Vol. 15 / No. 4 / April 2016

ASBMB TODAY

THE MEMBER MAGAZINE OF THE AMERICAN SOCIETY FOR BIOCHEMISTRY AND MOLECULAR BIOLOGY

SECOND SKIN

Cell Energetics and Metabolic Profiling using Biolog Phenotype MicroArrays™

- Profile cell lines or primary cells
- Measure metabolic rates for hundreds of substrates
- Detect metabolic changes that correlate with disease states
- Simple colorimetric assays any lab can perform

A1 Negative Control	A2 Negative Control	A3 Negative Control	A4 α-Cyclodextrin	A5 Dextrin	A6 Glycogen	A7 Maltitol	A8 Maltotriose	A9 D-Maltose	A10 D-Trehalose	A11 D-Cellobiose	A12 β-Gentiobiose
B1 D-Glucose-6-Phosphate	B2 α-D-Glucose-1-Phosphate	B3 L-Glucose	B4 α-D-Glucose	B5 α-D-Glucose	B6 α-D-Glucose	B7 3-O-Methyl-D-Glucose	B8 α-Methyl-D-Glucoside	B9 β-Methyl-D-Glucoside	B10 D-Salicin	B11 D-Sorbitol	B12 N-Acetyl-D-Glucosamine
C1 D-Glucosaminic Acid	C2 D-Glucuronic Acid	C3 Chondroitin-6-Sulfate	C4 Mannan	C5 D-Mannose	C6 α-Methyl-D-Mannoside	C7 D-Mannitol	C8 N-Acetyl-β-D-Mannosamine	C9 D-Melezitose	C10 Sucrose	C11 Palatinose	C12 D-Turanose
D1 D-Tagatose	D2 L-Sorbose	D3 L-Rhamnose	D4 L-Fucose	D5 D-Fucose	D6 D-Fructose-6-Phosphate	D7 D-Fructose	D8 Stachyose	D9 D-Raffinose	D10 D-Lactitol	D11 Lactulose	D12 α-D-Lactose
E1 Melibionic Acid	E2 D-Melibiose	E3 D-Galactose	E4 α-Methyl Galactos								
F1 Adonitol	F2 L-Arabinose	F3 D-Arabinose	F4 β-Methyl Xylopyra								
G1 Tricarballylic Acid	G2 D,L-Lactic Acid	G3 Methyl D-lactate	G4 Methyl pyruvat								
H1 Acetoacetic Acid (a)	H2 γ-Amino-N-Butyric Acid	H3 α-Keto-Butyric Acid	H4 α-Hydr Butyric								

96 well plates prefilled with energy substrates

Add cells, Biolog redox dye and incubate for 3 hours

1PM	01	02	03	04	05	06	07	08	09	10	11	12
A						Glycogen	Maltitol	Maltotriose	D-Maltose			
B	D-Glucose-6-Phosphate	α-D-Glucose-1-Phosphate		α-D-Glucose	α-D-Glucose	α-D-Glucose					D-Sorbitol	
C					D-Mannose							D-Turanose
D							D-Fructose					
E			D-Galactose									
F	Adonitol				Xylitol							
G		D,L-Lactic Acid			Pyruvic Acid				Mono-Methyl Succinate			
H		γ-Amino-N-Butyric Acid	α-Keto-Butyric Acid	α-Hydroxy-Butyric Acid	D,L-β-Hydroxy-Butyric Acid	γ-Hydroxy-Butyric Acid					Acetic Acid	Hexanoic Acid

Capture metabolic rates with the OmniLog®

Learn more about Phenotype MicroArrays at http://info.biolog.com/ASBMB.html

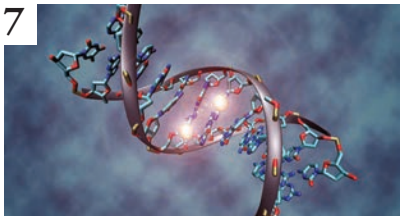
BIOLOG

CONTENTS

NEWS

4

7



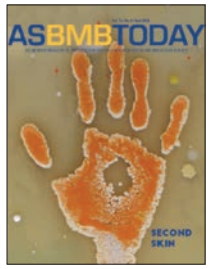
FEATURES

14

20

Working at the intersection of fashion and science, a bioartist reimagines skin bacteria as a kind of clothing.

Image courtesy of Sonja Baumel



PERSPECTIVES

36

26

TRANSITION STATES

ASBMB TODAY
THE MEMBER MAGAZINE OF THE AMERICAN SOCIETY FOR BIOCHEMISTRY AND MOLECULAR BIOLOGY

ASBMB
American Society for Biochemistry and Molecular Biology
www.asbmb.org/asbmbtoday
PRINT ISSN 2372-0409

EDITOR'S NOTE

Mind the gap

By Lauren Dockett

I went to graduate school late. So late in fact, that except for a retiree and a middle-aged war veteran who were both finally pursuing their passion for writing, I was the oldest person in my journalism program. My older cohorts had lived a lot of life between college and graduate school, and, frankly, so had I. I'd ridden the throes of a seizing media market for more than a decade as a writer and editor and was working at a venerable but struggling publishing house and pregnant with my first child when I enrolled. I went to grad school with few illusions about my field. I knew what I would be in for when I graduated, and I still wanted to be a part of it.

We three "nontraditional students" loved school. We spoke up in our classes, chatted with our professors about their lives like the peers that we were, read everything on the syllabus and more as we sought a greater deftness in the storytelling we'd been doing for years, and carefully considered the ethics and the real dangers of the work. Some of our 20-somethings classmates viewed us warily at first, but as we hit the pavement together and worked until daybreak on deadline we all became friends.

Gap years — or decades — between college and graduate school are something of a convention in fields like mine but less common in the life sciences. A Ph.D. or medical degree takes the kind of time and energy long associated with unencumbered youth and provides a neat path forward in a young person's life. Some undergraduate advisers might warn passionate science students against a gap year turning into two or — heaven forbid — five years away from research and inadvertently dissuade them from taking a break. But as more institutions try to keep science undergrads engaged by helping them explore science-related careers outside medical school and academia, gap years become a natural outgrowth of this effort.

We'd like to hear your perspective on gap years. If you took one (or two or more), how did it go? If you didn't, how did that go? If you advise undergraduates, do you think gap years put them at a disadvantage for academic, research, clinical or industry careers? Do they help? If you are an undergrad sweating the choice between a gap year and graduate school, what are your concerns? Head to our Submittable page (asbmbtoday.submittable.com/submit) and share your thoughts. We'll consider them for publication in a future issue.

CALL FOR SUBMISSIONS

ASBMB Today is seeking essays on gap years. Visit asbmbtoday.submittable.com/submit to send your contribution for consideration.

Lauren Dockett (ldockett@asbmb.org) is the managing editor of ASBMB Today.

PRESIDENT'S MESSAGE

Steven McKnight's column will resume next month.

Funding climate may change if some get their way

By Benjamin Corb

It is budget season in Washington, and, just as the famed cherry blossoms around the city's tidal basin are starting to fall, the U.S. Congress is providing the National Institutes of Health advocates with several tempting yet delicate proposals aimed at increasing funding for biomedical research. Unfortunately, just like the spring flower, the proposals are incredibly fragile and can be blown away in the blink of an eye, leaving those of us advocating for funding support stuck waiting for next year's blossoms.

This year's budget season actually started last year, with the U.S. House of Representatives overwhelmingly passing the 21st Century Cures Act. The proposal, among other things, explicitly called for five years of increases to the NIH's baseline funding and developed a new model for providing additional funds. NIH funding today comes from discretionary appropriations. Just as the name implies, these funds are at the discretion of the Congress and can change year to year based on political priorities. The 21st Century Cures Act created an additional fund to support the NIH that was not discretionary but mandatory. In this way, while the NIH's baseline operations would continue to be funded through discretionary funding, a bonus of $8 billion in funding over five years automatically would be baked into the budget process. The House passed this legislation nearly a year ago, but the U.S. Senate has not decided to move it forward. It is, at the moment, withering on the congressional vine.

In February, President Barack Obama proposed his fiscal year 2017 budget, which included a funding plan for the NIH that called for $1 billion in cuts to the NIH's baseline appropriation. These cuts — the White House argued — should be supplanted by a mandatory fund from Congress. In other words, the president requested a $1 billion increase to the NIH's budget through a blend of discretionary and mandatory appropriations. As is often the case when one political party controls the Congress while the other controls the White House, the president's proposal was soundly rejected.

The Senate, which could have adopted the 21st Century Cures Act, instead decided on a legislative agenda focusing on proposals outlined in a Bipartison Policy Center report that would support "innovation for a healthier America." Currently, the Senate is considering a series of individual pieces of legislation, each aimed at supporting the NIH, the Food and Drug Administration, and other parts of the treatment and drug development process. There has not yet been a piece of legislation as part of the Senate's agenda calling for any funding increases to the NIH. Both U.S. Sens. Lamar Alexander, R-Tenn., and Patty Murray, D-Wash., who chair the Senate committee that has jurisdiction over NIH, have supported the need for increased investments at the NIH. But there has been little agreement about the mechanism (discretionary or mandatory), the amount or the targets for the funding.

U.S. Sen. Elizabeth Warren, D-Mass., last month introduced her own funding plan to support the NIH: the National Biomedical Research Act. Warren's act would provide an additional $5 billion in funding above the annual NIH appropriation and help recover the financial support that has eroded after nearly a decade of stagnant funding. Warren's proposal is supported by a handful of her Democratic colleagues in the Senate.

After five years of austere budgets that caused advocates to scratch and claw for even flat funding for the NIH, there is a new level of congressional support for biomedical research, and political leaders from both parties are thinking about ways to support the research enterprise. The challenge now is making any of these proposals a reality.

Interested in science policy?

