

RCSB **PDB**
PROTEIN DATA BANK

RCSB.ORG

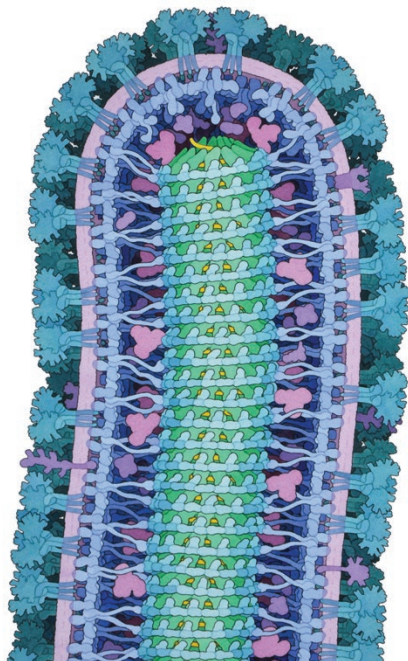
A Living Digital Data Resource that
Enables Scientific Breakthroughs

CALENDAR
20
20
YEARS OF
MOLECULE
OF THE MONTH

CELEBRATING

20

YEARS OF
MOLECULE
OF THE MONTH



For the past 20 years, the RCSB PDB *Molecule of the Month* series has introduced millions of visitors to the shape and function of the 3D structures archived in the Protein Data Bank.

The *Molecule of the Month* is presented as part of PDB-101, the education portal of the RCSB PDB. Created and illustrated by David S. Goodsell (RCSB PDB-Rutgers and The Scripps Research Institute), this feature tells stories about molecular structure and function, their diverse roles within living cells, and the growing connections between biology and nanotechnology. Each installment includes an introduction to the structure and function of the molecule, a discussion of the relevance to human health and welfare, and suggestions for 3D viewing, further reading, and questions to consider.

A variety of PDB-101 educational materials, such as articles, videos, posters, hands-on activities, lesson plans, and curricula, build on this series for use in a variety of educational settings.

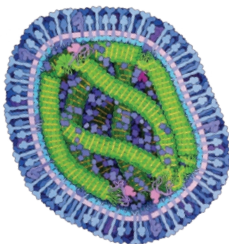
***Ebola Virus Proteins*, October 2014**

doi:10.2210/rcsb_pdb/mom_2014_10



Zika Virus, May 2016

doi:10.2210/rcsb_pdb/mom_2016_5



On the cover

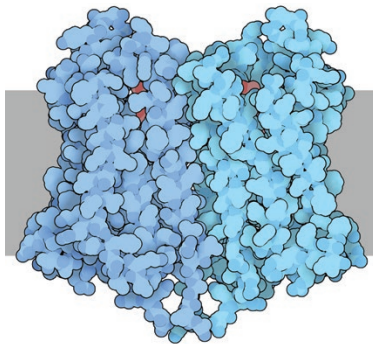
Measles Virus Proteins

March 2019

doi:10.2210/rcsb_pdb/
mom_2019_3

Molecule of the Month images have been recognized by several awards and publications, including the 2017 NSF/Popular Science Vizzies (for Zika Virus), the 2016 Wellcome Trust Image Awards (for Ebola Virus Proteins), and the 2015 FASEB BioArt Awards (for Ebola Virus Proteins). High resolution images for the entire series are available for download and reuse.

While topical features such as Zika Virus and Opioid Receptors draw large audiences, articles related to the topics commonly addressed in classrooms continue to be accessed year after year. The top-accessed articles are highlighted in this calendar, culminating in the highest-ranked articles Hemoglobin (co-authored with Shuchismita Dutta) and Catalase.

