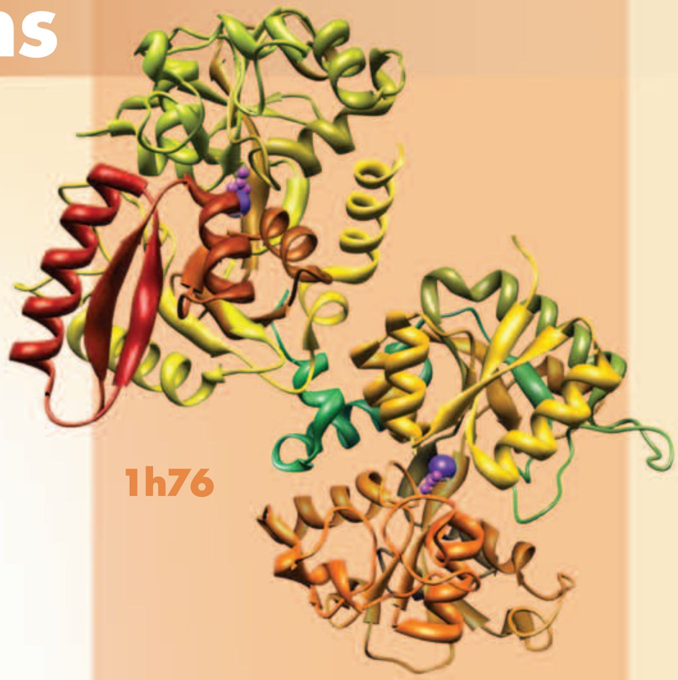
Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
		1	2	3	4 Indepenence Day	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30	31		

Transport and Storage Proteins

1fha



1h76



1uor

Many transport proteins carry insoluble molecules from place to place through the bloodstream. Iron, for instance, is not very soluble in water, but it plays essential roles in enzymes, hemoglobin, and myoglobin throughout the body. It is transported through the blood by the protein transferrin (1h76), which is picked up by special receptors on cell surfaces and transferred inside. Once the iron is released inside cells, it is stored inside ferritin (1fha). Ferritin's twenty-four chains assemble into a hollow shell that provides an iron-storage cavity for up to 4500 iron ions.

Serum albumin (shown in 1uor) carries fatty acids in the bloodstream. They bind in deep crevices in the protein, burying their carbon-rich tails safely away from the surrounding water. Serum albumin also binds to many other water-insoluble molecules. In particular, serum albumin binds to many drug molecules, such as ibuprofin, and can strongly affect the way they are delivered through the body.

August 2008

1fha: D.M. Lawson, P.J. Artymiuk, S.J. Yewdall, J.M. Smith, J.C. Livingstone, A. Treffry, A. Luzzago, S. Levi, P. Arosio, G. Cesareni, C.D. Thomas, W.V. Shaw, P.M. Harrison (1991) Solving the structure of human H ferritin by genetically engineering intermolecular crystal contacts. *Nature* **349**:541-544.

1h76: D.R. Hall, J.M. Hadden, G.A. Leonard, S. Bailey, M. Neu, M. Winn, P.F. Lindley (2002) The crystal and molecular structures of diferric porcine and rabbit serum transferrins at resolutions of 2.15 and 2.60 Å, respectively. *Acta Crystallogr.,Sect.D* **58**:70-80.

1uor: X.M.He, D.C. Carter (1992) Atomic structure and chemistry of human serum albumin. *Nature* **358**:209-215.

