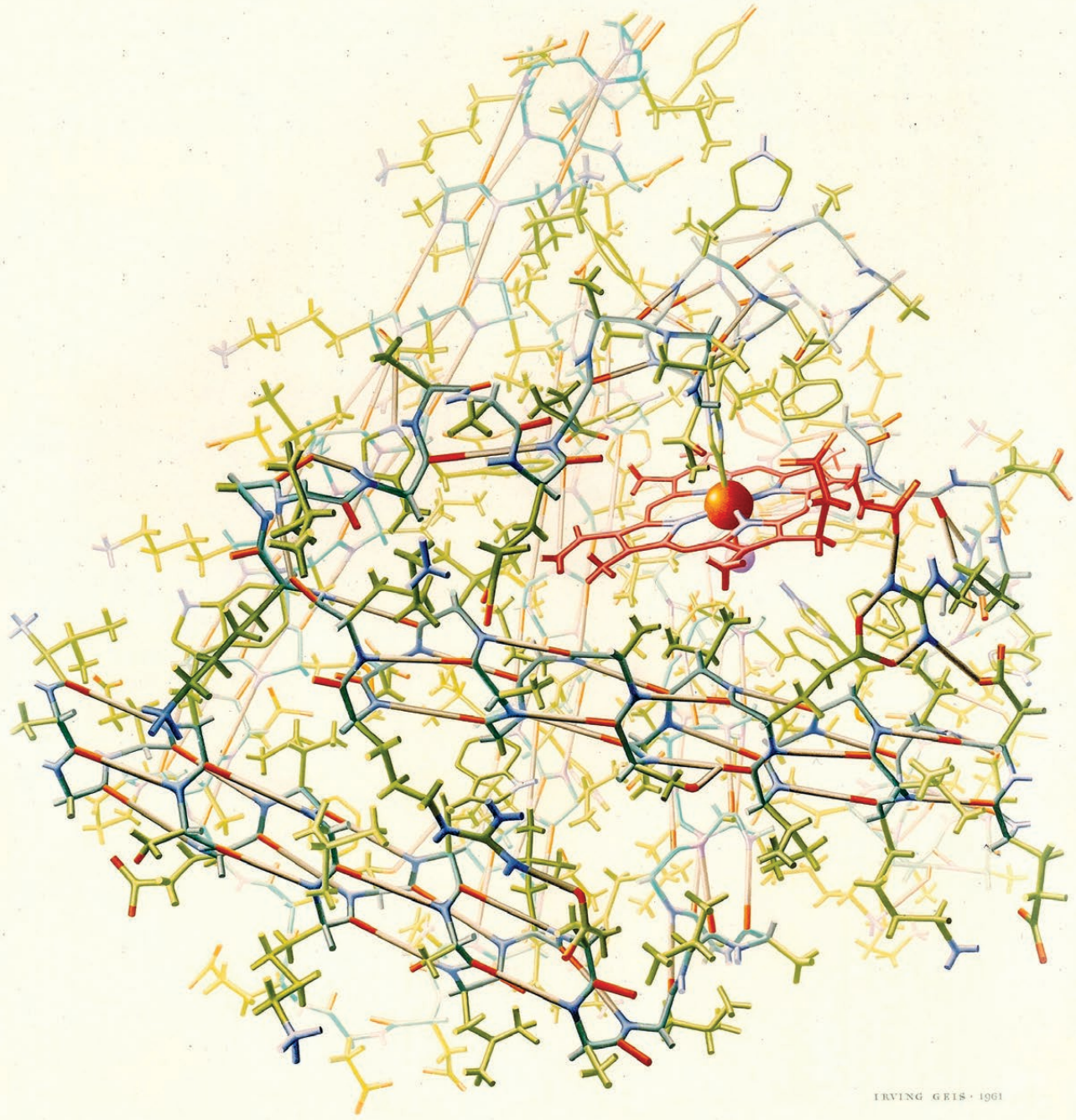


2017 CALENDAR

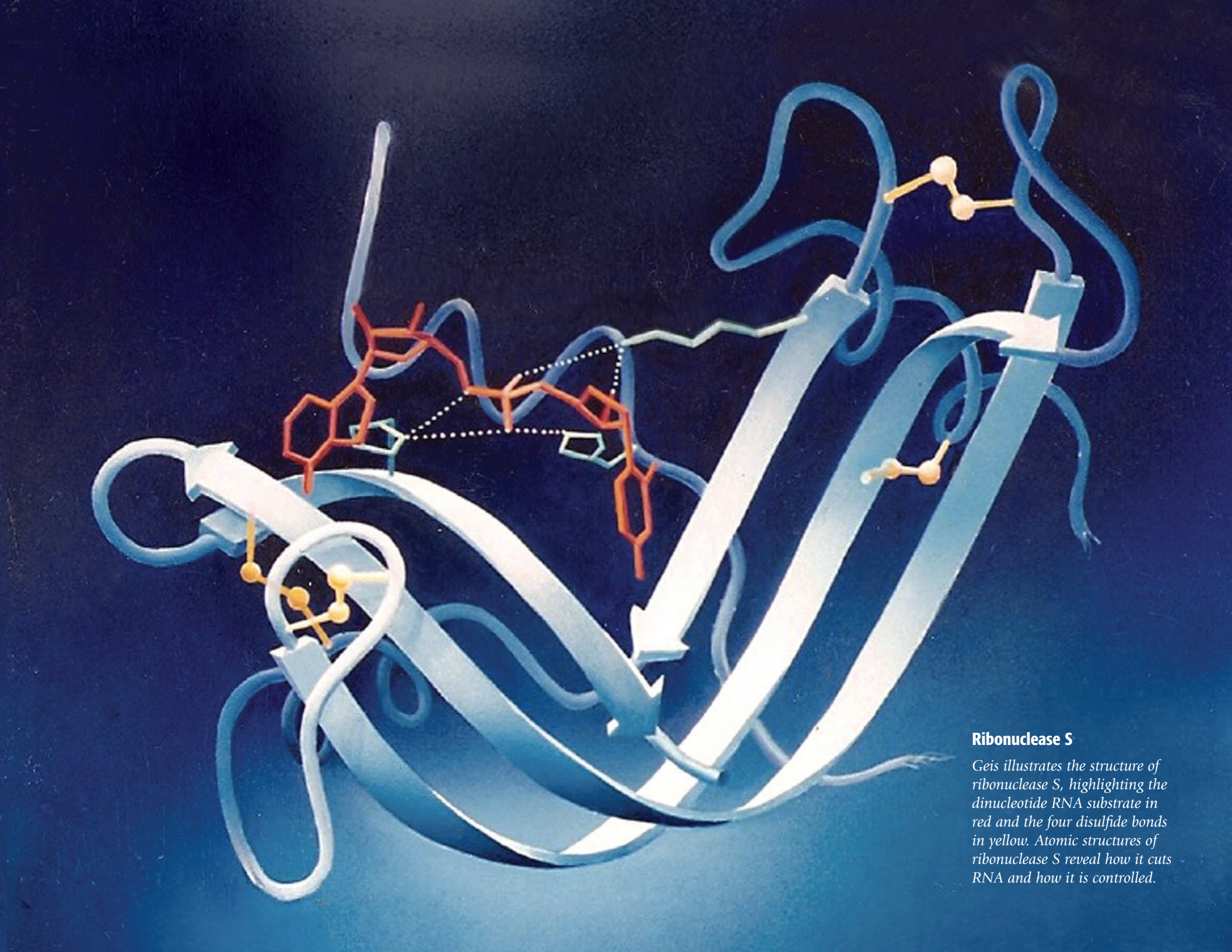
GEIS DIGITAL ARCHIVE

pdb101.rcsb.org

RCSB PDB-101

PDB-101 is the educational portal of the RCSB PDB | **rcsb.org**

RCSB PDB PROTEIN DATA BANK



Ribonuclease S

Geis illustrates the structure of ribonuclease S, highlighting the dinucleotide RNA substrate in red and the four disulfide bonds in yellow. Atomic structures of ribonuclease S reveal how it cuts RNA and how it is controlled.

JANUARY 2017

Molecular explorations
through biology and medicine

RCSB PDB-101

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 Martin Luther King Jr. Day	17	18	19	10	21
22	23	24	25	26	27	28 Lunar New Year
29	30	31				

DECEMBER 2016

Su	Mo	Tu	We	Th	Fr	Sa
				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 2017

Su	Mo	Tu	We	Th	Fr	Sa
			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				

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TATA-Binding Protein

This is a depiction of the TATA-Binding Protein (TBP, orange). Transcription is the first step in gene expression, in which DNA is copied to RNA. TATA-binding protein binds specifically to the DNA sequence referred to as the TATA box. This protein is active in most cells and tissues. Its function is to aid in regulating the activity of most genes.