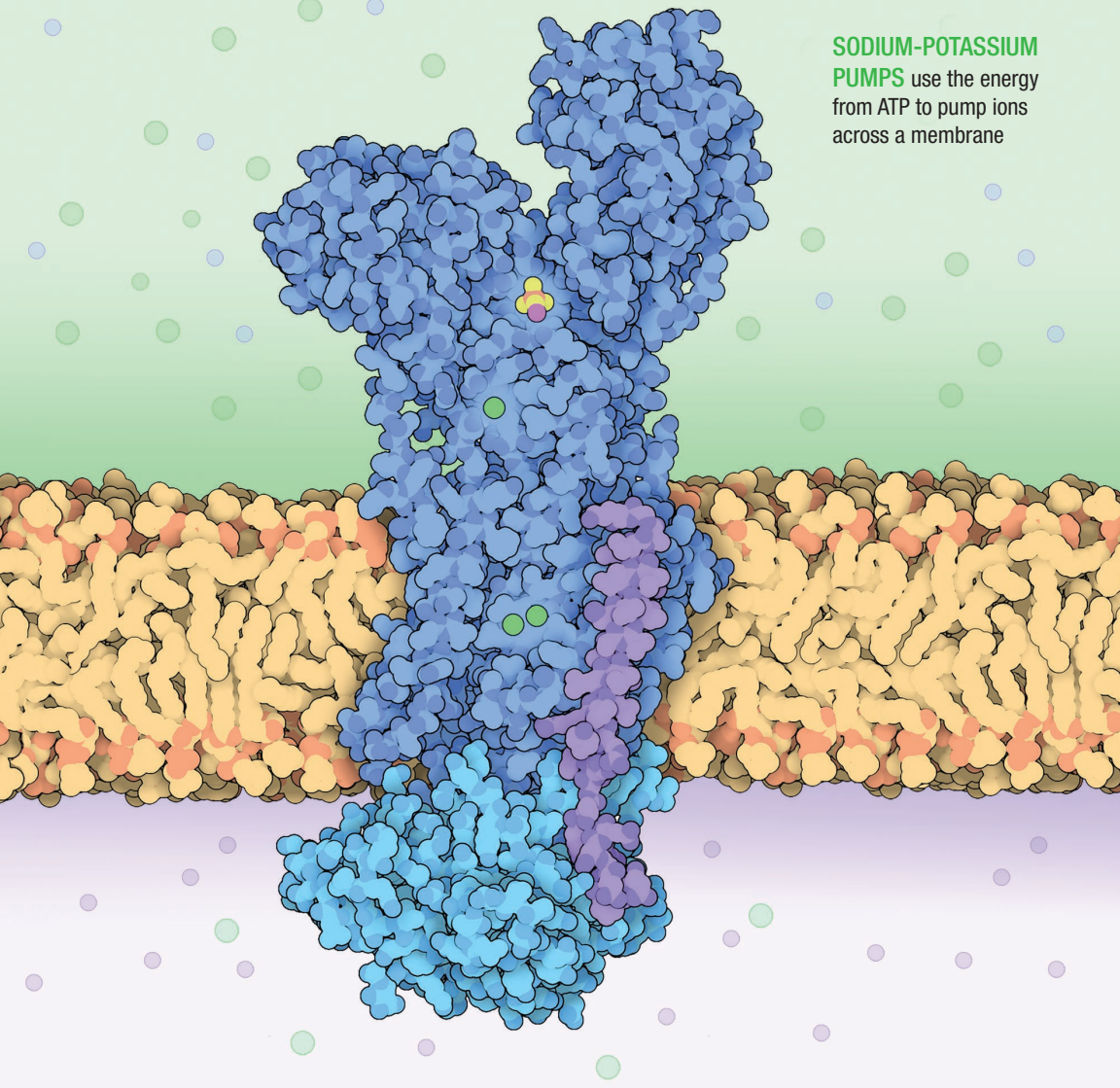


Opioid Receptors, January 2018

doi:10.2210/rcsb_pdb/mom_2018_1

David S. Goodsell, Shuchismita Dutta, Christine Zardecki, Maria Voigt, Helen M. Berman, Stephen K. Burley. (2015) The RCSB PDB "Molecule of the Month": Inspiring a Molecular View of Biology. *PLoS Biol* **13**: e1002140

**SODIUM-POTASSIUM
PUMPS** use the energy
from ATP to pump ions
across a membrane



January 2020

Sodium-Potassium Pump October 2009

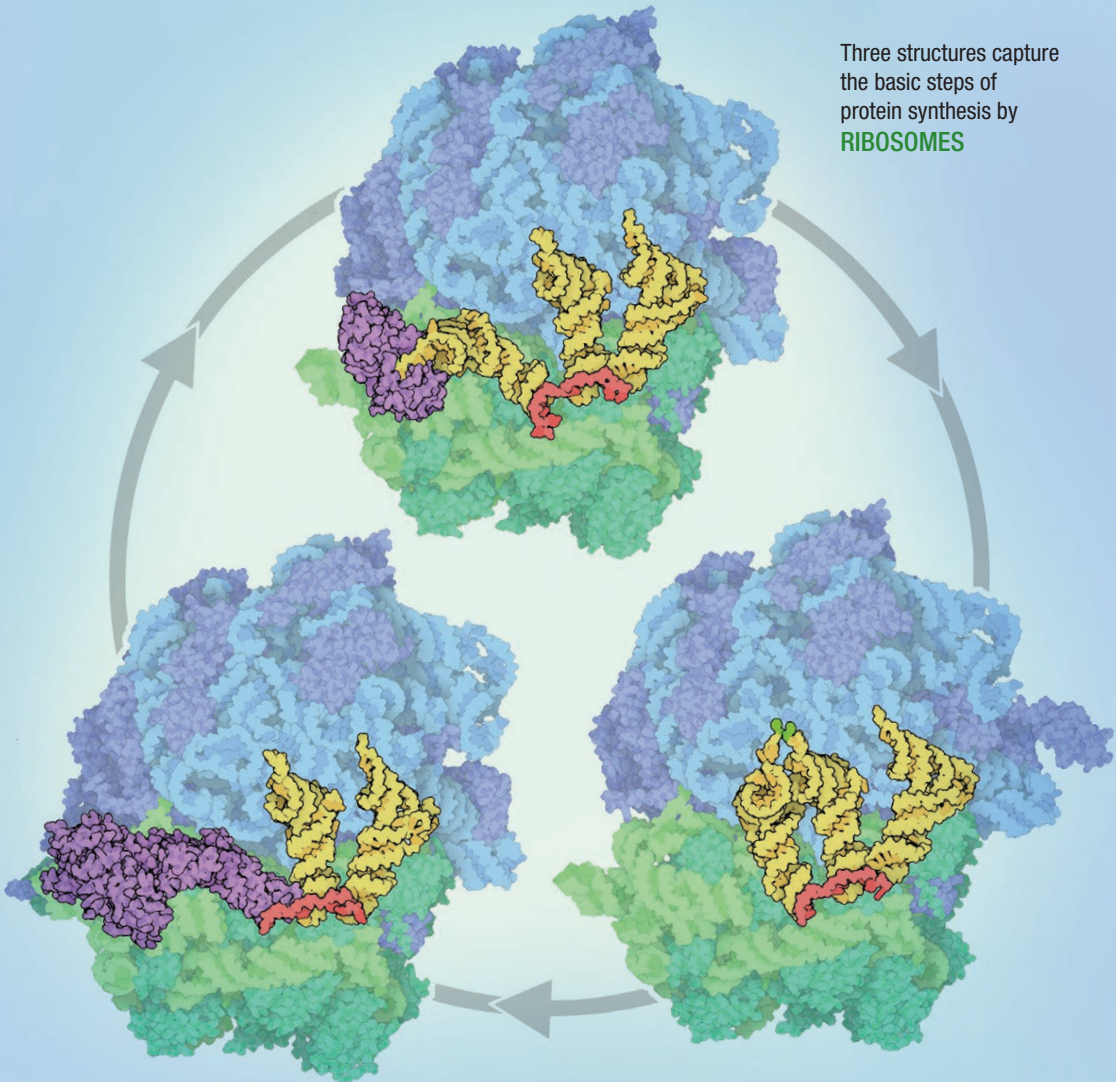
doi:10.2210/rcsb_pdb/mom_2009_10

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

2ZXE Crystal structure of the sodium-potassium pump at 2.4 Å resolution.