JULY

S	M	T	W	T	F	S
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30	31		

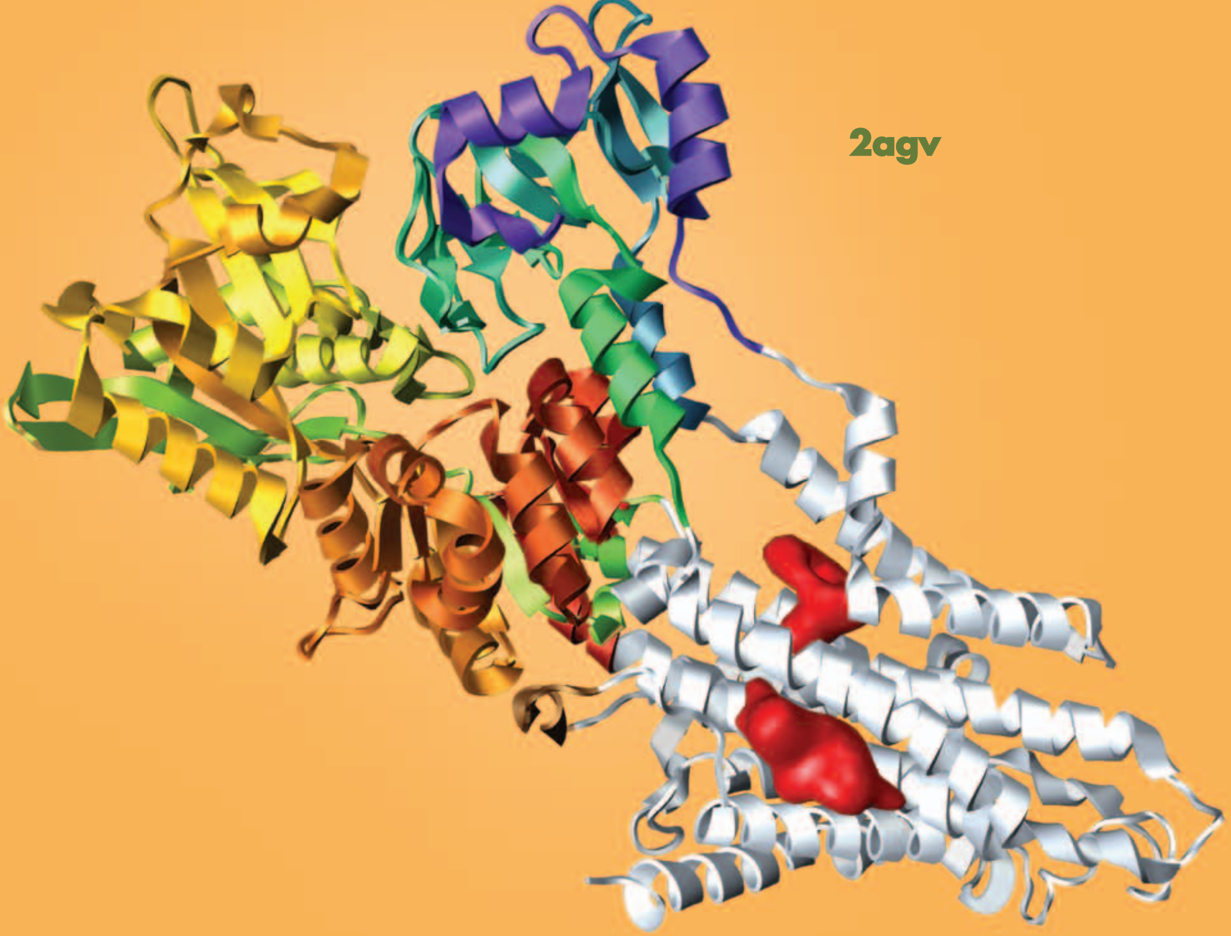
SEPTEMBER

S	M	T	W	T	F	S
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30				

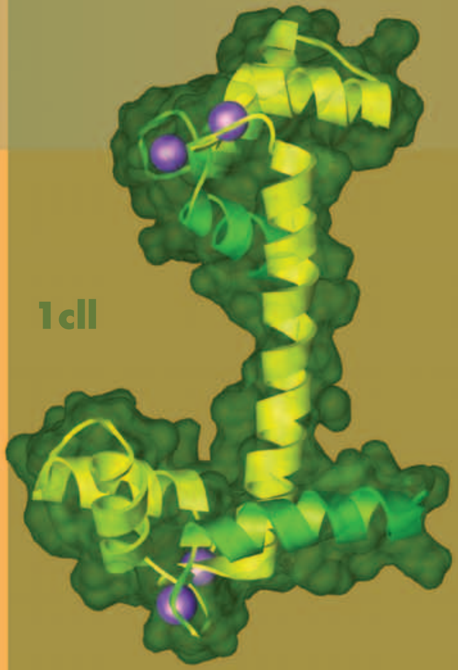
Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24 31	25	26	27	28	29	30

www.pdb.org

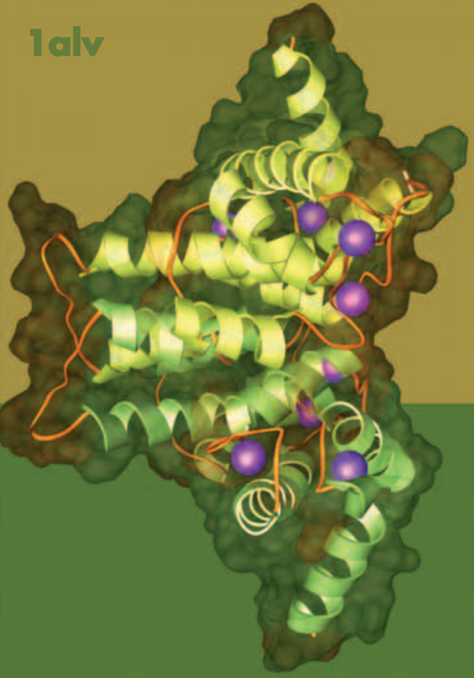
Calcium Sensing and Transport



2agv



1cll



1alv

Calcium cations (shown here in purple) are essential for cells to exchange signals, such in nerve signaling and muscle contraction.

When a muscle cell is given the signal to contract, a flood of calcium ions are released and contractions follow. The calcium pump (shown in 2agv) uses ATP to pump calcium ions back to the sarcoplasmic reticulum. This allows muscles to relax after this frenzied wave of calcium-induced contraction.