FEBRUARY 2017

Molecular explorations
through biology and medicine

RCSB PDB-101

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

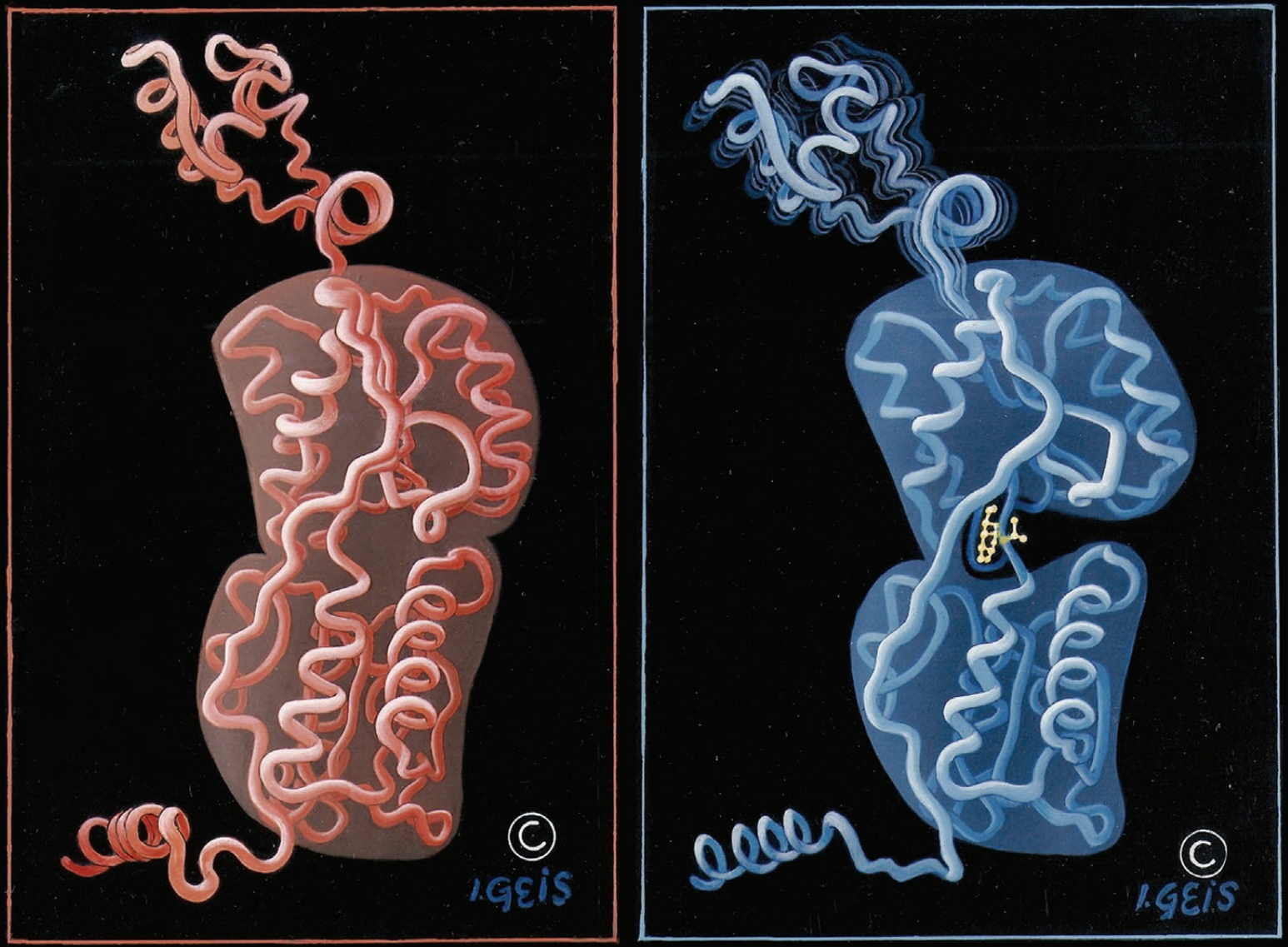
JANUARY 2017

Su	Mo	Tu	We	Th	Fr	Sa
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 2017

Su	Mo	Tu	We	Th	Fr	Sa
			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	

pdb101.rcsb.org



Lac Repressor

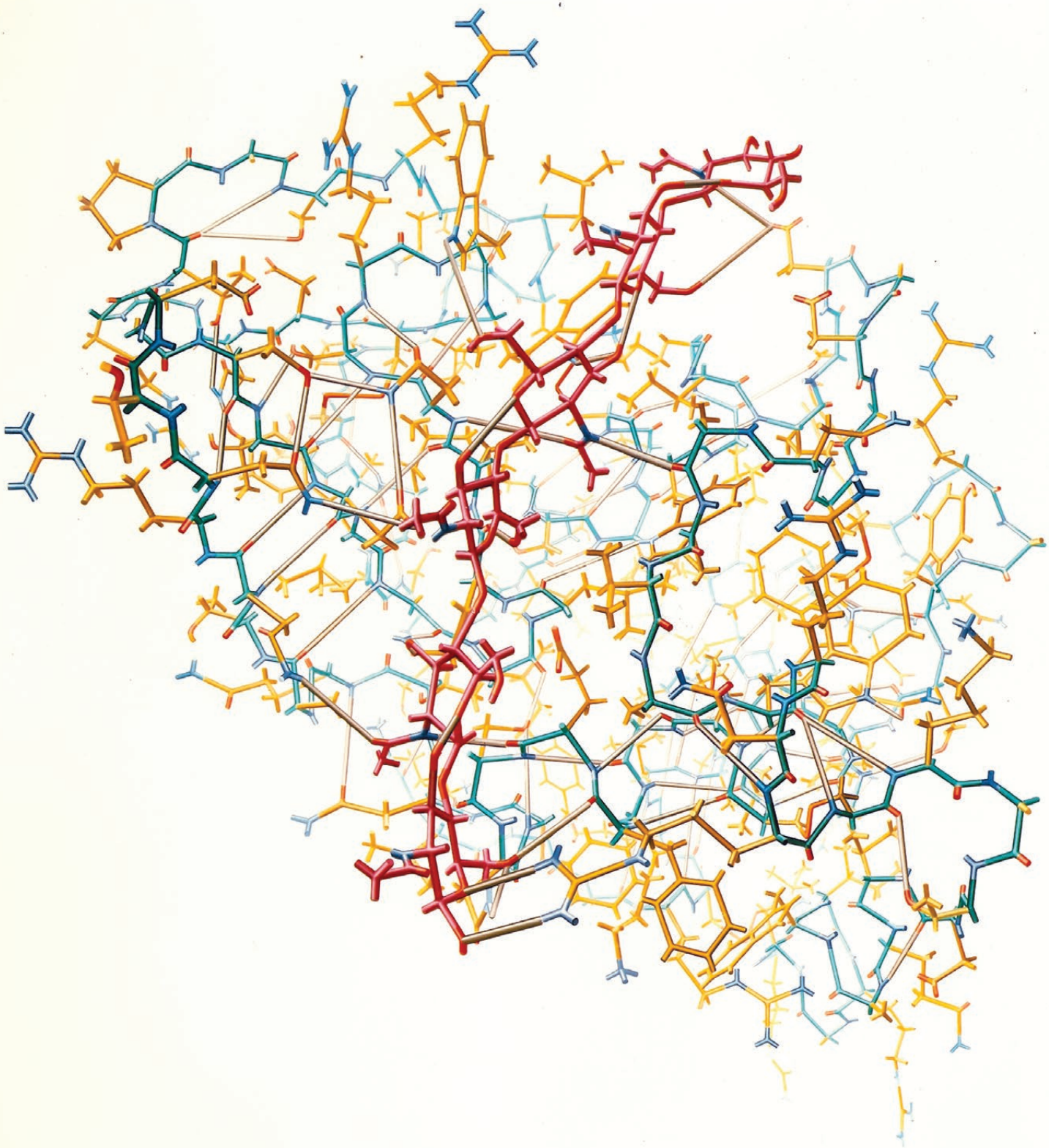
This was Geis' last completed painting. It depicts the structure of a lac repressor monomer, including the alpha-helical tetramerization domain at the bottom and the headpiece domain at the top which binds the lac operator. On the left is the repressed state, which has a high affinity for DNA. On the right is the induced state in which IPTG (isopropyl beta-D-1-thiogalactopyranoside), an inducer, causes a conformational change and reduces the affinity of the repressor for the lac operator, increasing lactose metabolism in bacteria cells.

MARCH 2017

Molecular explorations
through biology and medicine

RCSB PDB-101

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
FEBRUARY 2017 Su Mo Tu We Th Fr Sa 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	**APRIL 2017** Su Mo Tu We Th Fr Sa 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		1 Ash Wednesday	2	3	4
5	6	7	8	9	10	11
12 Daylight Saving Time (US)	13	14 Pi Day	15	16	17 St. Patrick's Day	18
19	20	21	22	23	24	25
26 Daylight Saving Time (EU)	27	28	29	30	31	