Follow our blog for news, analysis and commentary on policy issues affecting scientists, research funding and society. Visit policy.asbmb.org.

Benjamin Corb (bcorb@asbmb.org) is director of public affairs at ASBMB.

Bumpus wins Presidential Early Career Award


BUMPUS

Namandje Bumpus, associate professor of pharmacology and molecular sciences at the Johns Hopkins University, has won a Presidential Early Career Award for Scientists and Engineers. Established in 1996 during the Clinton administration, the awards are conferred annually following recommendations from government agencies. The young scientists, who are honored for doing innovative, independent research and demonstrating commitment to community service through scientific leadership, public education or community outreach, receive their awards at a White House ceremony.

President Barack Obama praised Bumpus and the 104 other winners of the government's highest honor for young scientists. "These early-career scientists are leading the way in our efforts to confront and understand challenges from climate change to our health and wellness," the president said. "We congratulate these accomplished individuals and encourage them to continue to serve as an example of their incredible promise and ingenuity of the American people."

Bumpus researches the molecular mechanisms underlying idiosyncratic, adverse events associated with the use of non-nucleoside reverse transcriptase inhibitors to treat HIV-1. She runs a lab at Hopkins that examines how drugs used to prevent and treat HIV infection are metabolized and seeks to aid in the development of next-generation therapies.

Mitchell named chair of Hemispherx


MITCHELL

William M. Mitchell, professor of pathology, microbiology and immunology at the Vanderbilt University School of Medicine, is the new chairman of the board of Hemispherx Biopharma, a Philadelphia-based biopharmaceutical company that develops and manufactures new drugs for the treatment of viral and immune-based disorders.

Hemispherx's flagship products include Alferon N Injection, a highly purified and glycosylated multispecies alpha interferon product, and Ampligen, an experimental immunotherapeutic drug for chronic fatigue syndrome.

Hemispherx has undergone several recent organizational changes, most notably the promotion of Thomas Equels as the new CEO.

Mitchell remains an independent director at Hemispherx, a role he has held since 1998.

Goc named professional woman of the year VIP


GOC

The National Association of Professional Women has inducted Anna Goc into its VIP Professional Woman of the Year Circle. The NAPW is a networking organization for professional women that boasts 850,000 members and is aimed at facilitating interaction and an exchange of ideas among female leaders in various fields.

"I'm pleased to welcome Anna to the exceptional group of professional women," said NAPW President Star Jones. "Her knowledge and experience in her industry are valuable assets to her company and community."

Goc, who studied at Jagiellonian Unversity in Cracow, Poland, is a senior researcher at the Dr. Rath Research Institute in Santa Clara, Calif., where she leads a microbiology lab that develops treatments for bacterial and fungal infections. She was recognized by NAPW for her leadership in research and development.

Written by Erik Chaulk

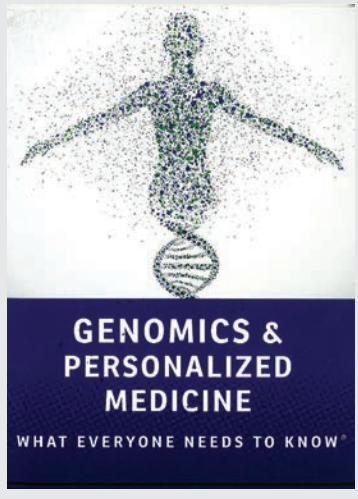
Snyder writes genomics book for lay readers


SNYDER

Michael Snyder, director of the Center for Genomics and Personalized Medicine at Stanford University, has penned a book for the general public. Published by Oxford University Press, "Genomics and Personalized Medicine: What Everyone Needs to Know" is intended to be an accessible guide to genomics and personal health.

Since the mapping of the human genome in 2003, genomics have become increasingly relevant in health care. Snyder, who runs a lab at Stanford that analyzes genomes and regulatory networks, employs a question-and-answer format and concise prose in his book to help readers grasp relevant terminology and access consumer-oriented genomics technologies and resources.

Written by Erik Chaulk



IN MEMORIAM
Robert J. Suhadolnik (1925 – 2016)


SUHADOLNIK

Robert J. Suhadolnik, professor emeritus of biochemistry at Temple University, passed away in January. He was 90. Known for his research and two books on the biosynthesis of nucleoside antibiotics, Suhadolnik helped advance the study of HIV and chronic fatigue syndrome.

Suhadolnik was born in 1925 in Forrest City, N.Y. A decorated World War II veteran, he received his bachelor's degree from Pennsylvania State University, a master's from Iowa State University and a Ph.D. from Pennsylvania State University. He completed his postdoctoral studies at the University of Illinois.

Suhadolnik was the director of the department of bio-organic chemistry at Albert Einstein Medical Center in Philadelphia from 1961 to 1974 before joining the faculty at Temple University. In addition to his dedication to teaching and research, Suhadolnik faithfully served as director of Temple's biochemistry graduate program for nearly 30 years.

Suhadolnik's research at Albert Einstein Medical Center centered on the biosynthesis of nucleoside antibiotics. He authored two books that are still considered to be the definitive publications in this area of research. Since the 1980s, Suhadolnik's research had focused on the interferon-associated 2-5A synthetase/RNase L and p68 kinase pathways, part of the antiviral defense mechanism in mammalian cells. Work from his laboratory demonstrated the potential of novel 2-5A agonists to enhance host-cell innate and acquired immune defense mechanisms against HIV infection. Suhadolnik discovered a novel low-molecular-weight form of 2-5A dependent RNase L in blood cells from patients with chronic fatigue syndrome, or CFS. He held a patent for a CFS diagnostic test that was licensed through Temple University to RED Laboratories of Belgium.

Suhadolnik maintained continuous research funding from the National Science Foundation and the National Institutes of Health from 1961 until his retirement in 2001. In 1990, he was honored by Temple University with its Outstanding Researcher Award.

Suhadolnik and his colleague of more than 30 years, Wolfgang Pfleiderer at Konstanz University in Germany, are co-inventors of 25 U.S. and international patents. A thesis adviser to 22 Ph.D. students and mentor to 26 postdoctoral fellows, Suhadolnik was vibrant and genuinely warm and caring. He was passionate about basic research, had an insatiable thirst for knowledge, and remained active in science until the time of his death. He leaves behind a wife and three children.

Written by Paul W. Doetsch

Upcoming ASBMB events and deadlines

APR **Apr. 28:** ASBMB Hill Day, Washington, D.C.

MAY **May 16:** Application deadline for the Marion B. Sewer Distinguished Scholarship for Undergraduates

JULY **July 14 – 16:** ASBMB Grant Writing Workshop, Washington, D.C.

AUG **Aug. 1:** Abstract and registration deadline for the ASBMB Transcriptional Regulation by Chromatin and RNA Polymerase II symposium

OCT **Oct. 6 – 9:** ASBMB Special Symposia: Transcriptional Regulation by Chromatin and RNA Polymerase II, Snowbird, Utah

ASBMB
American Society for Biochemistry and Molecular Biology

Chronic fatty liver disease

By Donald B. Jump

Nonalcoholic fatty liver disease, or NAFLD, and its progressive form, nonalcoholic steatohepatitis, or NASH, have emerged as significant public health concerns in Western societies. NAFLD is a continuum of chronic fatty liver diseases ranging from benign hepatic steatosis to NASH, which consists of fatty liver with inflammation and injury. NASH can progress to severe fibrosis or cirrhosis, and primary hepatocellular cancer, or HCC (1). The increase in NAFLD in adults and children over the last 20 years parallels the obesity epidemic in Western societies. Factors contributing to the increased incidence of NAFLD include a sedentary lifestyle and poor diet of fat, simple sugar and cholesterol.

Since there are no U.S. Food and Drug Administration-approved drugs for NASH treatment, current therapies rely on lifestyle modification and treatment of the comorbidities associated with NAFLD, including obesity, hyperglycemia, dyslipidemia, hypertension and type 2 diabetes. Several clinical studies have evaluated omega-3 fatty acids in NAFLD therapy (2), because omega-3 fatty acids have been reported to augment fatty-acid oxidation and triglyceride catabolism and suppress fatty-acid synthesis, inflammation and blood levels of triglycerides. Moreover, humans and mice with NAFLD have low hepatic omega-3 and omega-6 polyunsaturated fatty acid, or PUFA content, when compared with healthy individuals (3, 4).

Most clinical studies use a mix of eicosapentaenoic acid (20:5 EPA) and docosahexaenoic acid (22:6 DHA)

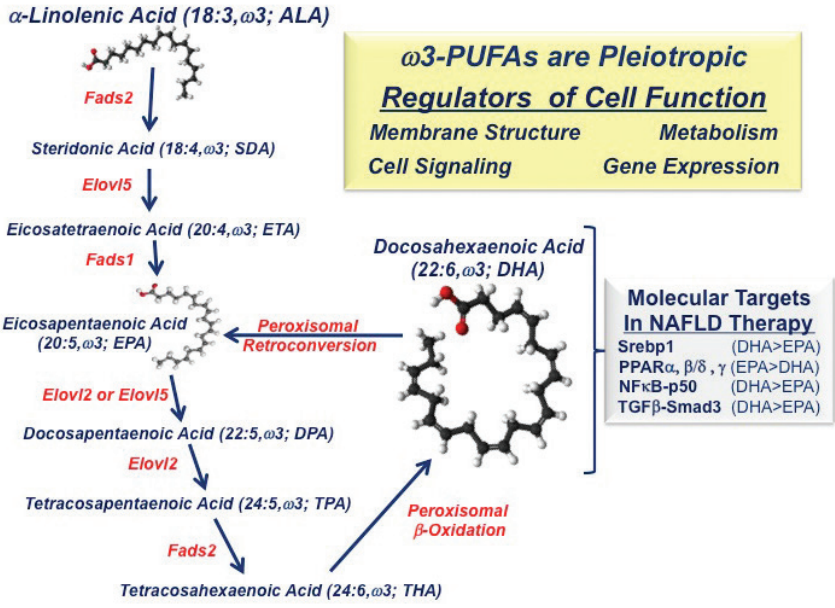


IMAGE COURTESY OF DONALD B. JUMP

and report that these dietary lipids lower liver fat but do not reduce liver fibrosis (5), a risk factor for cirrhosis and HCC. In contrast, NAFLD patients consuming EPA have no reduction in hepatic fat or fibrosis (6). Studies of mice with NASH that lack the low-density lipoprotein receptor, or LDLR $^{-/-}$ have shown that DHA, but not EPA, reduces Western diet-induced fatty liver, inflammation and fibrosis (3, 7).