T. Shinoda *et al.* (2009) *Nature* **459**: 446-450

Three structures capture
the basic steps of
protein synthesis by
RIBOSOMES



February 2020

Ribosome January 2010
doi:10.2210/rcsb_pdb/mom_2010_1

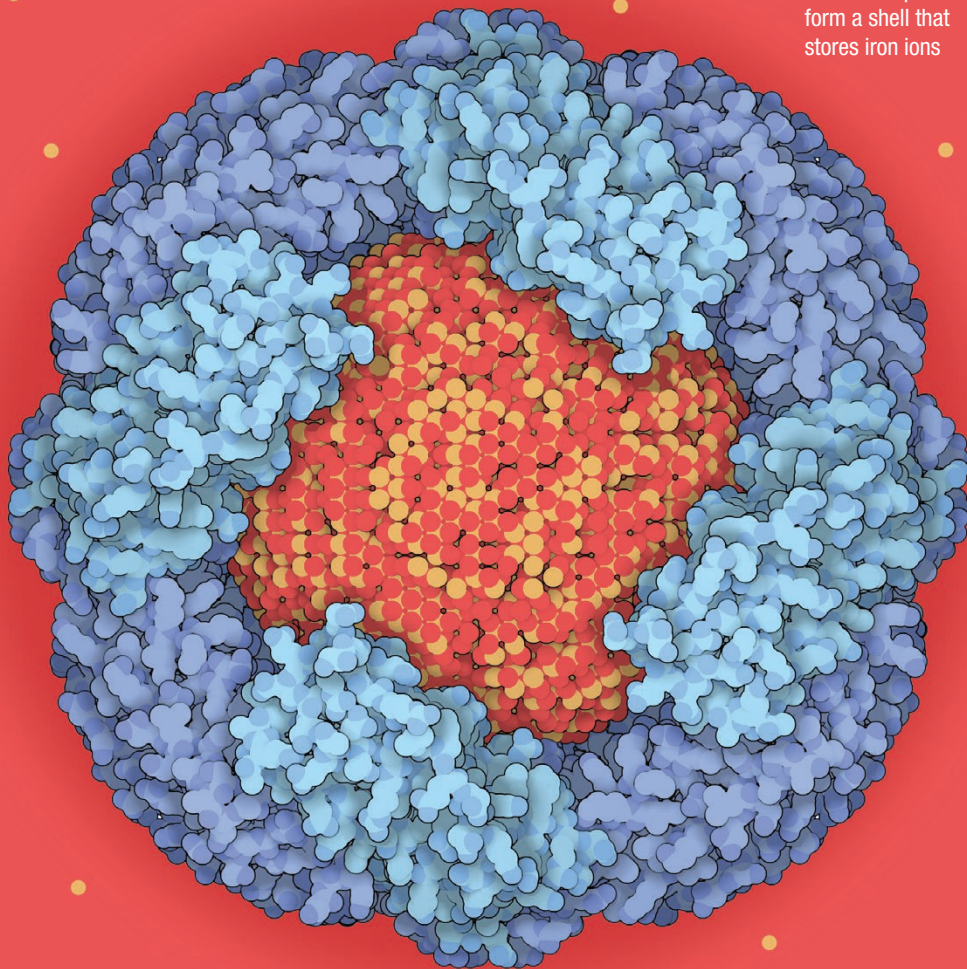
Ribosomal Subunits October 2000
doi:10.2210/rcsb_pdb/mom_2000_10

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

4V5G, 4V5F The structure of the ribosome with elongation factor G trapped in the posttranslocational state
Y.G. Gao *et al.* (2009) *Science* **326**: 694-699

4V5D Insights into substrate stabilization from snapshots of the peptidyl transferase center of the intact 70S ribosome
R.M. Voorhees *et al.* (2009) *Nat. Struct. Mol. Biol.* **16**: 528-533

FERRITIN proteins
form a shell that
stores iron ions



March 2020

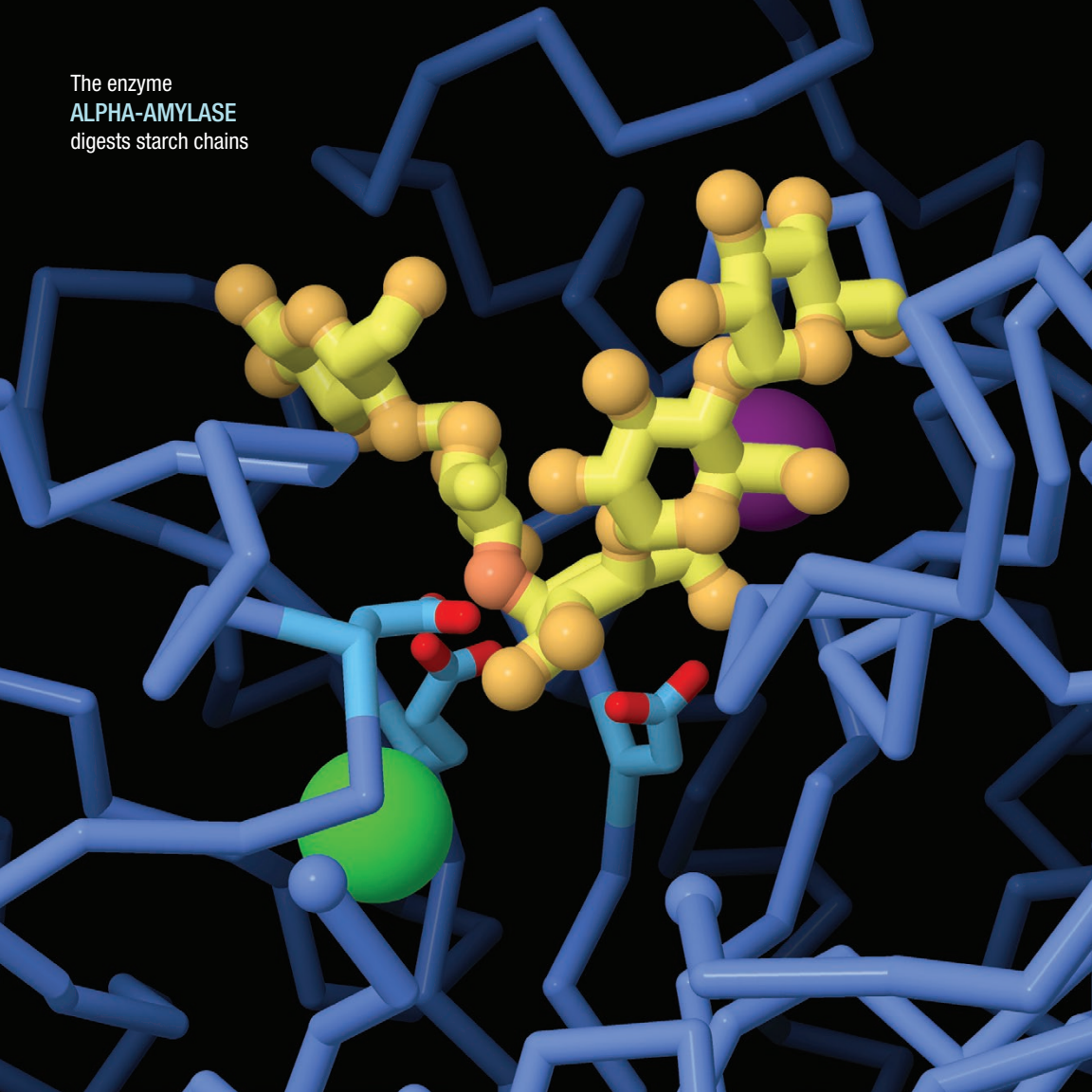
Ferritin and Transferrin November 2002

doi:10.2210/rcsb_pdb/mom_2002_11

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
1	2	3	4	5	6	7
8 Daylight Saving Time begins (US)	9	10	11	12	13	14 Pi Day
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29 Daylight Saving Time begins (EU)	30	31	1	2	3	4