Lysozyme

Geis illustrates the structure of lysozyme, the first enzyme structure revealed by X-ray crystallography. In this illustration, Geis carefully highlights the interaction between lysozyme and its substrate (red). Lysozyme is a small enzyme that cuts sugar chains in bacterial cell walls, which causes bacteria to burst. It is used by our bodies to fight infections, and it is found naturally in egg whites, human tears, and mucus. The long gray connections represent hydrogen bonds.

D.C. Phillips (1966)
The Three-Dimensional Structure of an Enzyme Molecule.
Sci. Am. ***215***, *78-90.*

APRIL 2017

Molecular explorations through biology and medicine

RCSB PDB-101

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
MARCH 2017 Su Mo Tu We Th Fr Sa 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 2017 Su Mo Tu We Th Fr Sa 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					1
2	3	4	5	6	7	8
9	10 Passover begins at sundown	11	12	13	14	15
16 Easter	17	18	19	20	21	22 Earth Day
23	24	25 DNA Day	26	27	28	29
30						

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Tomato Bushy Stunt Virus

Tomato Bushy Stunt Virus (TBSV), the first 3D virus structure determined, is an icosahedral virus enclosed by 180 coat proteins. It has a triangulation number of 3. The virus causes stunting, leaf mottling, and deformation or absence of fruit in plants. In this painting, Geis draws the coat proteins as the petals of a flower.