Calmodulin is a CALcium MODULated proteIN (1cll). Calmodulin acts as an intermediary protein that senses calcium levels and relays signals to various calcium-sensitive enzymes, ion channels and other proteins. Calmodulin is a small dumbbell-shaped protein composed of two globular domains connected together by a flexible linker. Each end binds to two calcium ions.

Calpain is a calcium-dependent protease. The structure of domain VI (in entry 1alv), which senses calcium, is shown here.

September 2008

2agv: K. Obara, N. Miyashita, C. Xu, I. Toyoshima, Y. Sugita, G. Inesi, C. Toyoshima (2005) Structural role of countertransport revealed in $Ca2^+$ pump crystal structure in the absence of $Ca2^+$. *Proc.Natl.Acad.Sci.USA* **102**:14489-14496.

1cll: R. Chattopadhyaya, W.E. Meador, A.R. Means, F.A. Quiocho (1992) Calmodulin structure refined at 1.7 A resolution. *J.Mol.Biol.* **228**:1177-1192.

1alv: G.D. Lin, D. Chattopadhyay, M. Maki, K.K. Wang, M. Carson, L. Jin, P.W. Yuen, E. Takano, M. Hatanaka, L.J. DeLucas, S.V. Narayana (1997) Crystal structure of calcium bound domain VI of calpain at 1.9 Å resolution and its role in enzyme assembly, regulation, and inhibitor binding. *Nat.Struct.Biol.* **4**:539-547.

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
	1 Labor Day	2 Ramadan begins	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22 Autumn begins	23	24	25	26	27
28 Rosh Hashanah begins at sundown	29 Rosh Hashanah	30			AUGUST	OCTOBER