The differential action of C_{20-22} omega-3 fatty acids on clinical outcomes can be explained, at least in part, by effects on fatty-acid metabolism and differences in the molecular actions of EPA versus DHA. DHA and EPA inhibit fatty-acid synthesis by suppressing the nuclear abundance of sterol regulatory element binding protein-1, a transcription factor controlling the expression of enzymes involved in de novo lipogenesis and PUFA synthesis. As such, humans and mice consuming EPA alone show no significant increase in blood or hepatic DHA content (3, 8). DHA consumption, however, increases blood and hepatic DHA, EPA and the long-chain n-3 fatty acid docosapentaenoic acid, or DPA. EPA and DPA increase through retroconversion (3).

Dietary DHA, but not EPA, attenuates Western diet-induced nuclear accumulation of transcription factors involved in inflammation, such as NF-kappa B, and fibrosis, such as phospho-Smad3. While NF-kappa B controls the expression of multiple inflammatory factors, including Cox2, chemokines and cytokines, phospho-Smad3 is a downstream mediator of TGF-beta signaling. TGF-beta is a major regulator of hepatic stellate cell function and fibrosis (7). The impact of DHA on mouse liver fibrosis is

CONTINUED ON PAGE 8

An epigenetic signature across five tumor types

By Aditi Dubey

Researchers at the National Institutes of Health's National Human Genome Research Institute have identified an epigenetic signature in tumor DNA that occurs in five different types of cancer. The signature has the potential to be a biomarker that could lead to a blood test for detecting cancer in early stages, when therapies are most effective.

The epigenetic modification is the methylation of DNA at a cytosine base. In a recent study published in the Journal of Molecular Diagnostics, the NHGRI researchers showed that recurrent, aberrant methylation of DNA at ZNF154 CpG island can alter the expression of the gene containing the modification like a dimmer on a light switch.

"Finding the methylation signature was an incredibly arduous and valuable process," said NHGRI Scientific Director Dan Kastner in an NIH press release.

The study was led by Laura Elnitski, a computational biologist in the Division of Intramural Research at NHGRI. Elnitski's team was able to uncover the methylation mark in colon, lung, breast, stomach and endometrial cancers and they think the signature could exist in many more types of the disease.

Her group first discovered hypermethylation of the CpG island near human ZNF154 in 2013 by using arrays that detected methylation levels at select CpG sites. They found hypermethylation in 15 tumor types in 13 different organs, suggesting that this modification could be a universal cancer biomarker.

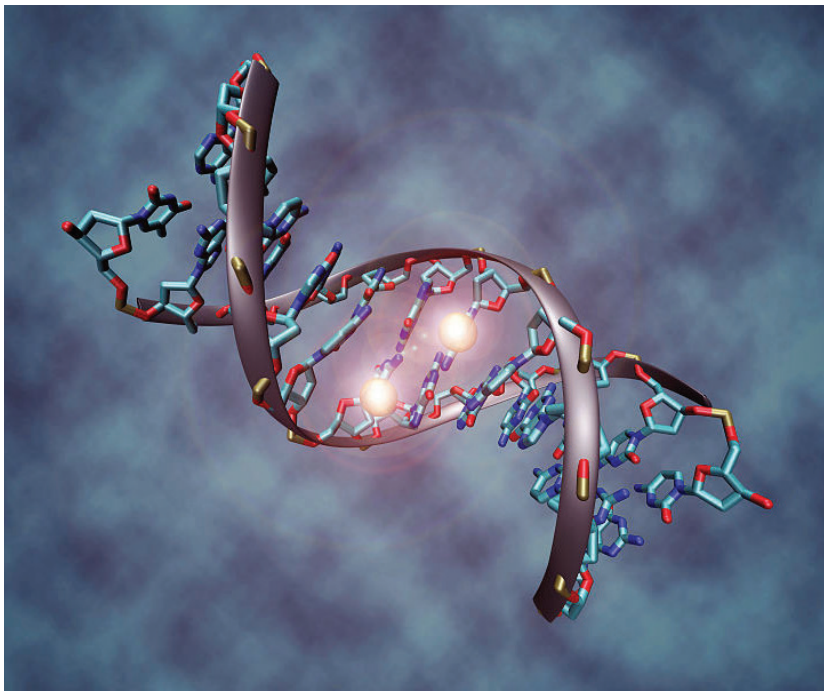


IMAGE COURTESY OF WIKIMEDIA USER CHRISTOPH BOCK

A DNA molecule is methylated on both strands on the center cytosine.

"No one in my group slept the night after that discovery," says Elnitski in the press release. "We were so excited when we found this candidate biomarker. It's the first of its kind to apply to so many types of cancer."

A main challenge of cancer treatment has been the small number of reliable technologies that can detect the disease in early stages. By the time a tumor is visible on a scan, it often is advanced. But detection techniques that rely on next-generation sequencing, to find genomic signatures that distinguish cancer cells from normal cells have shown promise. The sequence reads are used to detect specific changes in DNA and infer patterns from a vast range of samples. These reads allow for early and consistent detection of mutations or modifications that are characteristic of cancer cells. For their diagnostic application, Elnitski's group did not focus on next-generation sequencing of samples recovered from tumor biopsies, but on other sources of tumor DNA that potentially can be detected before the tumor can be seen on a scan.

Other sources of tumor DNA come from cell-free tumor DNA, which can be found in venous blood, buccal epithelium, saliva, urine, stools and bronchial aspirates. Venous blood also

CONTINUED ON PAGE 8

LIPID NEWS CONTINUED

CONTINUED FROM PAGE 6

extensive, affecting the expression of TGF-beta receptors, factors regulating TGF-beta signaling, collagen subtypes, and enzymes involved in protein crosslinking and extracellular matrix remodeling.

Together, these studies establish that DHA controls several transcriptional regulatory networks relevant to NAFLD. There remain, however, several unanswered questions. Chief among these is determining why the mix of EPA and DHA fails to affect hepatic fibrosis in humans significantly. It will require more investigation to understand how omega-3 PUFA control pathways linked to chronic fatty liver disease.

REFERENCES

1. Jump, D. B. *et al. Adv. Nutr.* **6**, 694–702 (2015).
2. Parker, H. M. *et al. J. Hepatol.* **56**, 944–951 (2012).
3. Depner, C. M. *et al. Plos. One* **8** (12), e83756 (2013).
4. Arendt, B. M. *et al. Hepatology* **61**, 1565–1578 (2015).
5. Scorletti, E. *et al. Hepatology* **60**, 1211–1221 (2014).
6. Sanyal, A. J. *et al. Gastroenterology* **147**, 377–384 (2014).
7. Lytle, K. A. *et al. J. Lipid. Res.* **56**, 1936–1946 (2015).
8. Itakura, H., M. *et al. J. Atheroscler. Thromb.* **18**, 99–107 (2011).

Donald B. Jump (Donald.Jump@oregonstate.edu) is a professor in the School of Biological and Population Health Sciences and a Principal Investigator in the Linus Pauling Institute at Oregon State University.

NIH UPDATE CONTINUED

CONTINUED FROM PAGE 7

can contain circulating tumor cells, another source of DNA. Although ciruculating tumor cells were not used in this study, both circulating cells and cell-free tumor DNA are sources from which DNA can be tested for common mutations and, as done in this study, genomic signatures such as hypermethylation of certain DNA segments.

Instead of scanning a large number of sites for modifications, the team used a more refined and cost-effective method to analyze cytosine methylation in CpG island modification. Elnitski and her team used polymerase chain reaction to identify modified versus unmodified cytosines from the DNA of healthy individuals and cancer patients in a high-throughput and easily quantifiable fashion. According to the journal article, this method provided greater resolution of the target area than in the 2013 study and showed patterns of DNA methylation in tumors that previously were unknown.

"Finding a distinctive methylation-based signature is like looking for a spruce tree in a pine forest," Elnitski said. "It's a technical challenge to identify."

Elnitski and her team took on the challenge by developing computational tools that can characterize the methylated bases and by using computational simulation to show how these modification signatures can be used reliably to identify cancer. It was these techniques that helped the researchers find consistent elevation of ZNF154 CpG island methylation across the five different tumor types.

All the information to detect this specific CpG methylation signature can be gathered from a small amount of DNA, about the same amount contained in a basic blood sample. The next step is honing the methodology and developing a simple blood test that can be used in clinics for rapid and early cancer screening.

Aditi Dubey (dubeyad@nyu.edu) is a postdoctoral associate at New York University studying mechanisms of placode development in Xenopus.

The unique biology of GPI anchors

By Bree Yanagisawa

Glycosylphosphatidylinositol-anchored proteins, or GPI-APs, are an important class of cell-surface protein. GPI-APs are essential for several normal processes, including development and immune function and, according to Taroh Kinoshita of Osaka University in Japan, "are used ubiquitously by eukaryotes to attach proteins to the outer leaflet of the plasma membrane."

Kinoshita is the coordinator of a new thematic review series published in the **Journal of Lipid Research** that brings together recent findings regarding GPI anchors and their associated proteins.