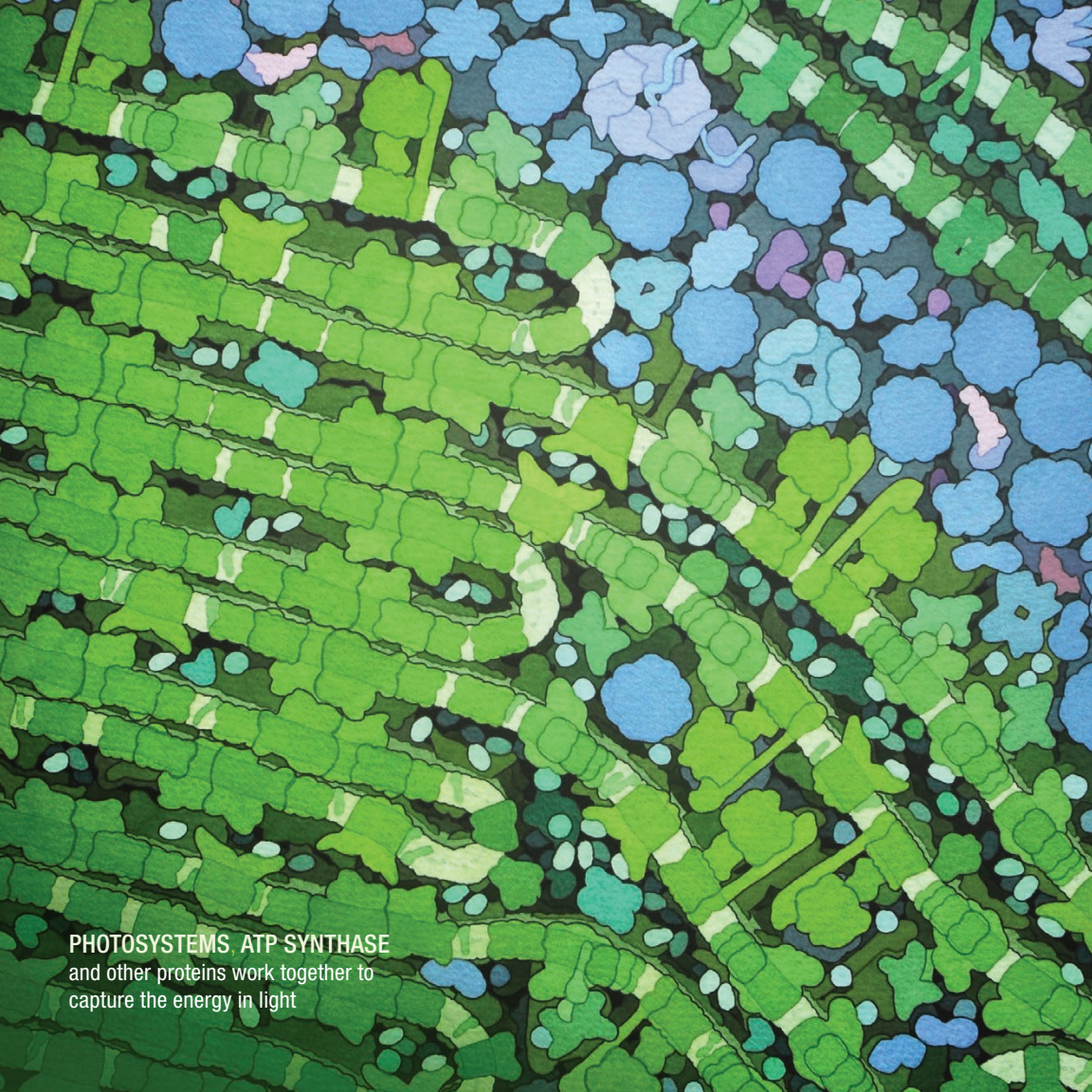
1HRS A crystallographic study of haem binding to ferritin
G. Precigoux *et al.* (1994) *Acta Cryst.* **D50**: 739-743

The enzyme
ALPHA-AMYLASE
digests starch chains



Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
29	30	31	1	2	3	4
5	6	7	8 Passover begins at sundown	9	10	11
12 Easter	13	14	15 Tax Day	16	17	18
19	20	21	22 Earth Day	23 Ramadan begins at sundown	24	25 DNA Day
26	27	28	29	30	1	2

1PPI The active center of a mammalian alpha-amylase. Structure of the complex of a pancreatic alpha-amylase with a carbohydrate inhibitor refined to 2.2-Å resolution
M. Qian *et al.* (1994) *Biochemistry* **33**: 6284-6294



PHOTOSYSTEMS, ATP SYNTHASE
and other proteins work together to
capture the energy in light


May 2020

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

Photosystem I October 2001
doi:10.2210/rcsb_pdb/mom_2001_10

Photosystem II November 2004
doi:10.2210/rcsb_pdb/mom_2004_11

ATP Synthase December 2005
doi:10.2210/rcsb_pdb/mom_2005_12



INSULIN binds to receptors
on cell surfaces and mobilizes
the machinery for storing glucose