MAY 2017

Molecular explorations through biology and medicine

RCSB PDB-101

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

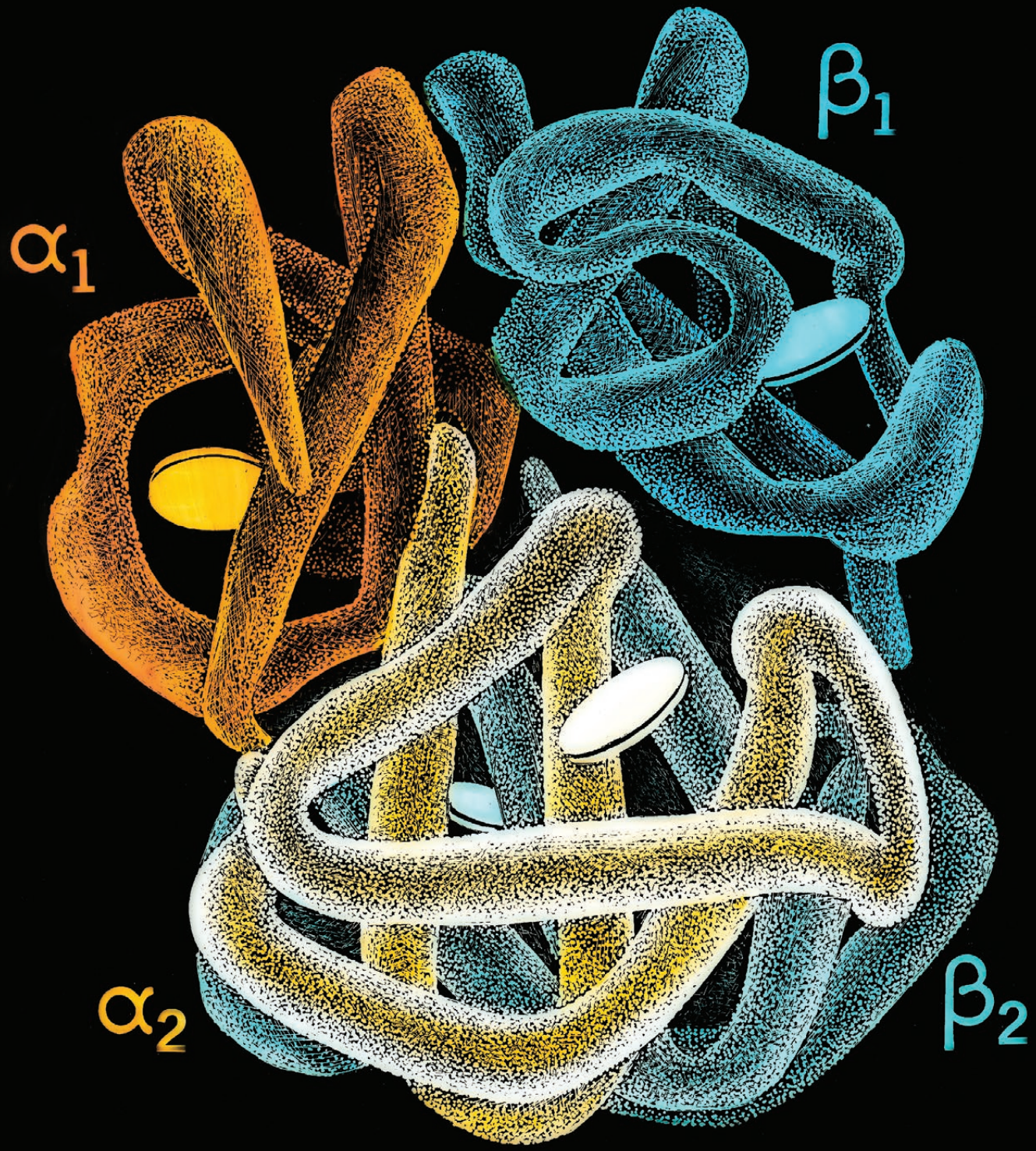
APRIL 2017

Su	Mo	Tu	We	Th	Fr	Sa
						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 2017

Su	Mo	Tu	We	Th	Fr	Sa
				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	

pdb101.rcsb.org



Hemoglobin S

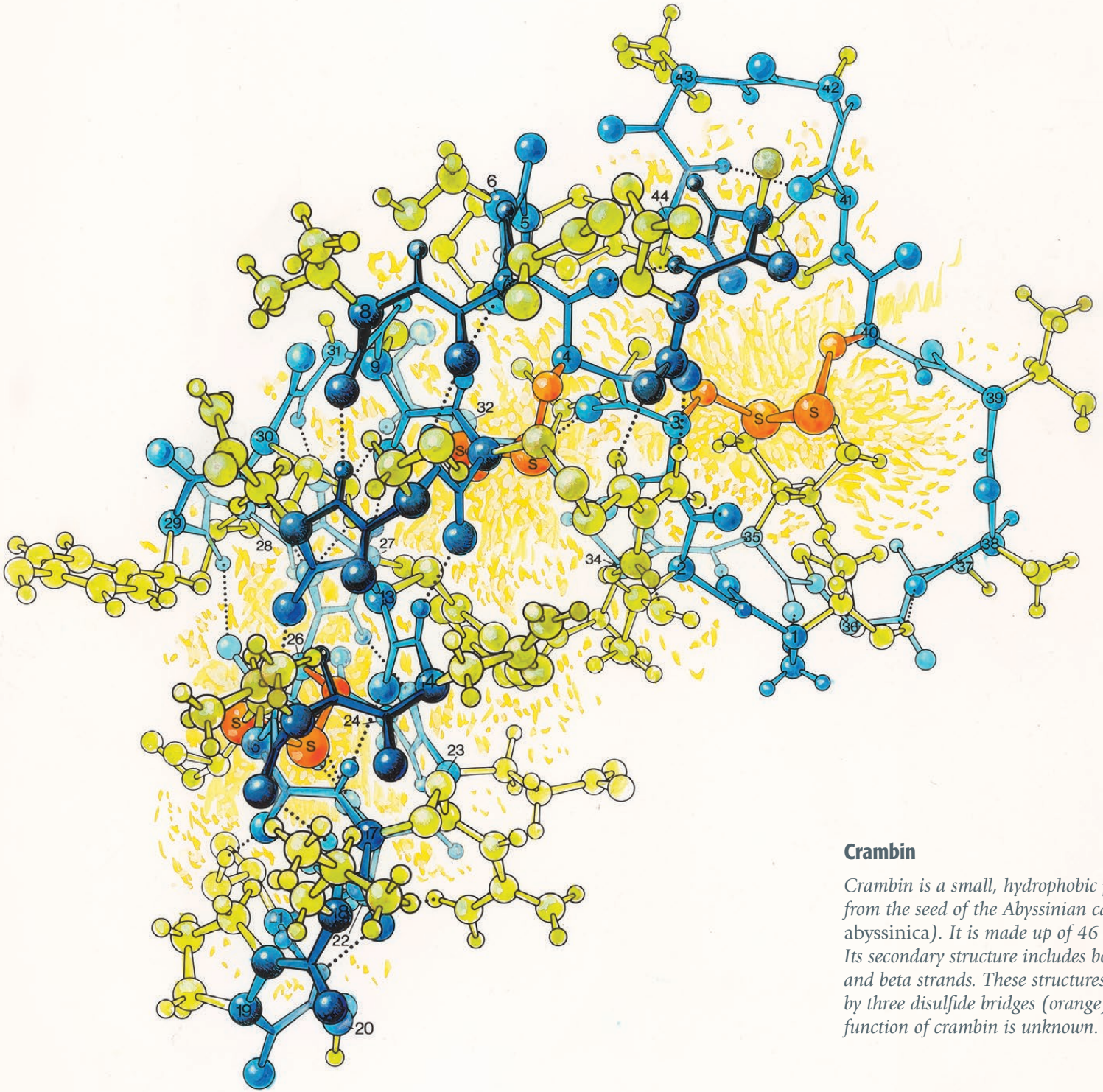
Hemoglobin S is a rare form of the hemoglobin tetramer arising from a mutation in the gene encoding the beta subunit, which changes the normal glutamic acid at position 6 into a hydrophobic valine. As a result of this change in the protein structure, the deoxygenated form of hemoglobin S forms long fibers that distort red blood cells into a characteristic crescent or sickle shape. These distorted cells cause sludging and blockages in capillaries, leading to organ damage and painful crises typical of sickle cell disease–the first molecular disease to be described.