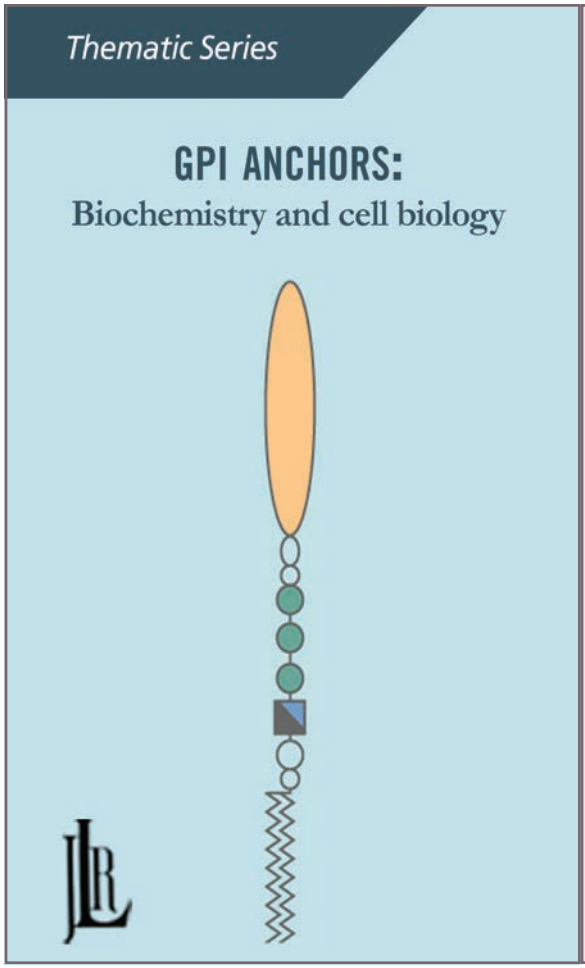
The series of four reviews asks important questions about GPI-APs. How are they made? How are they transported and organized at the cell's surface? What happens when they are released?

Findings presented in the JLR series challenge the current view that the cell's surface is a dynamic layer that only minimally restricts the free movement of molecules. The studies suggest a more complex relationship between the cell surface and the underlying structural skeleton in which the skeleton imposes a more orderly distribution of molecules at the cell surface.

Kinoshita notes that the series should help change the current perspective on molecular distribution at the cell surface — a remarkable shift.

An introduction from Kinoshita and the four reviews that make up the series "Glycosylphosphatidylinositol (GPI) Anchors: Biochemistry and Cell Biology" are currently available in the JLR.

Bree Yanagisawa (breannwoelfel@gmail.com) is a science writing intern at ASBMB Today and a Ph.D. candidate in pathobiology at Johns Hopkins School of Medicine.



Biosynthesis of GPI-anchored proteins: special emphasis on GPI lipid remodeling
Taroh Kinoshita, Osaka University, Japan
Morihisa Fujita, Jiangnan University, China

Trafficking of glycosylphosphatidylinositol-anchored proteins from the endoplasmic reticulum to the cell surface
Manuel Muñiz, University of Seville, Spain
Howard Riezman, University of Geneva, Switzerland

GPI-anchored protein organization and dynamics at the cell surface
Suvrajit Saha, Anupama Ambika Anilkumar and Satyajit Mayor, National Centre of Biological Sciences, India

GPI-AP release in cellular, developmental and reproductive biology
Yoshitaka Fujihara and Masahito Ikawa, Osaka University, Japan

Probing beneath the surface

Discovering O-GlcNAc on intracellular proteins

By Alexandra Taylor

In the early 1980s, when first-year graduate student Carmen-Rosa Torres brought Gerald Hart the first evidence of O-linked N-acetylglucosamine, or O-GlcNAc, he was sure the data were wrong. Only after making Torres repeat the experiments for a year and jumping into the lab himself was Hart finally convinced. Torres and Hart's discovery of O-GlcNAc was published in 1984 in the **Journal of Biological Chemistry.**

O-GlcNAc is an oligosaccharide bound to a hydroxyl moiety on a serine or threonine residue of a protein. It's formed when the enzyme O-GlcNAc transferase transfers a GlcNAc moiety from UDP-GlcNAc to a specific amino acid residue, a process known as O-GlcNAcylation.

In 2014, Gerald Hart, an associate editor for the Journal of Biological Chemistry, organized a thematic minireview series on O-GlcNAcylation.

In the 1980s, scientists were confident that all glycosylated proteins either were transported outside of the cell or were confined to intracellular compartments after processing. The 1986 JBC paper that came out of Hart's laboratory at the Johns Hopkins University School of Medicine laid out the first proof of O-GlcNAc in the cytosol and nucleus (1). The discovery described in the paper, now recognized as a JBC Classic, violated the reigning dogma of the time. Even within the glycobiology community, it was hard to accept the idea that glycoproteins would be functioning inside the cell.

"Frankly, it was controversial enough that when we presented the findings at conferences, I had people basically saying to my face that they didn't believe the results," says Gordon Holt, the chief science officer at NorthShore Bio, who was a graduate student in Hart's lab and a co-author on the 1986 paper. (Torres was working on another project at that time.)

O-GlcNAc is found on many different proteins throughout the cell. Its function varies dependent upon the protein to which protein it is attached. Much like phosphorylation, one known purpose of O-GlcNAc is to control signaling in response to nutrients. Holt, who is now describes O-GlcNAc as an orthogonal method of regulating the same proteins: "It's like a rivet: If there's a carbohydrate at a phosphorylation site, then that phosphorylation site is no longer regulated by classical phosphorylation pathways. Instead, it becomes regulated by the O-GlcNAc regulatory pathways."

Methods for studying phosphorylation have advanced rapidly in recent years, thanks in part to the existence of site-specific antibodies, while methods for studying O-GlcNAc continue to lag behind. Researchers only recently have begun to recognize the importance of O-GlcNAc to chronic diseases. Prolonged elevation of O-GlcNAc, as in hyperglycemia, can cause transcriptional processes to go haywire.

"It's something that we have to understand mechanistically very carefully, because it is essential for understanding lots of the intracellular signaling pathways and the way the cell can function when glucose goes up or down," says glycobiologist Vincent Hascall at the Cleveland Clinic.

Hart says a lot of the deleterious effects of diabetes are caused by elevated O-GlcNAc, and that "O-GlcNAc has also been elevated in every cancer type that's been examined to date." Low levels of O-GlcNAcylation in the brain also have been linked to Alzheimer's disease. Several drug companies are developing treatments that inhibit O-GlcNAc hydrolase,

the enzyme governing O-GlcNAc removal.

In their 1986 experiment, Hart and Holt used highly purified fractions of cells to pinpoint where the bulk of O-GlcNAc modification was located. Hart remembers sitting Holt down to break the news that preparation for the experiment would take him close to a year. Holt listened and nodded and then grabbed an ice bucket and went around to different labs at Johns Hopkins, collecting all the organelle samples needed — what Holt calls his "cup of sugar in the form of organelles" — from some of the leading experts in organelle purification. The preparation was completed in just a few days. "It was pretty amazing," says Hart. "He had a graduate student network. They know what's going on in the place way better than the faculty do."

Faculty members and students teased Holt for taking a shortcut. "It occurred to me, in retrospect, that the ice-bucket strategy was the path of least resistance, but it was also critically important, because it got us unquestionably pure organelles," says Holt. "Our results needed to be taken seriously as a result."

After obtaining the samples, they attached radioactive sugar residues to galactosyltransferase, an enzyme purified from cow's milk. They used radioactive tags to identify which proteins the enzyme attached to in each organelle.

"The prevailing opinion was that intracellular cytosolic proteins were not glycoproteins," says Hascall. "They showed in this paper, which opened up a whole new field, that that was not true. There is, in fact, a very specific glycosylation on a number of intracellular proteins."

"It's not very often in your career that you run across something completely novel and totally unexpected," says Hart. "When you do, you should probably follow your data."

This article originally was published in the Journal of Biological Chemistry.

Alexandra Taylor is a master's candidate in science and medical writing at Johns Hopkins University.

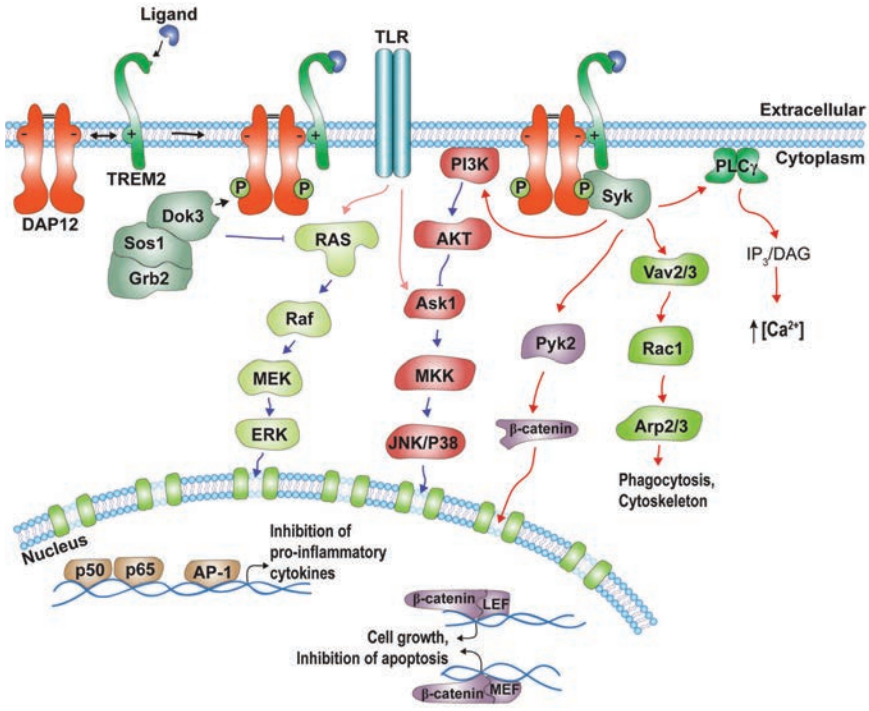
REFERENCES

1. Holt, G.D., and G. W. Hart, *J. Biol. Chem.* **261**:8049–8057 (1986).

TREM2 defects linked to neurodegeneration

By Christine C. Lee

Immunological responses are in place to help defend our bodies from infection. When those responses are out of balance, the risk of disease goes up. Imbalances in neuronal immunity, for example, are strongly associated with neurodegenerative diseases. In a recent minireview published in the **Journal of Biological Chemistry,** Jochen Walter at the University of Bonn in Germany explores current research examining the triggering receptor expressed on myeloid cells, or TREM2, which plays a key role in regulating intracellular signaling pathways and is expressed in cells that contribute to innate immunity. The review discusses defects in the expression and activity of TREM2 and its co-receptor, DNAX-activating protein of 12 kDa, or DAP12, which are linked to neurodegenerative diseases and dementia.