June 2020

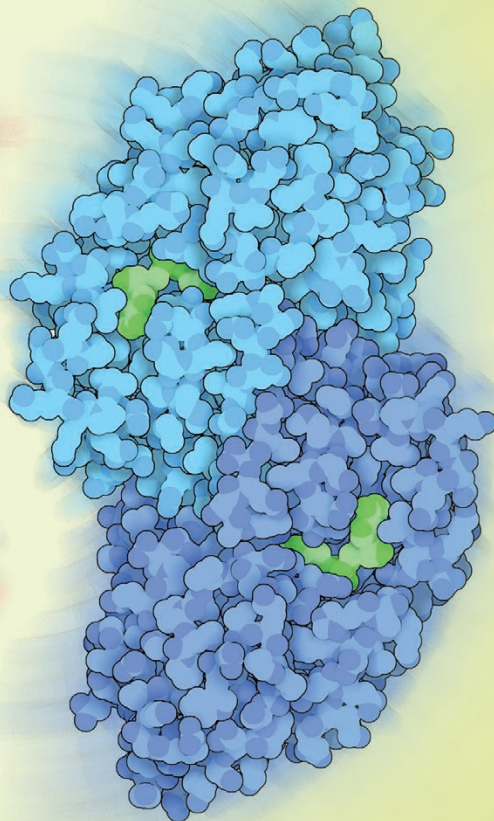
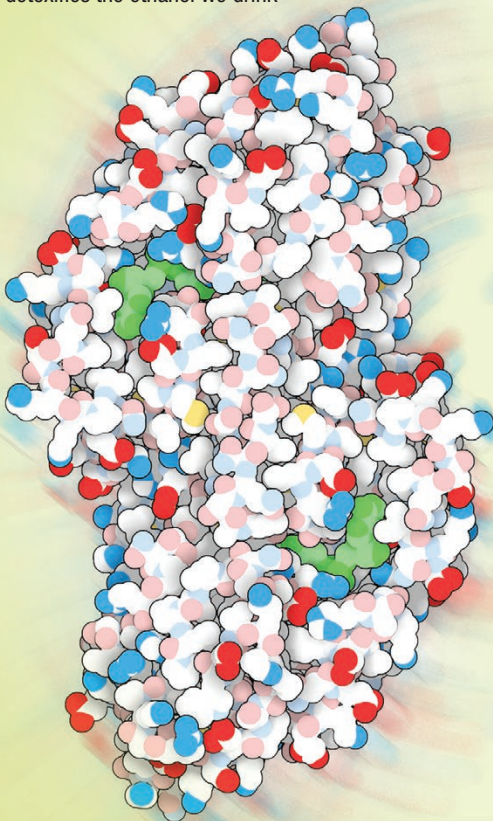
Insulin February 2001
doi:10.2210/rcsb_pdb/mom_2001_2

PDB-101 Resources on Diabetes
pdb101.rcsb.org/browse/diabetes

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

Seeing double?

ALCOHOL DEHYDROGENASE, shown
with two different coloring schemes,
detoxifies the ethanol we drink



July 2020

Alcohol Dehydrogenase January 2001

doi:10.2210/rcsb_pdb/mom_2001_1

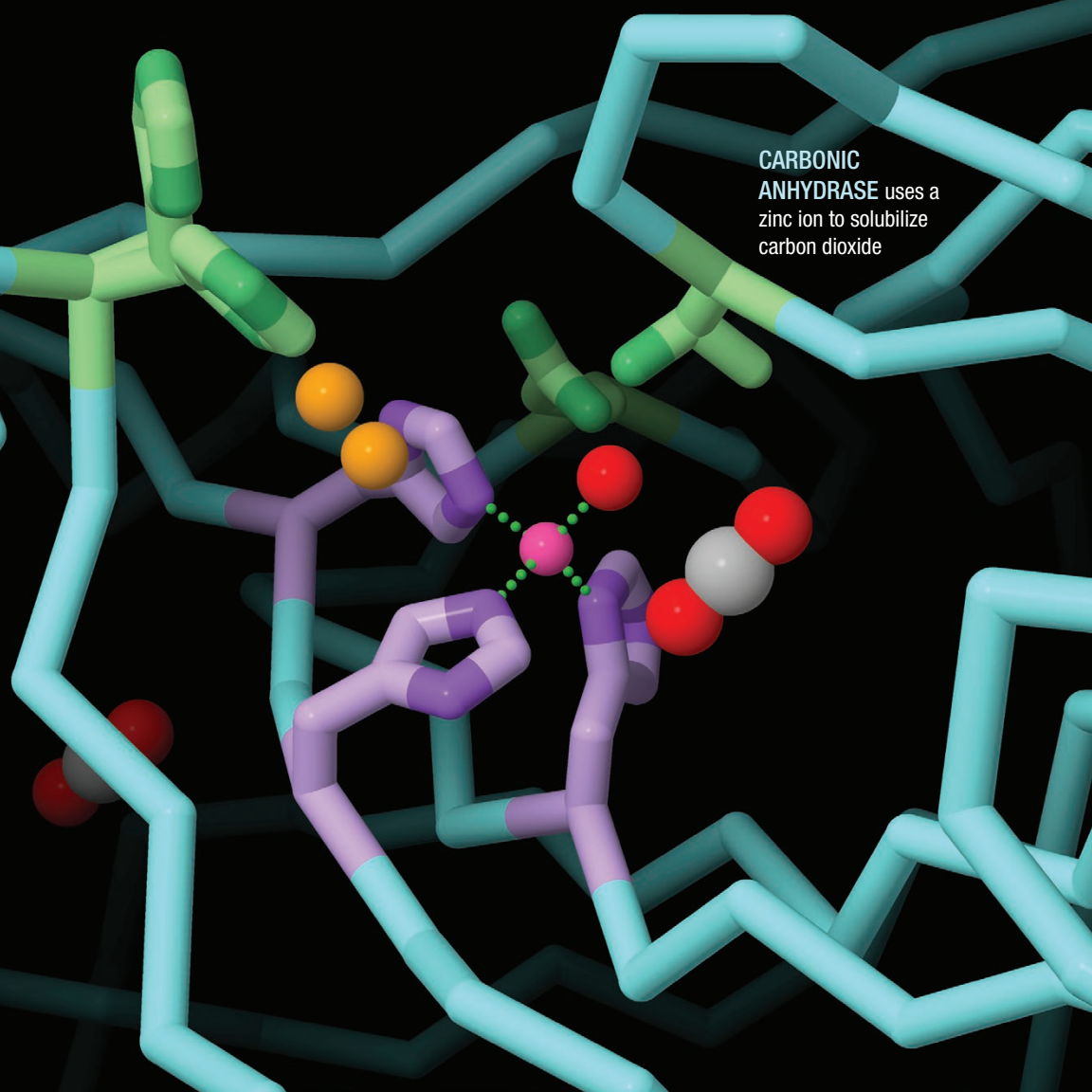
Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
28	29	30	1	2	3 Independence Day observed	4 Independence Day
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30	31	1

1HTB X-ray structure of human $\beta 3 \beta 3$ alcohol dehydrogenase.