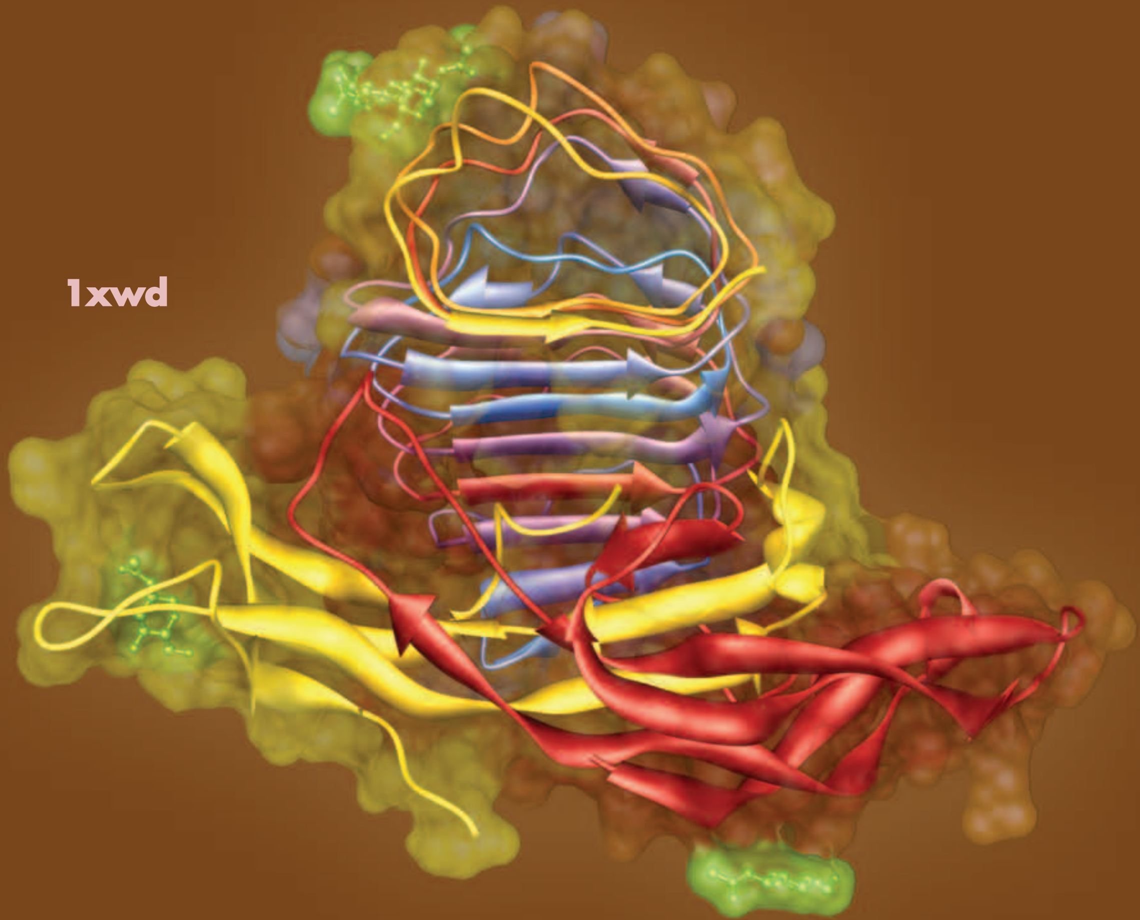
AUGUST

S	M	T	W	T	F	S
					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30
31						

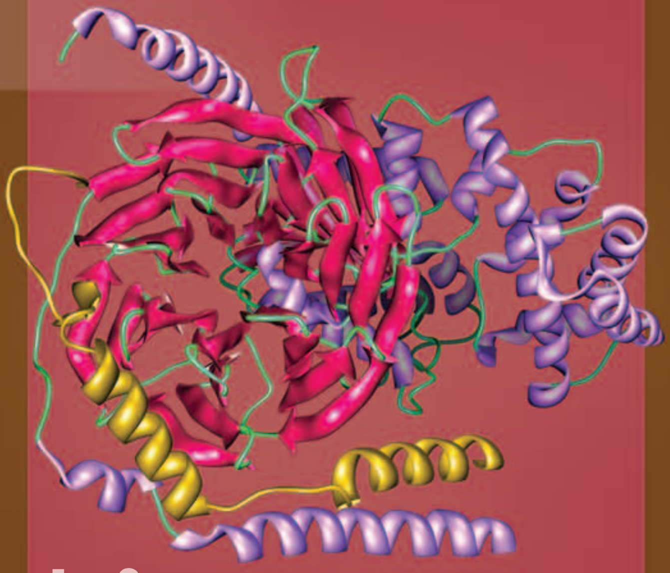
OCTOBER

S	M	T	W	T	F	S
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30	31	

Receptors and G-Proteins

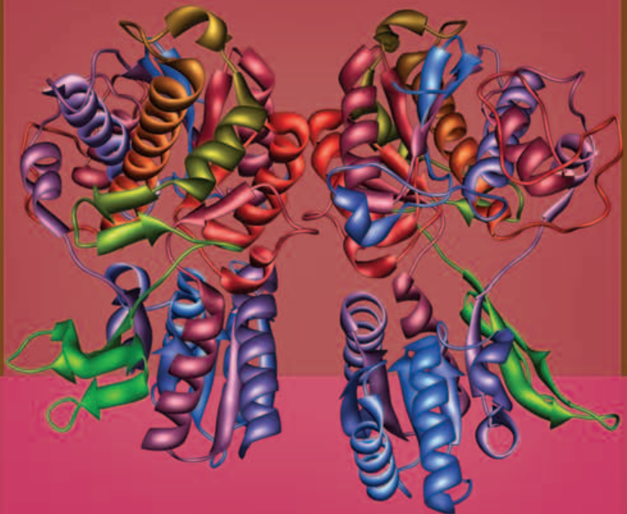


1xwd



1gg2

1ewk



Messages between cells are mediated by many different molecules. When a message reaches its target cell, it must be recognized, transmitted across the cellular membrane, and translated to an appropriate response. This process is achieved by extracellular receptors and intracellular signaling proteins.

1xwd shows a complex of human follicle-stimulating hormone (strands on the bottom in dark red and yellow) bound to the extracellular hormone-binding domain of its receptor; the hormone has an elongated, curved shape.

G proteins, such as the example shown in 1gg2, are molecular switches that use the exchange of GDP (guanosine diphosphate) for GTP (guanosine triphosphate) to control their signaling cycle.

Glutamate acts as an excitatory neurotransmitter in the central nervous system. Dimeric metabotropic glutamate receptors, as shown in 1ewk, are coupled with G-proteins. Thus, neurotransmitter binding leads to cell signalling via G-proteins and finally release of calcium ions from intracellular stores.

October 2008

1xwd: Q.R.Fan, W.A. Hendrickson (2005) Structure of human follicle-stimulating hormone in complex with its receptor *Nature* **433**:269-277.

1gg2: M.A. Wall, D.E. Coleman, E. Lee, J.A. Iniguez-Lluhi, B.A. Posner, A.G. Gilman, S.R. Sprang (1995) The structure of the G protein heterotrimer $G_{i\alpha1}\beta_1\gamma_2$. *Cell* **83**:1047-1058.

1ewk: N. Kunishima, Y. Shimada, Y. Tsuji, T. Sato, M. Yamamoto, T. Kumasaka, S. Nakanishi, H. Jingami, Morikawa, K. (2000) Structural basis of glutamate recognition by a dimeric metabotropic glutamate receptor. *Nature* **407**:971-977.