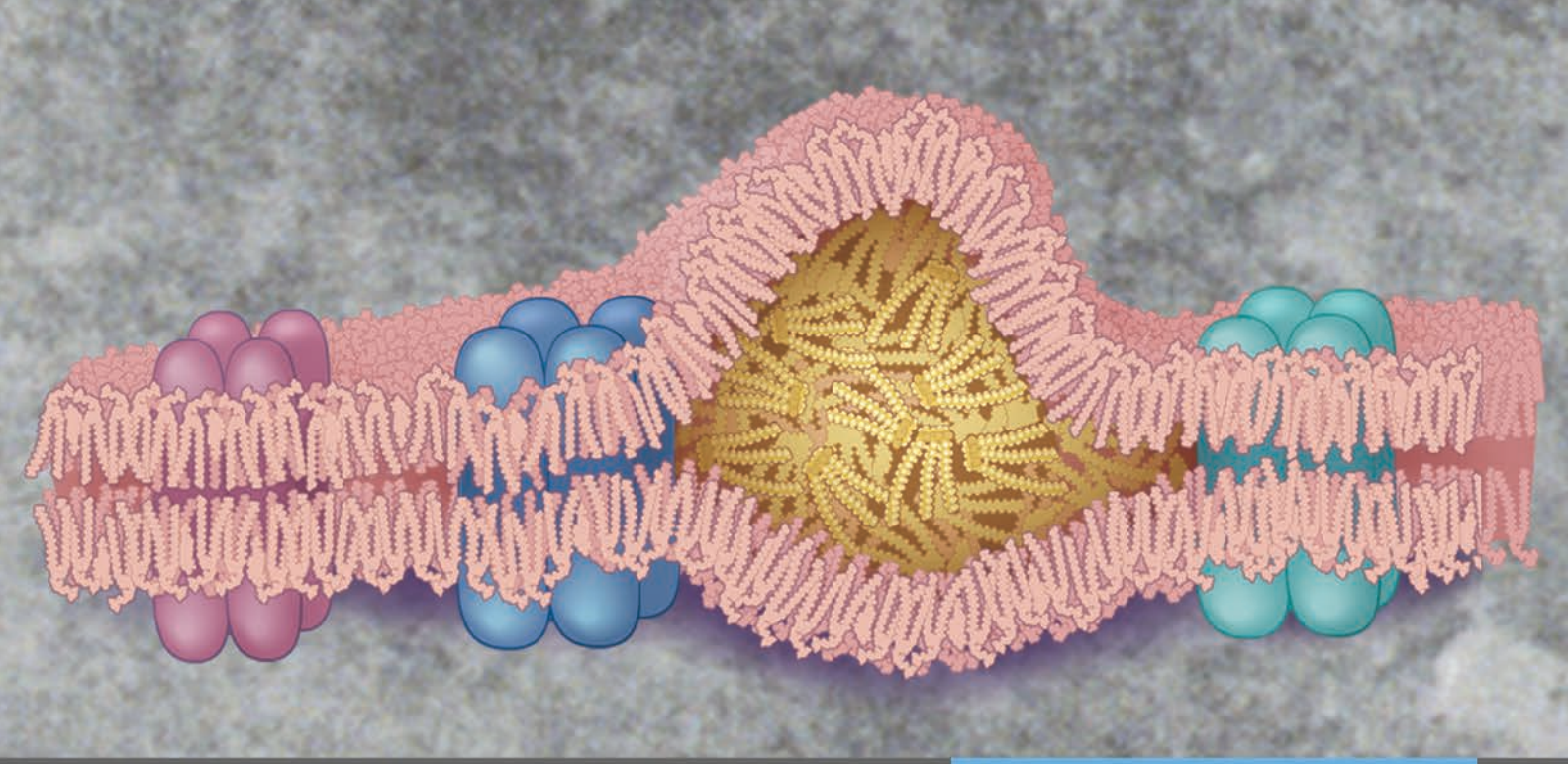
TREM2-DAP12 dependent intracellular signaling pathways. Ligand binding and electrostatic interactions with DAP12 activates TREM2. TREM2 activation results in phosphorylation-dependent recruitment of signaling proteins that regulate a variety of downstream effectors, including gene transcription of inhibitors of pro-inflammatory cytokines. In addition, TREM2-DAP12 regulation of PI3K and RAS allows cross-talk with Toll-like Receptor (TLR) signaling pathways.

The inflammatory response in the brain is maintained in part by microglia, brain phagocytes that scan and detect irregular pathogens or molecular patterns. Upon activation, microglia help to stimulate the generation of an immune response. However, chronic stimulation of the neuronal immune response has been observed in pathologies in the brain and frontotemporal diseases. Defects in TREM2 expression and regulation in microglia affect the innate immune response and may contribute to neuronal diseases.

TREM 2 and its co-receptor, DAP12, regulate signaling at the cell surface and are expressed in dendritic cells, osteoclasts and microglia. In the review, Walter focuses on specific mutations in TREM2 or DAP12 in relation to Nasu–Hakola disease, a rare, inherited disease which presents with bone fractures and early onset dementia, and he looks at the potential role of TREM2 in the pathogenesis of Alzheimer's disease. Key hallmarks of the disease are the accumulation of amyloid-beta plaques and aggregation of the microtubule-associated protein tau. Walter highlights the genetic studies on amyloid-beta and tau accumulation in addition to studies of the most common risk factor for late-onset Alzheimer's disease, the epsilon 4 allele of apolipoprotein E, or ApoE. According to Walter, in vitro studies show that ApoE is a ligand for TREM2, and other studies link TREM2 with amyloid-beta plaques and tau aggregation, further implicating the receptor in Alzheimer's disease.

This review also highlights work with genetic knockout mice and knockdown studies of TREM2, which show increased levels of neuronal inflammation and associated risks for neuropathologies. Furthermore, genetic analyses of patients reveal that a single point mutation in TREM2 is associated with an increased risk for late-onset Alzheimer's. While this point mutation is rare, Walter discusses additional studies implicating TREM2 in neurogenerative diseases and suggests that mechanistic studies examining the role of TREM2 are critical for future diagnosis and treatment of these diseases.

Christine C. Lee (clee217@jhu.edu) is a doctoral candidate in the department of biochemistry and molecular biology at the Johns Hopkins Bloomberg School of Public Health.



www.jlr.org

Journal of LIPID RESEARCH

Special Collections:
Thematic Review Series

Lipoprotein (a): coming of age, at last

Glycosylphosphatidylinositol anchors: biochemistry and cell biology

Phospholipases: central role in lipid signaling and disease

Intestinal lipid metabolism

Calorie restriction and ketogenic diets

Recent advances in the treatment of lysosomal storage diseases

Lysophospholipids and their receptors

*Visit **www.jlr.org/site/collections** to learn more.*

ASBMB
American Society for Biochemistry and Molecular Biology

Devoted to DNA

Fyodor Urnov of Sangamo Biosciences has built a career as a genome editor and a teacher of genetics

By Rajendrani Mukhopadhyay

It was day two of the three-day International Summit on Human Gene Editing in Washington, D.C. The morning panel discussions, with titles like "Applications of gene editing technology: basic research" and "Applications of gene editing technology: somatic cell therapy" were a long wade through the genetics and molecular and cell biology of gene-editing technologies. The National Academies lecture hall was dark and cavernous, and the steady flashing of PowerPoint slides was edging toward numbing.

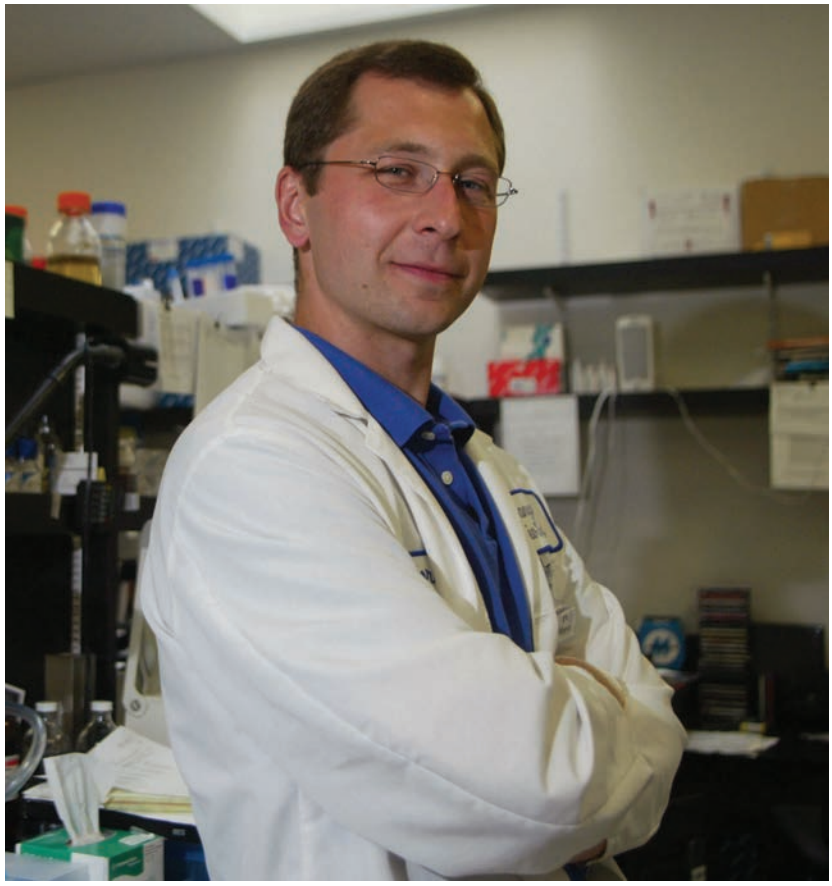


IMAGE COURTESY OF FYODOR URNOV

Fyodor Urnov at Sangamo BioSciences is one of the world's experts in exploiting zinc finger nucleases for gene editing applications. He is also an adjunct faculty member at the University of California, Berkeley.