JUNE 2017

Molecular explorations
through biology and medicine

RCSB PDB-101

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
MAY 2017 Su Mo Tu We Th Fr Sa 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 207 Su Mo Tu We Th Fr Sa 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			1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18 Father's Day (US)	19	20	21	22	23	24 Eid al-Fitr begins at sundown
25	26	27	28	29	30	



Crambin

*Crambin is a small, hydrophobic protein derived from the seed of the Abyssinian cabbage (*Crambe abyssinica*). It is made up of 46 amino acids. Its secondary structure includes both alpha helices and beta strands. These structures are stabilized by three disulfide bridges (orange). The biological function of crambin is unknown.*

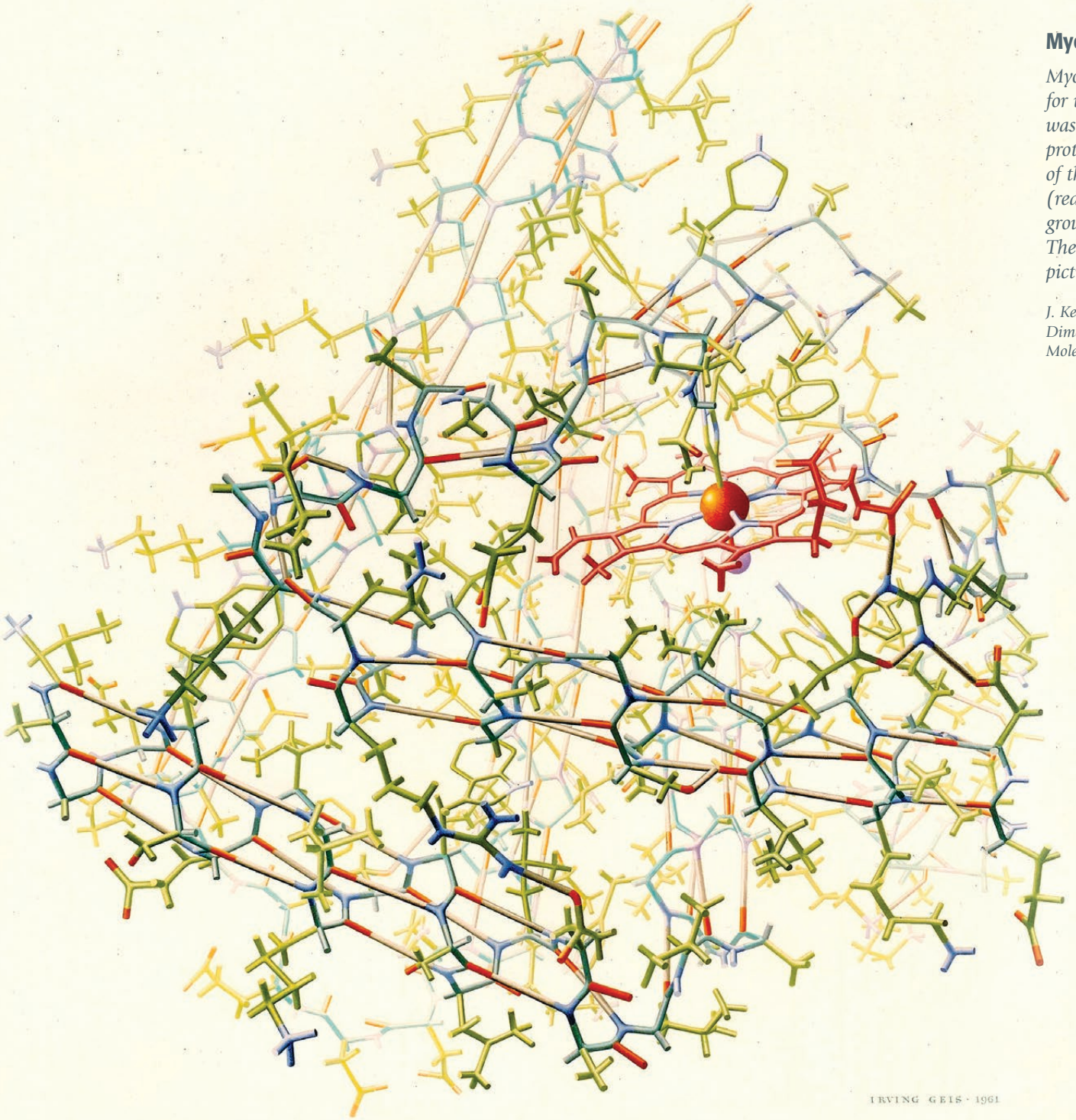
JULY 2017

Molecular explorations
through biology and medicine

RCSB PDB-101

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
JUNE 2017 Su Mo Tu We Th Fr Sa 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 2017 Su Mo Tu We Th Fr Sa 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					1
2	3	4 Independence Day (US)	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					

pdb101.rcsb.org



Myoglobin

Myoglobin was the first protein for which an atomic structure was determined. It is a small protein that is bright red because of the iron-containing heme group (red). The function of the heme group is to store oxygen in cells. The long gray connections in the picture illustrate hydrogen bonds.