SEPTEMBER

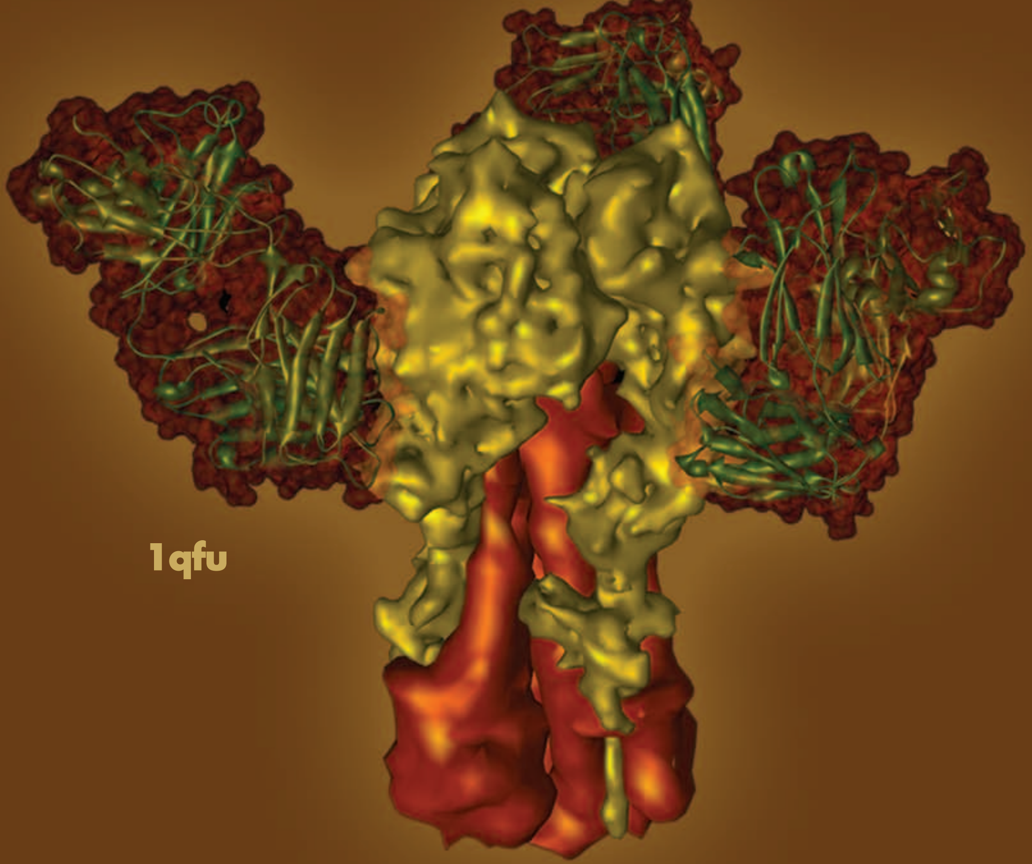
S	M	T	W	T	F	S
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30				

NOVEMBER

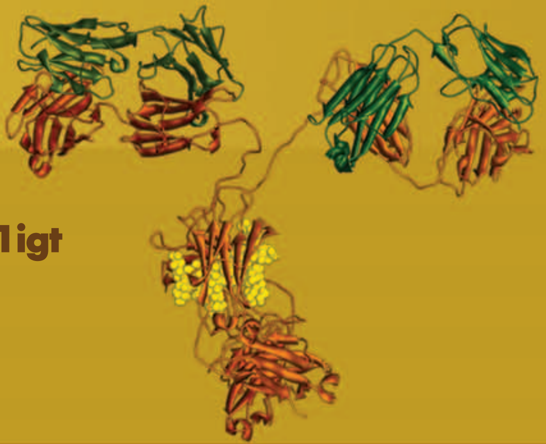
S	M	T	W	T	F	S
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30						

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
			1	2 Eid al-Fitr	3	4
5	6	7	8 Yom Kippur begins at sundown	9	10	11
12	13 Columbus Day	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30	31 Halloween	

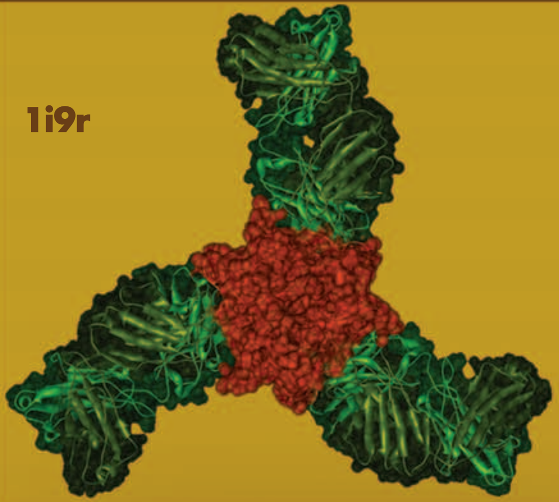
Antibodies



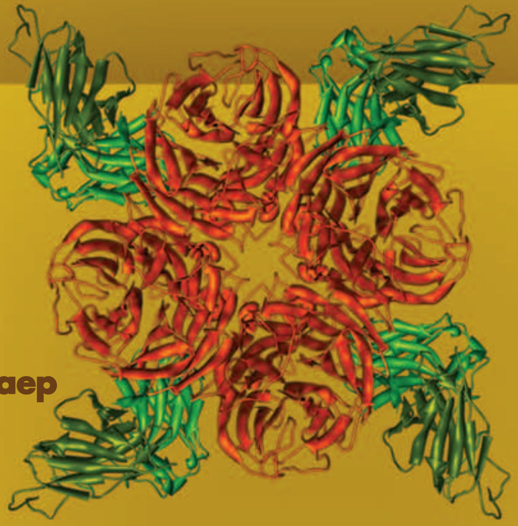
1qfu



1igt



1i9r



2aep

When a foreign molecule is found in the blood, many different antibodies may bind to it, attacking at different angles.