Then Fyodor Urnov of Sangamo BioSciences got up to speak. In a strong, clear voice, flecked with Russian and British accents, Urnov dissipated the torpor hovering over the lecture hall as he told a story about the biology of inherited blood disorders and how gene editing could be used to tackle them.

Urnov's ability to grab audiences goes back to his graduate school days. Recalling Urnov's presentation at a Cold Spring Harbor meeting in the late 1990s, Jasper Rine at the University of California, Berkeley, says, "Fyodor's delivery was so articulate, passionate and scientifically interesting that I was just captivated through the entire thing."

Even on the phone with me, Urnov spoke with a storyteller's ear, peppering the conversations with references as disparate as Henry David Thoreau and "The Martian." The man loves to tell a good tale and share what he knows. It doesn't come as a surprise to find out that in his spare time Urnov teaches undergraduate courses in general biology, biochemistry and genetics at Berkeley.

As a scientist, Urnov has had one molecule in his sights: DNA. His obsession with the molecule stems from James Watson's book "The Double Helix." Like many of Urnov's generation of molecular biologists, reading the book as a preteen led him to decide to dedicate his life to DNA.

Urnov says he now recognizes the

book's flaws, but at the time he had concluded that "DNA is the only thing worth devoting one's life to." He adds, "I just can't really explain why I felt that except that this book lit that fire in me."

When Urnov began his independent research career at Sangamo in 2000, he delved into understanding how complicated genomes, whether of plants or of humans, can lend themselves to sophisticated tinkering. Along with a Sangamo colleague, Michael Holmes, he coined the phrase "genome editing." In 2014, Thomson Reuters listed Urnov in its compilation of "The World's Most Influential Scientific Minds." He was one of the few scientists in industry to make the list.

Back in the USSR

Urnov grew up in Soviet-era Russia in a family of academics that believed in the power of words. His mother is a linguist. His father is a literary critic and a writer. Urnov lived in Moscow, "10 minutes away from the Bolshoi ballet and 10 minutes away from the Moscow Conservatory," which made him fluent in analogies to Western classical music, although his true musical passion is the Beatles. ("He is a walking encyclopedia of the entire Beatles catalog," notes Rine.)

His father brought in a steady stream of books. "Books are his trade," says Urnov. "At all stages of my life, he made sure there were plenty of books for me to read."

On Urnov's 12th birthday, his father gave him "The Double Helix." Urnov read it as an "incredibly exhilarating narrative of the thrill of scientific discovery," he says.

For the same birthday, an aunt gifted him a microscope. Urnov immediately used it to examine the antennae of a crawling insect he caught on the dining table. He was awestruck by the ridges he saw on the tiny antennae. "It was a bolt-of-lightning moment of how extraordinary life is when you look at it closely," he says.

With those two gifts, his calling to biology coalesced. Urnov says he was very fortunate to attend Moscow State University for his undergraduate degree in biology, learning the fundamentals of botany and zoology, which later came in handy as he worked on different animals and plants over the course of his research.

His other good fortune was timing. "(Mikhail) Gorbachev came into power and then (Boris) Yelstin came into power and dissolved the Soviet Union," says Urnov. "The Iron Curtain fell."

Once it did, the United States, with its biomedical research enterprise, beckoned. "So I applied to graduate schools in the States and went to Brown (University), bright-eyed and bushy-tailed," he says.

Urnov joined the laboratory of Susan Gerbi, where he began to make his mark as a researcher, teacher and public speaker. Gerbi, who is unabashedly proud of her protégé, says that Urnov excelled during his research to identify locations for DNA amplification initiation in the chromosomes of a fly called Sciara: "He was a model graduate student in terms of looking up the literature about methods that he was employing and seeking out advice from other faculty in the department who were using that methodology," she says, adding that Urnov won a prize for his work in molecular biology when he graduated.

Gerbi also watched an aptitude for teaching emerge in Urnov. Every Brown graduate student does a year of assistant teaching. Urnov helped with a cell biology course Gerbi co-taught with Kenneth Miller.

Urnov "is dynamite in a classroom," says Gerbi. "The students, in their course evaluations wrote that he should be given tenure as a graduate TA and kept at Brown forever! They

CONTINUED ON PAGE 16

CONTINUED FROM PAGE 15

thought he was so fabulous." Upon graduation, Urnov received a presidential award for his teaching from Brown.

Also in graduate school, Urnov displayed a knack for keeping the soporific effects of scientific presentations at bay. Gerbi still remembers a Cold Spring Harbor meeting where Urnov was scheduled to give a talk during the unfortunate 10:30 p.m. slot. As the evening wore on, "people were starting to doze off," recalls Gerbi. But when Urnov got up to speak, "everybody woke up and got so turned on by his talk."

She says the speaker who followed Urnov got up and said, "Who am I to try and sing after the great Caruso has just performed an aria?"

Targeting specific genes

After getting his Ph.D. in the late 1990s, Urnov moved down the East Coast to Bethesda, Md., to join the laboratory of Alan Wolffe at the National Institutes of Health as a postdoctoral fellow. There, he continued to work with DNA, this time in the form of chromatin and nuclear hormone receptors in frog cells.

But his postdoctoral stint at the NIH was short. Sangamo recruited Wolffe to be its chief scientific officer, so Urnov moved with him to the company's headquarters in the San Francisco Bay area in 2000. (In 2001, Wolffe died from injuries sustained in a traffic accident while attending a meeting in Rio de Janeiro.)

Urnov's first task at Sangamo was to see if there was a means to edit DNA in a specific, targeted way and not rely on the standard method of the time, which was random integration of genes based on homologous recombination and a healthy dose of luck.

In a 2005 Nature paper, the Sangamo team, led by Holmes and Urnov, described how special zinc finger nucleases engineered to recognize a specific position could correct mutated genes in human cells. As proof of concept, they corrected the gene for severe combined immune deficiency in cultured human cells with an efficiency that would pass muster for clinical applications. Researchers took note. "My inbox started to fill up with requests for collaboration," says Urnov.

One request for collaboration came from the agriculture company Dow Agrosciences. About "90 percent of cotton, soybean and corn grown in North America is genetically engineered. But genetic engineering, since its invention in the 1970s, has relied on the random integration of external genetic material," says Urnov. "It's time-consuming and labor-intensive. It takes 10 years to go from wanting to have a corn plant that carries a desired gene to when you can commercialize that plant."

Dow Agrosciences wanted to see if engineered zinc finger nucleases could speed up genetic engineering. Eventually, the team of Dow and Sangamo scientists showed that it could engineer zinc finger nucleases that gave a two-for-one deal. The nucleases were capable of pushing out an undesirable trait in a plant — such as a gene for a chemical that acted as an environmental pollutant when consumed by livestock — and replacing it with a desirable trait, such as herbicide resistance, in a single shot. The technology worked so well that Dow Agrosciences licensed it from Sangamo.

By this point it was the late 2000s, and the requests for engineered zinc finger nucleases were getting overwhelming. Something had to be done, so Sangamo partnered with Sigma Aldrich, one of the world's largest suppliers of chemical and biological reagents.

The goal was to scale up synthesis of many different types of engineered zinc finger nucleases so that researchers around the world could order them as easily as they would order

oligonucleotides. The project, which consumed a little more than two years of Urnov's life after he finished working on the Dow partnership, resulted in a technology that Sangamo ultimately licensed to Sigma–Aldrich. It's now Sigma–Aldrich's CompoZr brand.

DNA as a druggable target

Urnov's focus now is back on humans, this time on actual patients. In collaboration with Biogen, Sangamo is working out how to treat two blood diseases, beta-thalassemia and sickle-cell disease. In the U.S., the Centers for Disease Control and Prevention estimates that 1,000 people have beta-thalassemia. It is most common among people of Mediterranean descent and also is found in people from Southeast Asia, the Arabian Peninsula, Iran, Africa and Southern China. Currently, the only way to cure someone of the disease is to do a bone marrow transplant.

The CDC estimates that there are 90,000 to 100,000 Americans with sickle-cell disease, which also can be cured only with a bone marrow transplant. But "the public health burden worldwide from these diseases is severe," says Urnov. According to a 2006 report in the journal Bone Marrow Transplantation, blood transfusions and drugs to treat beta-thalassemia in Taiwan, a country that has hundreds of patients, can cost the national healthcare system hundreds of thousands of dollars per patient.

In both of these inherited diseases, the gene for making beta-hemoglobin is disrupted. In beta-thalassemia, there is little or no beta-hemoglobin made; in sickle-cell disease, the mutant beta-hemoglobin causes the erythrocytes to take on an abnormal sickle shape.