J. Kendrew (1961) The Three-Dimensional Structure of a Protein Molecule. Sci. Am. ***205***, *96-110.*

AUGUST 2017

Molecular explorations through biology and medicine

RCSB PDB-101

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 International Union of Crystallography (IUCr) Congress begins in Hyderabad, India	22	23	24	25	26
27	28 IUCr Congress ends	29	30	31 Eid al-Adha begins at sunset		

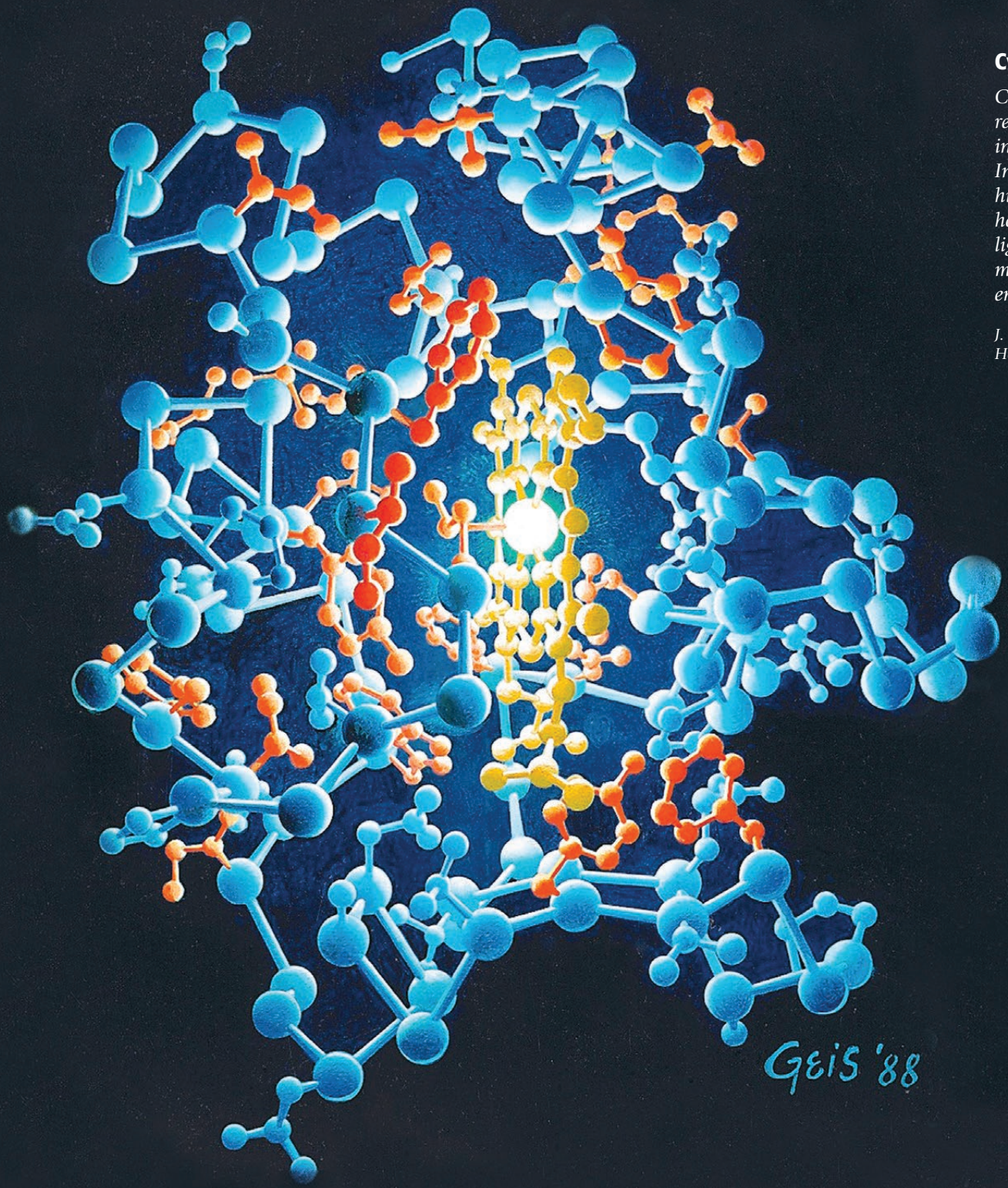
JULY 2017

Su	Mo	Tu	We	Th	Fr	Sa
						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 2017

Su	Mo	Tu	We	Th	Fr	Sa
					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

pdb101.rcsb.org



Cytochrome c

Cytochrome c is one of the proteins responsible for energy transfer in the electron transport chain. In this illustration, Geis chose to highlight the central iron in the heme group, depicting it as the light source for the molecule. This molecule is a key component for energy production in the body.

J. G. Voet & D. Voet (1990) Biochemistry Hoboken, NJ: John Wiley & Sons Inc.

SEPTEMBER 2017

Molecular explorations
through biology and medicine

RCSB PDB-101

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
AUGUST 2017 Su Mo Tu We Th Fr Sa 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 2017** Su Mo Tu We Th Fr Sa 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				1	2
3	4 Labor Day (US)	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20 Rosh Hashanah begins at sundown	21	22	23
24	25	26	27	28	29 Yom Kippur begins at sundown	30

pdb101.rcsb.org

Collagen

Geis paints a triple helix in his depiction of collagen. He portrays the chains in a thick, rope-like manner, which reflects the function of the collagen protein in strengthening tendons and muscles in animals.

OCTOBER 2017

Molecular explorations through biology and medicine

RCSB PDB-101

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
1	2	3	4	5	6	7
8	9 Columbus Day	10	11	12	13	14
15	16	17	18 Irving Geis' Birthday	19 Diwali	20 PDB announced in *Nature New Biology* in 1971	21
22	23	24	25	26	27	28
29 Daylight Saving Time ends (EU)	30	31 Halloween				

SEPTEMBER 2017

Su	Mo	Tu	We	Th	Fr	Sa
					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 2017

Su	Mo	Tu	We	Th	Fr	Sa
			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		

pdb101.rcsb.org

Myoglobin Fold

Geis' illustration focuses on the tertiary structure of the myoglobin molecule. Myoglobin is an extremely compact heme-containing protein found primarily in cardiac and red skeletal muscles. The primary function of this protein is to store oxygen in the cells.

NOVEMBER 2017

Molecular explorations
through biology and medicine

RCSB PDB-101

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
OCTOBER 2017 Su Mo Tu We Th Fr Sa 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 2017** Su Mo Tu We Th Fr Sa 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		1	2	3	4
5 Daylight Saving Time ends (US)	6	7	8	9	10	11 Veterans Day
12	13	14	15	16	17	18
19	20	21	22	23 Thanksgiving (US)	24	25
26	27	28	29	30		

pdb101.rcsb.org

Carboxypeptidase A

Geis depicts the structure of carboxypeptidase A, highlighting the central twisted beta sheet of the enzyme. The enzyme cuts polypeptide chains from the carboxyl terminal end. Included in the painting is an orange sphere representing a zinc ion in the active site.