Antibodies, as exemplified with 1igt, are composed of two long heavy chains (brown) and two shorter light chains (green). The specific binding site is found at the tips of the two arms (each termed "Fab" for "antigen-binding fragment") in a pocket formed between the light and heavy chain. The binding site is composed of several loops in the protein chain that have very different lengths and amino acid composition. Differences in these "hypervariable loops" form the many types of pockets in different antibodies, each of which bind specifically to a different target. The rest of the antibody--the rest of the arms and the large constant domain that ties the two arms together--is relatively uniform in structure, providing a convenient handle when antibodies interact with the rest of the immune system.

1qfu shows the structure of a complex of influenza hemagglutinin with neutralizing antibodies. Three copies of light and heavy Fab fragments of the antibody (in green) bind to the base of the stalk of hemagglutinin (in gold and brown).

Neuraminidase, another protein on the surface of influenza virus (brown), is complexed with four Fab fragments of monoclonal antibody Mem5 (green) in 2aep.

1i9r shows a member of the tumor necrosis factor family (brown) neutralized by three Fab fragments of 5c8 antibody (green).

November 2008

1qfu: D. Fleury, B. Barrere, T. Bizebard, R.S. Daniels, J.J. Skehel, M. Knossow (1999) A complex of influenza hemagglutinin with a neutralizing antibody that binds outside the virus receptor binding site. *Nat.Struct.Biol.* **6**:530-534.

2aep: L. Venkatramani, E. Bochkareva, J.T. Lee, U. Gulati, W.G. Laver, A. Bochkarev, G.M. Air (2006) An epidemiologically significant epitope of a 1998 human influenza virus neuraminidase forms a highly hydrated interface in the NA-antibody complex *J.Mol.Biol.* **356**:651-663.

1i9r: M. Karpusas, J. Lucci, J. Ferrant, C. Benjamin, F.R. Taylor, K. Strauch, E. Garber, Y.M. Hsu (2001) Structure of CD40 ligand in complex with the Fab fragment of a neutralizing humanized antibody. *Structure* **9**:321-329.

1igt: L.J. Harris, S.B. Larson, K.W. Hasel, A. McPherson (1997) Refined structure of an intact IgG2a monoclonal antibody. *Biochemistry* **36**:1581-1597.

OCTOBER

S	M	T	W	T	F	S
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30	31	

DECEMBER

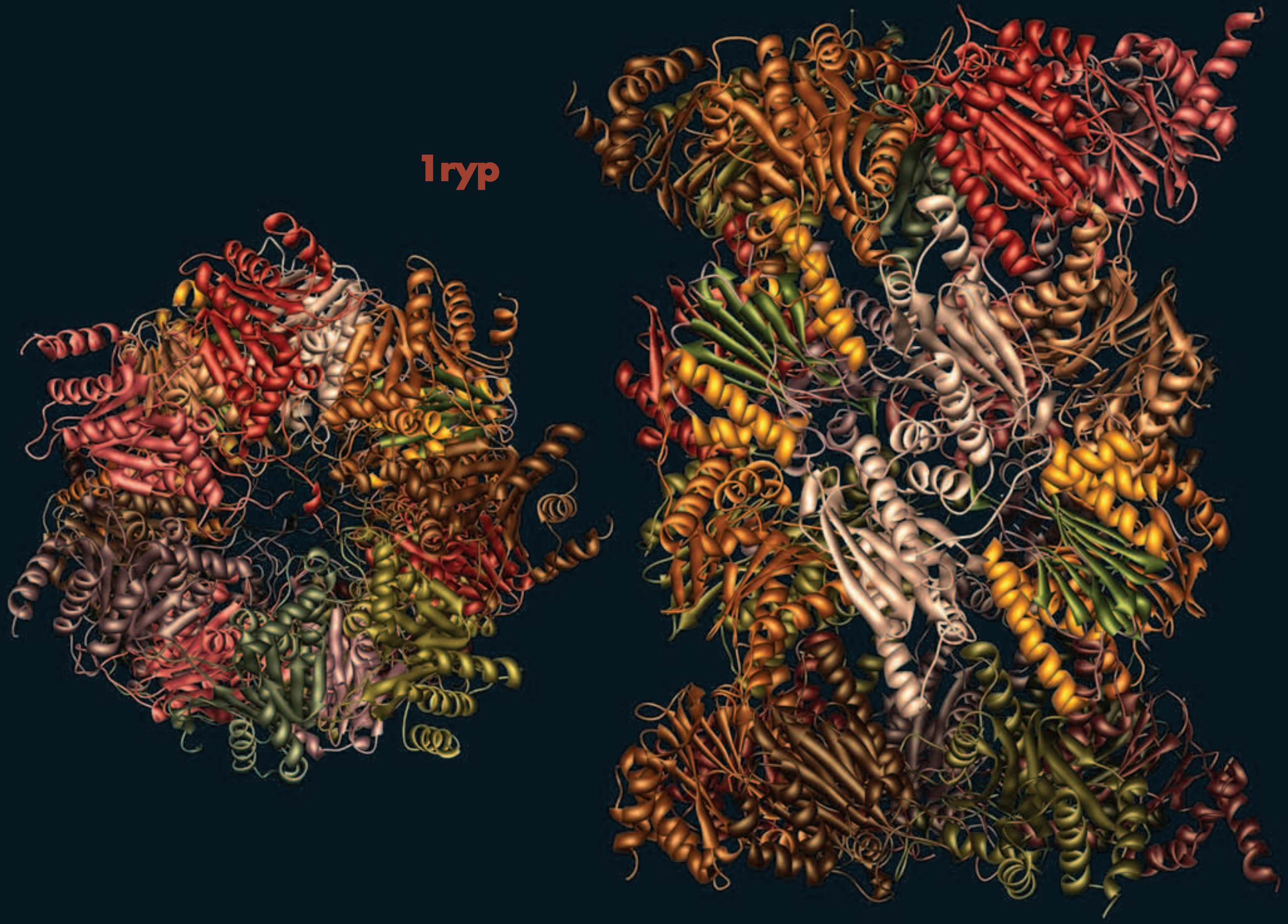
S	M	T	W	T	F	S
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30	31			