So the team at Sangamo and Biogen is tackling the diseases by using genome editing with zinc finger nucleases in certain stem cells taken from patients. The cells are tweaked to make fetal hemoglobin instead, and they are put back into the patients to increase the production of fetal hemoglobin. Making fetal hemoglobin decreases the severity of the disease. Urnov says that the U.S. Food and Drug Administration has given the go-ahead to test the safety, tolerability and potential efficacy of another approach of using zinc finger nucleases to treat adults with a form of hemophilia.

IMAGE COURTESY OF MARIA JASIN AT MEMORIAL SLOAN KETTERING CANCER CENTER

Urnov at Cold Spring Harbor Laboratory in front of the blender used by Alfred Hershey and Martha Chase in a series of experiments conducted in 1952 that helped to confirm DNA as the genetic material.

Urnov marvels at how quickly the fundamental research into the biology of these diseases has made its way into the clinic. He points out that the therapeutic strategy developed by Sangamo and Biogen is based on findings from a genomewide association study done in the late 2000s. "A study dissecting, to a finer resolution, the mechanism of how the genetic circuit plays itself out to protect people from sickle and beta-thal was only published in 2013," he says. "And here we are."

Urnov also drives home the point that gene-editing technologies have changed dramatically the way researchers can approach the development of therapeutic strategies, a point he also emphatically made at the National Academy of Sciences summit in December. "The invention of genome editing expanded the definition of the term 'druggable target.' Once upon a time, classical targets were things like enzymes," says Urnov. "Today we can drug something that's directly in the DNA."

CONTINUED ON PAGE 18

IMAGE COURTESY OF NATIONAL ACADEMY OF SCIENCES

Urnov gave a talk at the International Summit on Human Gene Editing at the National Academies in December.

CONTINUED FROM PAGE 17

'A tremendous sense of drama'

Despite all he does at Sangamo, Urnov has not let go of his passion for teaching. Shortly after Urnov joined Sangamo in 2000, it just so happened that Rine's department at Berkeley had a lecturer bail on a section of an undergraduate biology course. No one on staff could fill the hole. Rine suggested that Urnov be the replacement. "The rest, as they say, is history," says Rine.

Urnov now holds an adjunct faculty position in the molecular and cell biology department. "On top of his more-than-full-time job with Sangamo, he volunteers to put up with the ridiculous driving in the Bay Area and then the even more ridiculous parking near campus, all for the privilege of working hard for us to teach as many as 600 smiling faces at 8 o'clock in the morning," Rine says.

Urnov views teaching as an endeavor from which he stands to gain as much as his students. "In order to teach something, you have to understand it incredibly well," he says. Teaching "infuses me with an appreciation for the grandeur of our discipline and a respect for how much there is to know and how much the little details matter."

Rine, who pairs up with Urnov to teach an undergraduate biology class for nonmajors, says he enjoys watching Urnov teach. "He has a wonderful old-world charm and a beautiful capacity to weave the historical narrative along with the fundamentals of the experiments in a way that provides context in which to understand things," he says. Urnov imparts "a tremendous sense of drama such that while hearing about experiments, you can imagine being in the lab and watching the data appear before your eyes."

Urnov also relishes the challenge of connecting with younger adults. "Nothing beats taking 100 Berkeley undergrads who feel themselves to be slightly jaded and getting them to be excited about Gregor Mendel's or Thomas Hunt Morgan's experiments in the pea and the fruit fly," he says.

Urnov sums up his enthusiasm for teaching and for his work on editing DNA by saying, "It's just intellectually exhilarating."

Rajendrani Mukhopadhyay (rmukhopadhyay@asbmb.org) is the chief science correspondent for ASBMB. Follow her on Twitter at twitter.com/rajmukhop.

Clothed in bacteria

By Martina Efeyini

Bioartist Sonja Bäumel is developing new concepts of clothing inspired by the bacteria that coat human skin. Based in Amsterdam and working across the disciplines of art, design, fashion and biology, Bäumel hopes to create awareness of microbial life and make the fashion world take note of the connectedness and continuity of life forms. She has captured and bred her own bacteria to create a visible bacterial map of the body, and she has knit membranelike coverings that are modeled on the actions of colonies of bacteria, which adaptively respond to climactic factors and the body's thermal requirements.

ALL IMAGES COURTESY OF SONJA BÄUMEL

Bäumel, holding a bacterial map of her body, wants fashion to take note of the connectedness and continuity of life forms.

In her work "Crocheted Membrane," Bäumel created wearable pieces that cover lightly or more heavily based on the needs of a particular body part to be cooled or warmed. She is looking into slime fungi as a kind of coating of clothing — a visible, flexible membrane that could interact with existing skin bacteria and adapt to its climactic surroundings. The fungi could coat every body differently and become an expression of each individual's microbiome. And in her film, "(In) Visible Membrane," Bäumel asked what would happen if clothing could be designed to use skin bacteria's knowledge of heat and modulate itself actively to cover us in cold and shed when we're warm.

Born in Vienna, Austria, Bäumel studied fashion design at the Fashion Institute of Vienna and began exploring the idea of clothing as a literal second skin while working on her master's project in conceptual design in context at the Design Academy Eindhoven in the Netherlands. She ended up interning in a microbiology lab at the Wageningen University in the Netherlands, where she learned to grow and study her own body's bacteria in various environments.

Our conversation with Bäumel has been edited for length and clarity.

How did you get started?

During my master's thesis, I began questioning the fashion system we know today. I wanted to use fashion in a more authentic and meaningful way. I wanted to explore clothing as a second skin and started to look at my work in terms of physiological needs.

What sparked your interest in science and fashion?

I am trying to understand the existing microorganisms living in and on us. During my studies, I was critically reflecting on fashion. I was driven by how clothing or a second skin could look when developed out of one's socio-physical needs and individual beliefs.

What kind of science is involved in your work?

I have been collaborating for the past seven years with microbiologists and molecular biologists, depending on the project's needs.

Can you talk about the different work you did in microbiology labs?

I worked in different labs, and in 2008, at the Wageningen University, I grew my skin's bacteria using agar from 30 different parts of my body. This was aesthetically pleasing to the eye. It was amazing to see my body's bacteria growing independently of my body in a Petri dish.

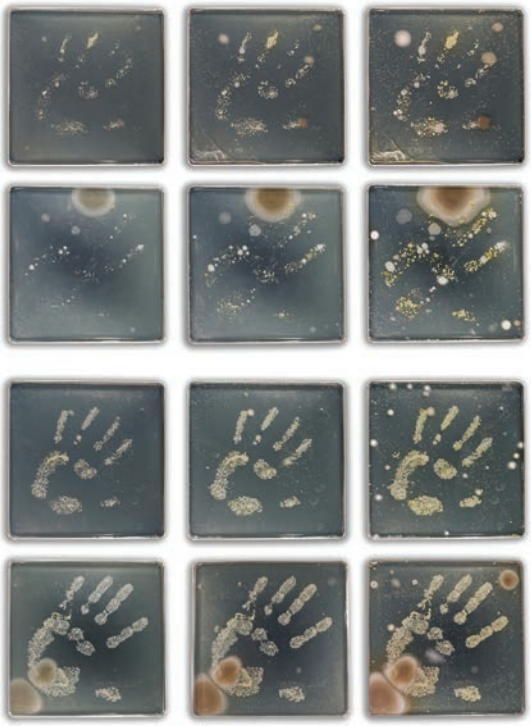
In her work "Crocheted Membrane," Bäumel's wearable pieces reflect the body's true thermal requirements.

In another project, "Cartography of the Human Body," I walked outside on one day in Vienna to cultivate bacteria from my own skin. I (came back inside) then collected the bacteria of my temporary skin flora and grew them first on agar plates. The different morphologies, colors and quantities of bacteria on different body areas were examined, analyzed, counted and documented. The bacteria were bred, partially reanimated and stored at -70 degrees C. In the framework of an interaction study, experiments were made to study the bacteria's hierarchies. Weak bacteria that didn't seem to grow much at all or grew smaller were applied first to guarantee their unhindered growth and to achieve the desired colors on the bacteria's image. The colors emerged naturally from the different bacteria species found on this specific day on the human skin.

Bacteria in fluid culture are invisible. When you let them grow on an agar plate they (become) visible. After applying an invisible bacterial fluid on the body, a body print was made on a textile material that had been provided with nutrients to support the bacteria's growth. As soon as the bacteria visibly grew, their growth was stopped, and the actual state was documented with a body print.

My first synthetic biology-related project was a collaborative work called "Metabodies," which I worked on

CONTINUED ON PAGE 22


Bäumel has grown skin bacteria from 30 different parts of her body.

CONTINUED FROM PAGE 21

during a residency at the Ars Electronica Futurelab/ Biolab in Linz, Austria. Synthetic biology allowed us to obtain and visualize data deriving from the human body. (We focused on) the human skin bacterial species staphylococcus aureus and staphylococcus epidermis. These bacteria are known for performing quorum sensing through a peptide and are visualized by using the bacteria escherichia coli modified with green fluorescent protein.

(With this project) we were also aiming to bring synthetic biology into social spheres, to raise questions and provoke a dialogue with the general public regarding current scientific discoveries.

How did your scientific research influence the crocheted membrane?

The crocheted membrane emerged out of interviews I conduceted with scientists and also out of a microbiology lab internship. The crocheted membrane is not living (and is part of a larger project called the ((In)visible membrane)). To explain my (In)visible membrane work further, I made the (in)visible film (www.sonjabaeumel.at/work/film/invisible).

This film shows the four layers of the (in)visible membrane: already existing skin bacteria, a communication layer, a slime mold and plants, and how theoretically this clothing could transmute into different forms, colors and functions related to environmental changes. Finally, the film shows plants growing from a human skin, and it portrays a human being who is able to breathe underwater — a utopian vision and inspiration.