DECEMBER 2017

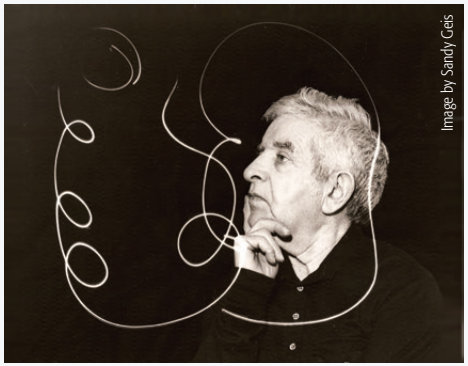
Molecular explorations through biology and medicine

RCSB PDB-101

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
NOVEMBER 2017 Su Mo Tu We Th Fr Sa 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 2018** Su Mo Tu We Th Fr Sa 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				1	2
3	4	5	6	7	8	9
10	11	12 Hanukkah begins at sunset	13	14	15	16
17	18	19	20	21	22	23
24	25 Christmas	26 Kwanzaa	27	28	29	30
31 New Year's Eve						

pdb101.rcsb.org

IRVING GEIS



For much of his career, Irving Geis (1908-1997) regularly contributed paintings for *Scientific American*, with subjects ranging from astronomy, astrophysics, geophysics to biochemistry. He portrayed molecules with accuracy, consulting scientists many times before producing a final product. In 1961, well before the age of computer graphics, Geis was commissioned by *Scientific American* to illustrate Nobel laureate John Kendrew's landmark article, *The Three Dimensional Structure of a Protein Molecule*. The article represents the first protein structure, sperm whale myoglobin.

Geis' work has since served as a guide and an inspiration for researchers and students. His unique style of lucid visualization would lead to worldwide recognition. In a tribute written for a Geis exhibit at the National Academy of Sciences in 1988, Dr. Richard E. Dickerson (UCLA) declared:

> *Irving Geis defined structural molecular biology in a visual sense. We have been following his lead–consciously or unconsciously–ever since.*

ABOUT

GEIS DIGITAL ARCHIVE

Geis' archive of molecular structures was purchased by the Howard Hughes Medical Institute (HHMI) in 2000.

In 2015, RCSB PDB and HHMI established the **GEIS DIGITAL ARCHIVE** to make his molecular art publicly available.

The growing Geis Digital Archive connects many of his illustrations in the context of their molecular structures on the PDB-101 website as a tool for education. Images are available for download for non-profit use.

The Geis Digital Archive is being developed by undergraduates working with the RCSB PDB team: Raheel Ahmad, Alex Alvarado, Pamela Amechi, Keyerra Daniels, Belle Lin, Christopher Markosian, and Nicole Werpachowski.

The team would like to thank those who helped establish the Irving Geis Digital Archive: Sandy Geis, Irving Geis' daughter and the Howard Hughes Medical Institute. Questions about the HHMI Geis Archives should be sent to **archives@hhmi.org**.

PDB-101

pdb101.rcsb.org

Molecular Explorations through Biology and Medicine

PDB-101 is an online portal developed by RCSB PDB for teachers, students, and the general public to promote exploration in the world of proteins and nucleic acids.

Learning about the diverse shapes and functions of these biological macromolecules helps to understand all aspects of biomedicine and agriculture, from protein synthesis to health and disease to biological energy.

All resources are freely available, including the Geis Digital Archive, curricular materials, paper molecular models, animations, and more.

Resources are searchable as well as organized by topics such as Health and Disease, Molecules of Life, Biotech and Nanotech, and Structures and Structure Determination.

RCSB PDB

rcsb.org

An Information Portal to Biological Macromolecular Structures

RCSB PDB provides rich structural views of biological systems to enable breakthroughs in scientific inquiry, medicine, drug discovery, technology, and education.

It provides access to the Protein Data Bank archive (PDB), the worldwide repository of information about the 3D structures of large biological molecules, including proteins and nucleic acids.

RCSB PDB is funded by a grant (DBI-1338415) from the National Science Foundation, the National Institutes of Health, and the US Department of Energy.

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

RUTGERS

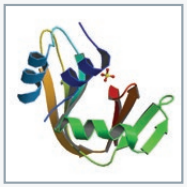
UC San Diego SDSC SAN DIEGO SUPERCOMPUTER CENTER

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

EXPLORE PDB ENTRIES RELATED TO GEIS' ILLUSTRATIONS IN 3D AT RCSB.ORG:

January: Ribonuclease S

PDB ID 1RNU



E. E. Kim, R. Varadarajan, H. W. Wyckoff, F. M. Richards. (1992) Refinement of the crystal structure of ribonuclease S. Comparison with and between the various ribonuclease A structures. *Biochemistry* **31**: 12304-12314.

G. Kartha, J. Bello, D. Harker. (1967) Tertiary structure of ribonuclease. *Nature* **213**: 862-865.

H. W. Wyckoff, K. D. Hardman, N. M. Allewell, T. Inagami, D. Tsernoglou, L. N. Johnson, F. M. Richards. (1967) The structure of ribonuclease-S at 6 Å resolution. *J. Biol. Chem.* **242**: 3749-3753.

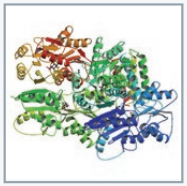
February: TATA-Binding Protein

PDB ID 1VTL

K. L. Clark, E. D. Halay, E. Lai, S. K. Burley. (1993) Co-crystal structure of the HNF-3/Fork head DNA-recognition motif resembles histone H5. *Nature* **364**: 412-420.

March: Lac Repressor

PDB ID 1TLF



A. M. Friedman, T. O. Fischmann, T. A. Steitz. (1995) Crystal structure of lac repressor core tetramer and its implications for DNA looping. *Science* **268**: 1721-1727.

April: Lysozyme

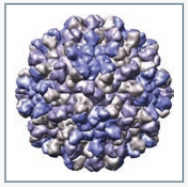
PDB ID 1LYZ

C. C. F. Blake, D. F. Koenig, G. A. Mair, A. C. T. North, D. C. Phillips, V. R. Sarma. (1965) Structure of hen egg-white lysozyme. A three dimensional Fourier synthesis at 2 Å resolution. *Nature* **206:** 757-761.

C. C. F. Blake, L. N. Johnson, G. A. Mair, A. C. T. North, D. C. Phillips, V. R. Sarma. (1967) Crystallographic studies of the activity of hen egg-white lysozyme. *Proc. R. Soc. London Ser. B* **167**: 378-388.

May: Tomato Bushy Stunt Virus

PDB ID 2TBV



P. Hopper, S. C. Harrison, R. T. Sauer. (1984) Structure of tomato bushy stunt virus. V. Coat protein sequence determination and its structural implications. *J Mol Biol* **177**: 701-713.