The contribution of ionic interactions to coenzyme binding

G.J. Davis *et al.* (1996) *J.Biol.Chem.* **271**: 17057-17061

CARBONIC
ANHYDRASE uses a
zinc ion to solubilize
carbon dioxide



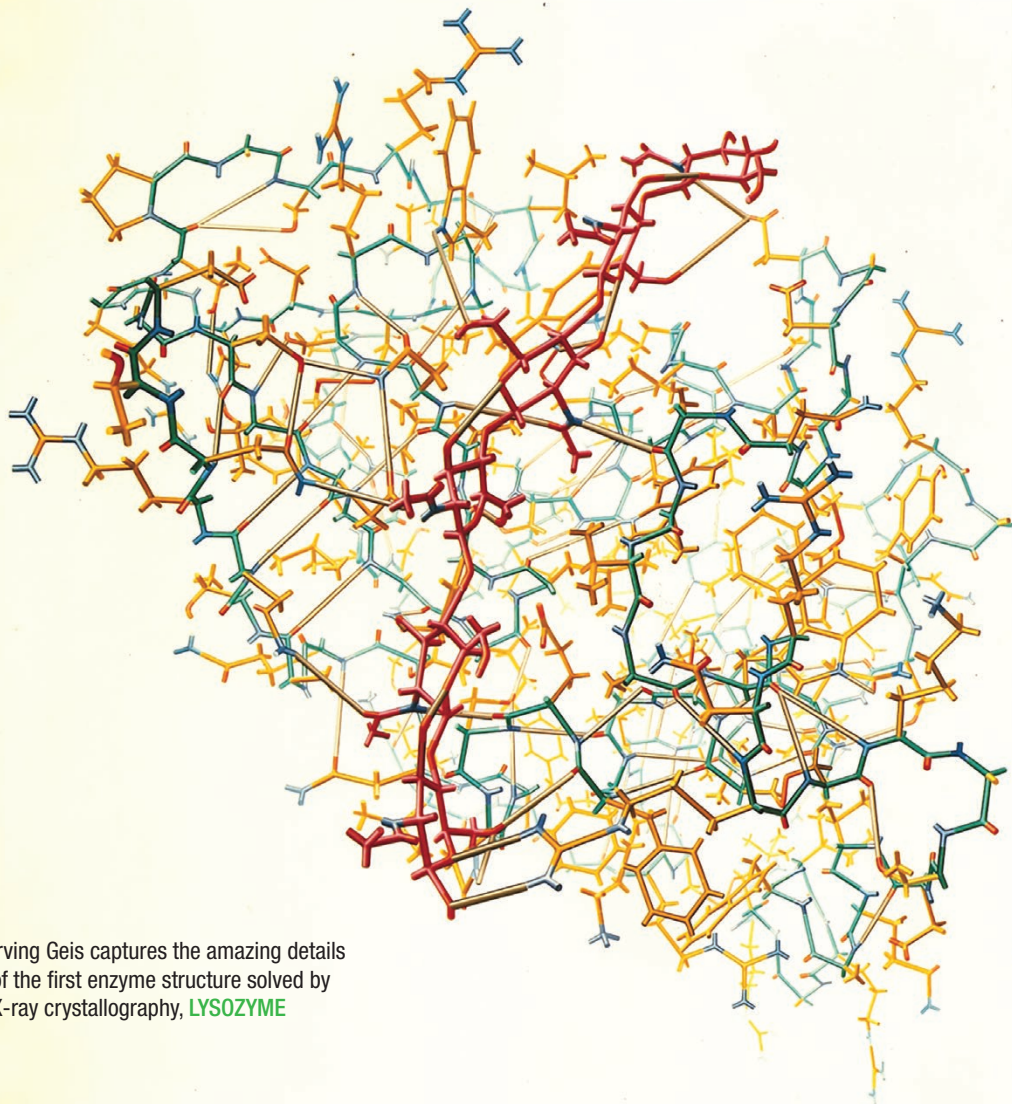
August 2020

Carbonic Anhydrase January 2004
doi:10.2210/rcsb_pdb/mom_2004_1

Image created by Belle Lin; article co-authored with Shuchismita Dutta

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
26	27	28	29	30	31	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					

5YUI Tracking solvent and protein movement during CO2 release in carbonic anhydrase II crystals
C.U. Kim *et al.* (2016) *Proc. Natl. Acad. Sci. U.S.A.* **113**: 5257-5262



Irving Geis captures the amazing details
of the first enzyme structure solved by
X-ray crystallography, **LYSOZYME**

September 2020

Lysozyme September 2000
doi:10.2210/rcsb_pdb/mom_2000_9

PDB Pioneers October 2011
doi:10.2210/rcsb_pdb/mom_2011_10

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

Painting from D. Phillips (1966). The Three-Dimensional structure of an enzyme molecule.
Sci. Am. **215**: 78-90. doi: 10.1038/scientificamerican1166-78