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
						1
2	3	4	5	6	7	8
9	10	11 Veterans Day	12	13	14	15
16	17	18	19	20	21	22
23 30	24	25	26	27 Thanksgiving	28	29

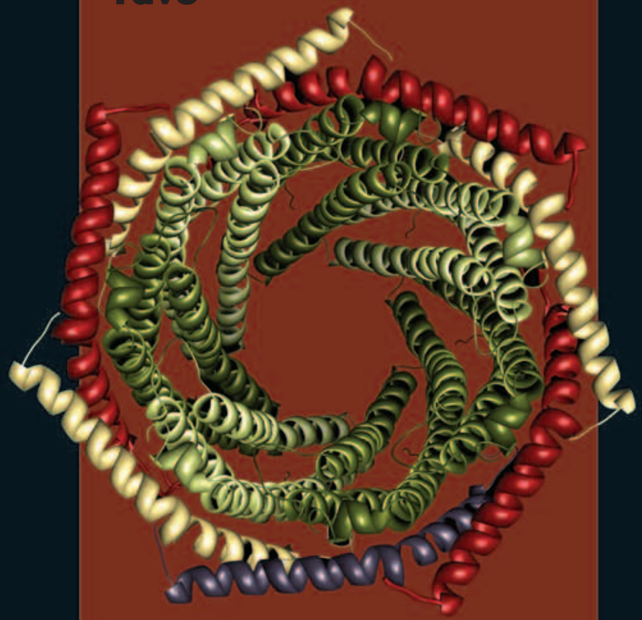
www.pdb.org

Proteasomes

1ryp



1avo



Proteasomes degrade damaged and misfolded proteins by breaking them into short peptides about seven amino acids long. These peptides are then further degraded into individual amino acids that can be re-used. Proteasomes are involved in cellular processes, including the cell division cycle and the regulation of gene expression.

The proteasome is a large barrel-like protein particle. It is formed by four stacked rings, each formed by seven distinct protein chains (1ryp).

The action of the proteasome must be regulated so that it does not degrade proteins indiscriminately. The 11S regulator REGalpha, shown in 1avo, binds at each end of the proteasome. This opens up the entry channel and activates the proteasome.

December 2008

1ryp: M. Groll, L. Ditzel, J. Lowe, D. Stock, M. Bochtler, H.D. Bartunik, R. Huber (1997) Structure of 20S proteasome from yeast at 2.4 Å resolution. *Nature* **386**:463-471.

1avo: J.R. Knowlton, S.C. Johnston, F.G. Whitby, C. Realini, Z. Zhang, M. Rechsteiner, C.P. Hill (1997) Structure of the proteasome activator REGalpha (PA28alpha) *Nature* **390**:639-643.

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
	1	2	3	4	5	6
7	8	9 Eid al-Adha	10	11	12	13
14	15	16	17	18	19	20
21 Winter begins Hanukkah begins at sundown	22	23	24	25 Christmas	26 Kwanzaa	27
28	29	30	31			