S. C. Harrison, A. J. Olson, C. E. Schutt, F. K. Winkler, G. Bricogne. (1978) Tomato bushy stunt virus at 2.9 Å resolution. *Nature* **276**: 368-373.

June: Hemoglobin S

PDB ID 2HBS

D. J. Harrington, K. Adachi, W. E. Royer, Jr. (1997) The high resolution crystal structure of deoxyhemoglobin *S. J Mol Biol* **272**: 398-407.

July: Crambin

PDB ID 1CRN

M. M. Teeter. (1984) Water structure of a hydrophobic protein at atomic resolution: pentagon rings of water molecules in crystals of crambin. *Proc. Natl. Acad. Sci. USA* **81**: 6014-6018.

W.A. Hendrickson. & M.M. Teeter (1981) Structure of the hydrophobic protein crambin determined directly from the anomalous scattering of sulfur. *Nature* **290**: 107-113.

A. Schmidt, M. Teeter, E. Weckert, V.S. Lamzin (2011). Crystal structure of small protein crambin at 0.48 Å resolution. *Acta Crystallogr.* **F67**: 424-428.

August: Myoglobin

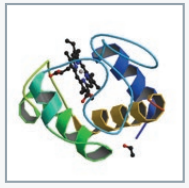
PDB ID 1MBN

J. C. Kendrew, G. Bodo, H. M. Dintzis, R. G. Parrish, H. Wyckoff, D. C. Phillips. (1958) A three-dimensional model of the myoglobin molecule obtained by x-ray analysis. *Nature* **181**: 662-666.

J. C. Kendrew, R. E. Dickerson, B. E. Strandberg, R. G. Hart, D. R. Davies, D. C. Phillips, V. C. Shore. (1960) Structure of myoglobin: A three-dimensional Fourier synthesis at 2 Å. resolution. *Nature* **185**: 422-427.

September: Cytochrome c

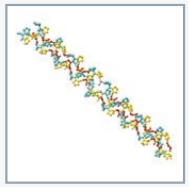
PDB ID 3CYT



T. Takano, R. E. Dickerson. (1980) Redox conformation changes in refined tuna cytochrome c. *Proc Natl Acad Sci USA* **77**: 6371-6375.

October: Collagen

PDB ID 1CAG



J. Bella, M. Eaton, B. Brodsky, H. M. Berman. (1994) Crystal and molecular structure of a collagen-like peptide at 1.9 Å resolution. *Science* **266**: 75-81.

Rich, A. & Crick, F. (1955). The structure of collagen. *Nature* **176**: 915-916.

November: Myoglobin fold

PDB ID 1MBN

J. C. Kendrew, G. Bodo, H. M. Dintzis, R. G. Parrish, H. Wyckoff, D. C. Phillips. (1958) A three-dimensional model of the myoglobin molecule obtained by x-ray analysis. *Nature* **181**: 662-666.

J. C. Kendrew, R. E. Dickerson, B. E. Strandberg, R. G. Hart, D. R. Davies, D. C. Phillips, V. C. Shore. (1960) Structure of myoglobin: A three-dimensional Fourier synthesis at 2 Å resolution. *Nature* **185**: 422-427.

December: Carboxypeptidase A

PDB ID 5CPA

D. C. Rees, M. Lewis, W. N. Lipscomb. (1983) Refined crystal structure of carboxypeptidase A at 1.54 Å resolution. *J Mol Biol* **168**: 367-387.

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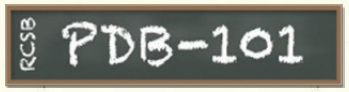
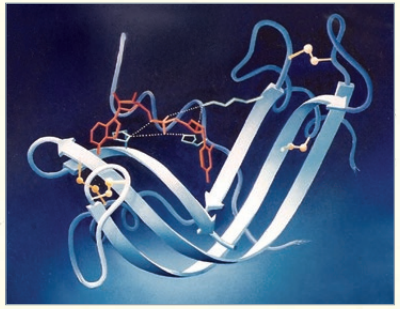
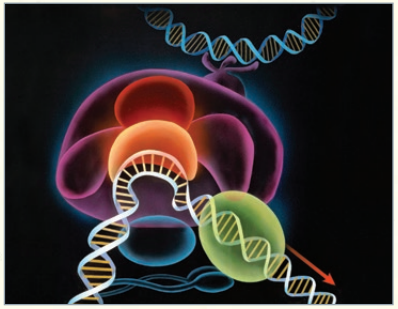


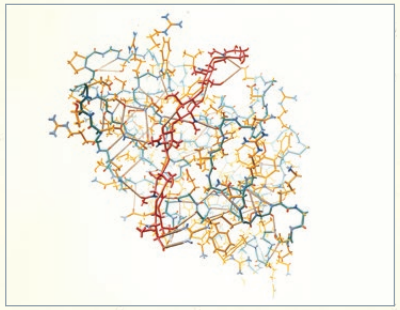


January: *Ribonuclease S*



February: *TATA-Binding Protein*

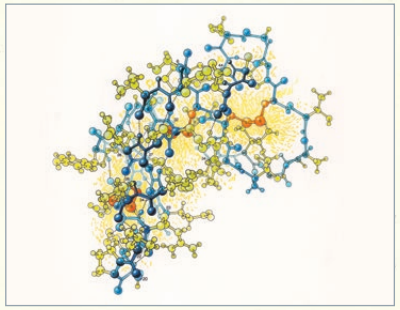
March: *Lac Repressor*



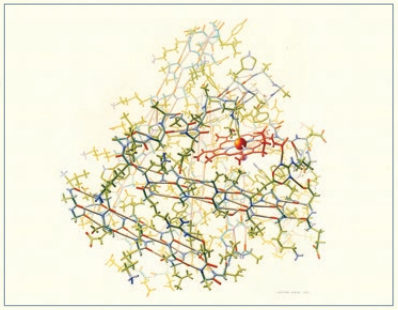
April: *Lysozyme*

May: *Tomato Bushy Stunt Virus*

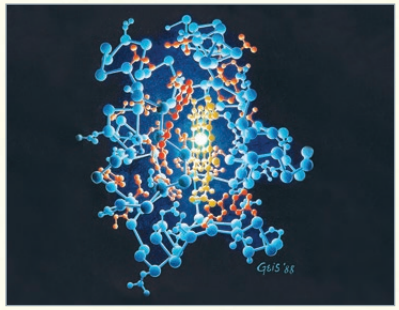
June: *Hemoglobin S*



July: *Crambin*



August: *Myoglobin*



September: *Cytochrome C*

October: *Collagen*

November: *Myoglobin Fold*

December: *Carboxypeptidase A*