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EGFP

Citrine

mOrange

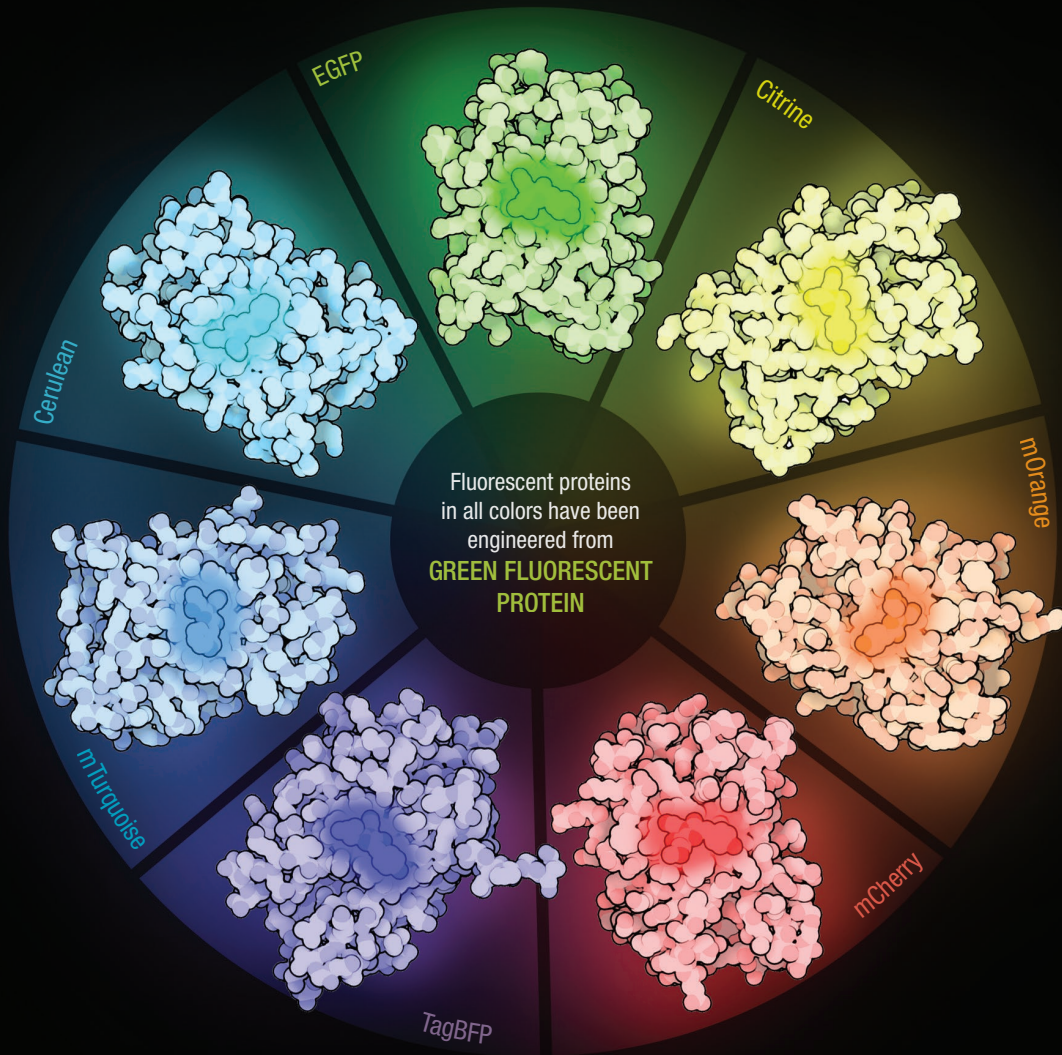
mCherry

TagBFP

mTurquoise

Cerulean

Fluorescent proteins
in all colors have been
engineered from
**GREEN FLUORESCENT
PROTEIN**



Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
27	28	29	30	1	2	3
4	5	6	7	8	9	10
11	12 Columbus Day	13	14	15	16	17
18	19	20	21	22	23	24
25 Daylight Saving Time ends (EU)	26	27	28	29	30	31 Halloween

3M24 Structural characterization of acylimine-containing blue and red chromophores in mTagBFP and TagRFP fluorescent proteins
O.M. Subach *et al.* (2010)
Chem.Biol. **17**: 333-341

2Q57 X-ray structure of Cerulean GFP: a tryptophan-based chromophore useful for fluorescence lifetime imaging
G.D. Malo (2007) *Biochemistry* **46**: 9865-9873

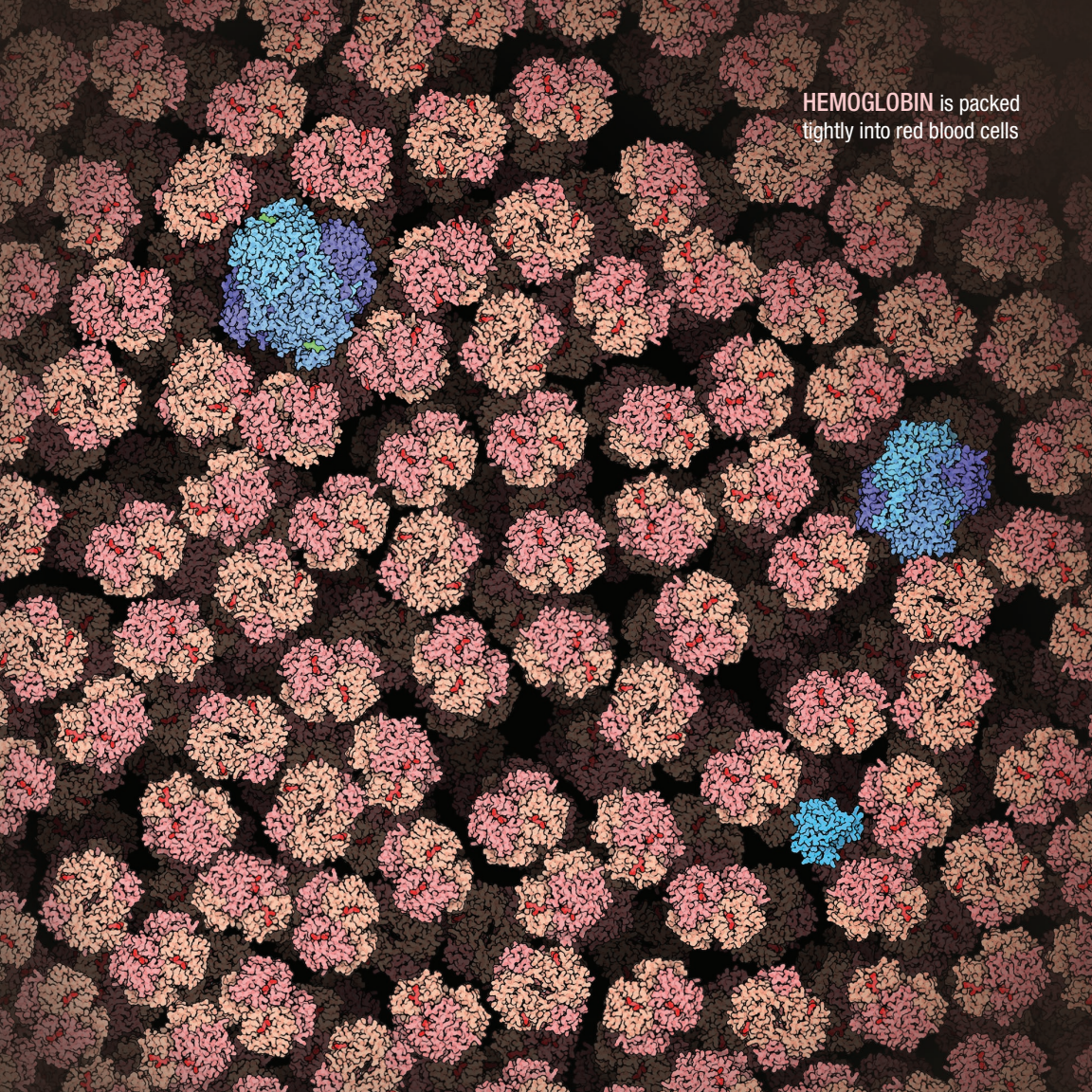
4AR7 Structure of a Fluorescent Protein from Aequorea Victoria Bearing the Obligate-Monomer Mutation A206K
D. von Stetten *et al.* (2012)
Acta Cryst. **F68**: 878-872