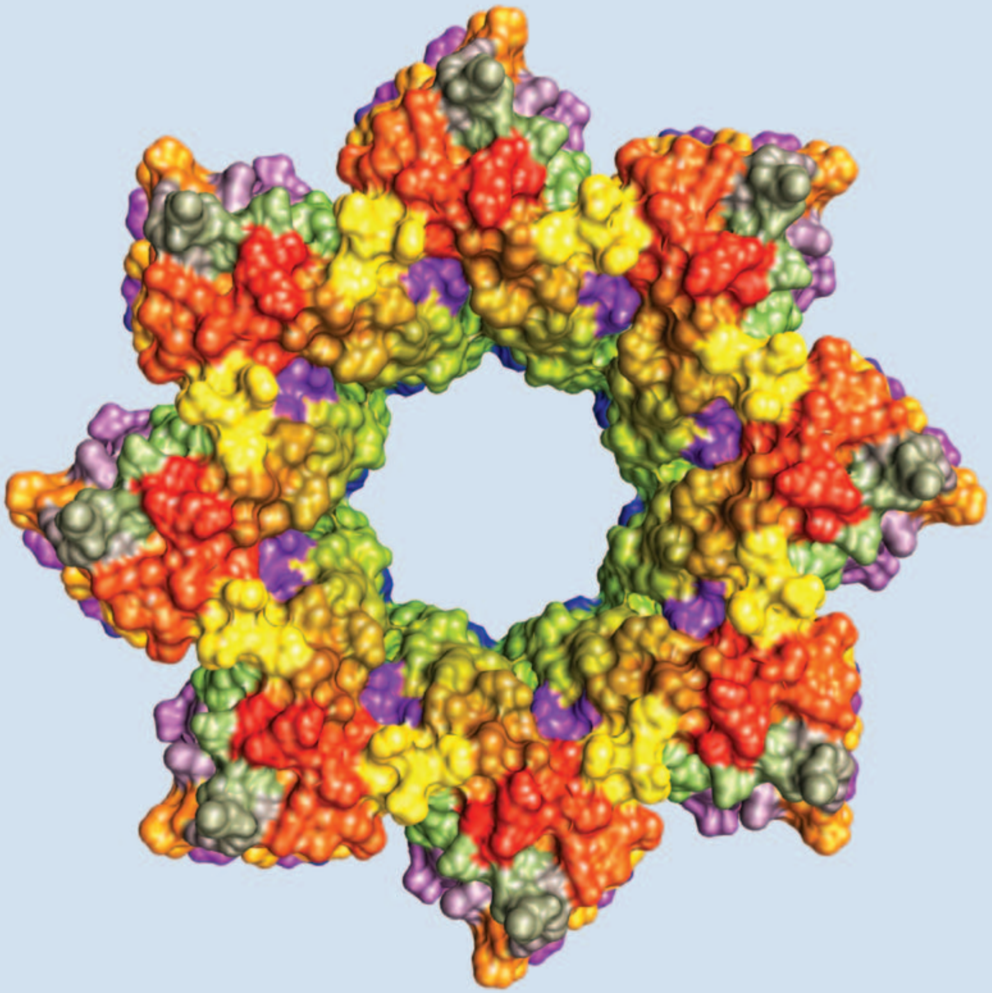
NOVEMBER

S	M	T	W	T	F	S
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30						

JANUARY 2009

S	M	T	W	T	F	S
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	31

On the Cover



1n0g: S.Chen, J. Jancrick, H. Yokota, R. Kim, S.-H. Kim (2004) Crystal structure of a protein associated with cell division from *Mycoplasma pneumoniae* (GI: 13508053): a novel fold with a conserved sequence motif. *Proteins* **55**:785-791.

Acknowledgements

This calendar was created using the resources of the RCSB Protein Data Bank. Special thanks goes to RCSB PDB members Bohdan Schneider (RCSB PDB and Czech Academy of Sciences, Prague), Shuchismita Dutta, David S. Goodsell, Rachel Kramer Green, Cathy Lawson, Maria Voigt, and Christine Zardecki, and to Martin Filip (Prague Institute of Chemical Technology).

The images were generated using Chimera (E.F. Pettersen, T.D. Goddard, C.C. Huang, G.S. Couch, D.M. Greenblatt, E.C. Meng, and T.E. Ferrin, (2004) UCSF Chimera–A visualization system for exploratory research and analysis. *J. Comput. Chem.* **25**:1605-1612).

The RCSB PDB is managed by two members of the RCSB:

Rutgers, The State University of New Jersey

San Diego Supercomputer Center and Skaggs School of Pharmacy and Pharmaceutical Sciences at the University of California, San Diego

It is supported by funds from the:

National Science Foundation
National Institute of General Medical Sciences
Office of Science, Department of Energy
National Library of Medicine
National Cancer Institute
National Center for Research Resources
National Institute of Biomedical Imaging and Bioengineering
National Institute of Neurological Disorders and Stroke
National Institute of Diabetes and Digestive and Kidney Diseases

The RCSB PDB is a member of the **Worldwide Protein Data Bank** (wwPDB; www.wwpdb.org).

RCSB PDB PROTEIN DATA BANK

www.pdb.org • info@rcsb.org

2009 Calendar

JANUARY

S	M	T	W	T	F	S
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	31

FEBRUARY

S	M	T	W	T	F	S
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28

MARCH

S	M	T	W	T	F	S
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

APRIL

S	M	T	W	T	F	S
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	5	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30		

MAY

S	M	T	W	T	F	S
					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30
31						

JUNE

S	M	T	W	T	F	S
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	5	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30				

JULY

S	M	T	W	T	F	S
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30	31	

AUGUST

S	M	T	W	T	F	S
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30	31					

SEPTEMBER

S	M	T	W	T	F	S
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30			

OCTOBER

S	M	T	W	T	F	S
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	31

NOVEMBER

S	M	T	W	T	F	S
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30					

DECEMBER

S	M	T	W	T	F	S
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30	31		