2Y0G Stabilizing role of glutamic acid 222 in the structure of enhanced green fluorescent protein
A. Royant, M. Noirclic-Savoye (2011)
J.Struct.Biol. **174**: 385-390

1HUY Reducing the environmental sensitivity of yellow fluorescent protein. Mechanism and applications
O. Griesbeck *et al.* (2001) *J.Biol.Chem.* **276**: 29188-29194

2H50, 2H5Q Novel chromophores and buried charges control color in mFruits
X. Shu *et al.* (2006) *Biochemistry* **45**: 9639-9647

HEMOGLOBIN is packed
tightly into red blood cells



November 2020

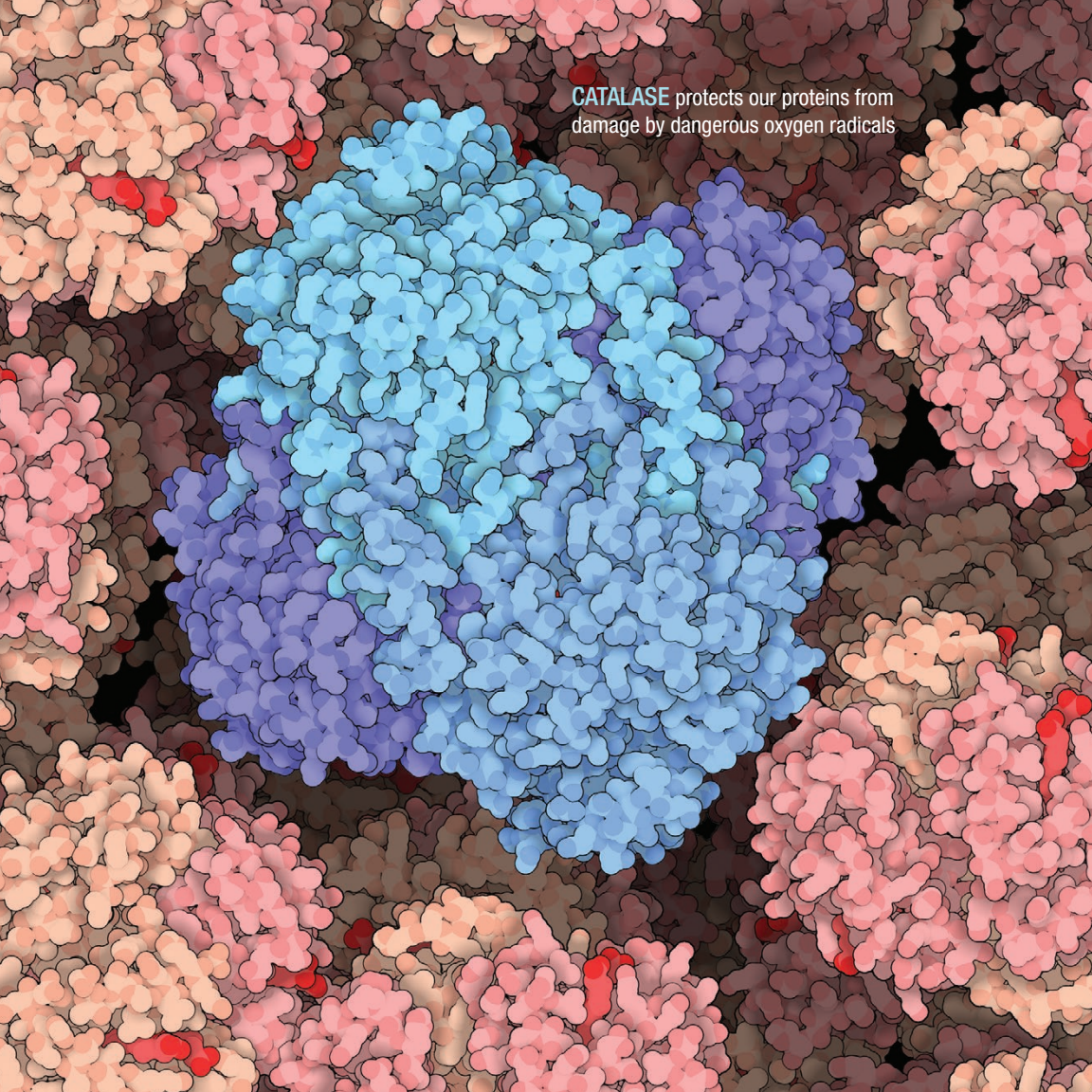
Hemoglobin May 2003
doi:10.2210/rcsb_pdb/mom_2003_5

N-nitrosylated Hemoglobin May 2019
doi:10.2210/rcsb_pdb/mom_2019_5

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

2HHB Structure of hæmoglobin: a three-dimensional Fourier synthesis at 5.5-Å resolution, obtained by X-ray analysis. M.F. Perutz *et al.* (1960) *Nature*, **185**: 416-422.

CATALASE protects our proteins from
damage by dangerous oxygen radicals



December 2020

Catalase September 2004
doi:10.2210/rcsb_pdb/mom_2004_9

#1 accessed
*Molecule of
the Month*
article

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

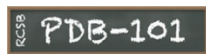
1QQW Structure of human erythrocyte catalase
T.P. Ko *et al.* (2000) *Acta Cryst.* **D56**: 241-245

RCSB.ORG

*A Living Digital Data
Resource that Enables
Scientific Breakthroughs*

Cells rely on many large molecular machines that carry out the complex biological and chemical tasks that sustain life.

3D structures of these machines are freely available at the Protein Data Bank (PDB), the global storehouse of biomolecular structures central to research and education.



PDB101.RCSB.ORG

*Molecular Explorations
through Biology and
Medicine*

PDB-101 is an educational portal developed by the RCSB PDB for teachers, students, and the general public.

Launched in 2011, the PDB-101 website first organized *Molecule of the Month* articles into a fully browsable collection, divided among browsable by high-level functional categories (such as protein



RCSB PDB has
hosted the
Molecule of the Month
series since
January 2000

RCSB.ORG serves millions of users worldwide each year, providing services that

- Inform basic and applied research across the sciences
- Are central to understanding human, animal, and plant health and disease
- Are critical for drug discovery/development and biotechnology
- Enable education across biology and medicine

synthesis, health and disease, and biological energy). Today, PDB-101 is a rich online resource aimed at promoting biomolecular education and understanding.

PDB-101 resources are freely available, including curricular materials, paper molecular models, and videos/animations.

RCSB PDB is a member of the Worldwide PDB (wwPDB.ORG).

RCSB PDB is hosted by:

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