What did you learn from intersecting fashion and art with science?

One thing I immediately recognized as a creative entering the scientific realm was that scientists focus on their own microcosm. There's a scientist working with skin bacteria, one working with plant bacteria, etc., and they don't really communicate with each other. I think a huge advantage on the creative side is that you somehow recognize relationships more easily and connect them. Scientists are very fruitful collaborators, and these collaborations will work as long as both partners accept each other. Often, I go in and ruffle their world with extremely simple questions that kick them out of their comfort zones. As an independent artist, I can maneuver more easily through what's going on in that environment.

What does the future hold for you?

I recently received funding to start a new project, which kicked off in October. It's going to be an even more interdisciplinary project, as I'll be working with a scientist, a cultural historian and a fellow artist. This artistic research project focuses on current biological discoveries, such as the human microbiome, the related shift from genomics to metagenomics and the evolving perception of what our body is composed of. For the first time in my work, I will be using metagenomics methodologies that will allow me to better analyze and show microbial social interactions.

Martina Efeyini (mefeyini@gmail.com) is a toxicologist and freelance science writer who blogs at MadamemoiselleScientist.wordpress.com. She also writes for the National Society of Black Engineers and ScientistaFoundation.com.

MCP MOLECULAR & CELLULAR PROTEOMICS

ABOUT MCP

Molecular & Cellular Proteomics, a peer-reviewed journal published by the American Society for Biochemistry and Molecular Biology, showcases cutting-edge biological research in areas such as proteomics, metabolomics and bioinformatics.

MCP SPECIAL COLLECTIONS

- Chromatin Biology and Epigenetics
- Neuroproteomics
- Eleventh International Symposium on Mass Spectrometry in the Health and Life Sciences: Molecular and Cellular Proteomics
- Changing the View of Complex Systems: The National Technology Centers for Networks and Pathways

IMAGE COURTESY OF JULIE NEWDOLL

www.mcponline.org

ASBMB

Five reasons to play sports in graduate school

By Robert Frawley

I am a sixth-year graduate student in the physiology, biophysics and systems biology program at Weill Cornell Graduate School. I am also a competitive swimmer and recreational softball, dodgeball, volleyball and inner tube water polo player.

I've been an athlete for most of my life. Not the kind of athlete with name recognition — I wasn't a popular quarterback or a basketball player — but an average, dedicated swimmer all the way through high school and college. When I got to graduate school and the mandatory practices that I'd attended for years evaporated, I found I needed to impose some of the structure and rigor of a sports schedule upon myself. My mind and body just didn't feel right without the daily exercise and focus of sports.

During my time at Cornell, I've observed the habits of many of my fellow graduate students and found consensus among them that engaging in sports can enhance the experience of pursuing a degree in biomedical sciences.

Finding a sport and sticking with it not only is a great way to stay sane during graduate school but it also confers a number of other benefits. The top five of those benefits make my list below.

Sports improve time management and professional development

Sports can help to set our daily rhythms. Whether it's exercise in the morning or a game after work, sports always have framed my days and forced my schedules into place.

Swimming put restraints on my free time in college, and I found myself putting real effort into scheduling my work and working efficiently. Imposing game and practice commitments on myself as an adult in graduate school functions in the same way. Obviously, my research comes first. I will skip a game to conduct an essential experiment. But the threat of missing a sporting event is usually enough for me to work efficiently during the day.

IMAGE COURTESY OF ROBERT FRAWLEY

The writer, top left, with the Isotopes, Weill Cornell Graduate School's championship softball team. The team plays games on summer evenings at Randall's Island near Manhattan.

Sports also make us tired! Some nights it's a huge relief to fall asleep on time instead of listlessly editing a draft or watching Netflix until the early morning hours. This early bedtime makes waking up less painful, so I can get into lab on time the next day.

Sports may have a bigger effect on work routines than just improved time management. In James Shulman and William Bowen's book "The Game of Life," the authors note that those who play a sport on the side typically make more in salary than their nonathletic counterparts. This finding is supported by a 2014 survey sponsored by ESPN-W and the Women Athletes Business Network, which showed that women who participate in sports are more successful. Whether by working better in a team, having mastered time management or just maintaining a certain confidence, it may be that athletes have an edge.

Sports improve mental well-being

We swimmers never were expected to throw or catch much of anything, and, as a whole, swimmers are not famous for their coordination. This meant that to play sports other than swimming I not only had to learn the rules but also to develop new skills from scratch. Honing a new physical skill is a fantastic mental challenge completely different from the work we graduate students do in lab and a great way to shake out the cobwebs and step back from research.

Sports also can be exhilarating and truly improve your spirits. I can vouch for this and always have liked what

I've observed the habits of many of my fellow graduate students and found consensus among them that engaging in sports can enhance the experience of pursuing a degree in biomedical sciences.

public radio host Ilya Marritz of New York's WNYC said about his first time playing football: "Here's the funny thing: I step onto the field all anxious, but the moment we start playing catch all that mental junk just disappears, my mind empties, I only want to play."

That's what I feel every time I step out onto a sports field. Anxiety over paper submissions, troublesome experiments or running out of reagents temporarily melts away.

Science backs this up. The Mayo Clinic notes that exercise improves mood and boosts energy, and playing sports regularly can help combat depression and anxiety. A 2008 paper in the journal Psychology of Sport and Exercise showed that men with severe mental illnesses could restructure their lives through sports.

Sports make time pass more quickly

It is my personal experience that having sports events in your schedule helps break up the humdrum, research-and-lab-meeting routine. It gives contour and relief to your week. You can spend a few days looking forward to a game, and the day or two after reveling in the fun of it. Having one or two big events a week can help graduate students keep their heads above the rushing tides of research science.

Sports improve physical well-being

Any number of sources will tell you that running around is good for you. It increases cardiac strength, improves muscle tone, pumps blood, clears lymph and resets your body. Sports can help aid digestion and relieve migraines, and, at the end of the day, exercise can make you think more clearly. Doctors recommend 30 minutes a day of activity if not more, and schools across the country are fighting to keep recess and mandatory physical education requirements. Exercise is important, and playing games is one of the most social, enjoyable ways to do it. New research even suggests that bouts of aerobic exercise may increase neurogenesis, based on evidence in mouse models.

Sports forge bonds

Finally, sports are social. Having a team to play on is a great way to get to know your fellow students, lab mates and co-workers and a great way to meet new friends, potential collaborators and that postdoc or principal investigator who may someday find you a job.

Playing on a team is a very different social dynamic than sitting in a lab or office, and it creates camaraderie and memories that last. My graduate school is fairly large, and students can get inundated with lab and class work, but I will always remember the classmates who played on my softball team — the Isotopes — every summer, and, sure enough, those are the Ph.D. alumni with whom I have kept in closest touch.

In closing, sports have made graduate school far more bearable and enjoyable for me. I've had numerous peers express their gratitude for the opportunity to play sports and get out of the lab. It doesn't have to be much, but I believe picking one sport to commit to in graduate school gives students just the break they need to withstand the physical, experimental and academic rigor of a Ph.D. program.

Robert Frawley (Robert.frawley.3@gmail.com) is a Ph.D. student at Weill Cornell Graduate School, where he works with faculty at the Hospital for Special Surgery.

Mentoring through transitions

By Laura Furge

I have on my shelf a short book published in 1997 by the National Academy of Sciences titled "Advisor, Teacher, Role Model, Friend." As a professor at a small liberal arts college, I have the opportunity every day to practice fulfilling the first three of these roles as I help young scientists pursue their passions. In the process of advising, teaching and being a role model, I hope over time to earn the reward of friendship.

I am very engaged with my students, but, despite my daily interaction with them, I sometimes forget what a serious responsibility it is to mentor young scientists. That responsibility is especially pressing when it becomes clear that many of my mentees are focused on the next exam or the next swim meet or myriad other activities that consume the time of 18 to 22-year-olds.

At this stage of their careers in science, these young learners are here for a few years and then gone, and, with some notable exceptions, they view their time in college as a process to endure. Most are not keen on establishing lasting relationships with professors and mentors. I imagine that for many professors like me it can be challenging to put all that energy into mentoring hours and not see immediate effects. Fortunately, I recently had an experience that reminded me of the importance and long-term career impact of engaged mentoring for every scientist.

In October 2015, I attended a laboratory reunion and symposium for former scientists who had trained in the laboratory of Fred Guengerich at Vanderbilt University. Guengerich has run a lab for nearly 40 years, and the symposium was conceived and organized by Dan Liebler, one of his first graduate students, who is now a professor and director of his own institute at Vanderbilt. I was a graduate student in the Guengerich lab in the mid '90s.

More than 150 scientists were invited to attend from more than a dozen countries. Around 70 came, at their own expense, representing four different continents and seven different countries and going back more than 35 years! The two-day event included talks from more than 30 attendees. The format had two parts: first a look back at the work you contributed to during your time in the

IMAGE COURTESY OF FRED GUENGERICH

Former students in Fred Guengerich's lab at Vanderbilt gathered for a reunion and symposium. Many thanked their mentor for his guidance during career transistions.

"I was struck in particular by stories from colleagues who had made significant career transitions. They recounted the role their old mentor played — and continues to play — in how they approached often difficult transition decisions."

research lab and then a look at your career and what your passions are now. It became apparent as the talks went on that almost all the speakers had an additional message to impart — the importance of the mentoring received while working in Guengerich's lab. I was struck in particular by stories from colleagues who had made significant career transitions. They recounted the role their mentor played — and continues to play — in how they approached often-difficult transition decisions. Their slides listed mentoring elements such as guidance, support, generosity, collaboration, cooperation, leadership by example, the teaching of critical thinking skills, support in creating connections and much more. It became apparent that, even as much as 35 years later, an early and constant mentor had a lasting impact on the long-term careers of scientists and professionals, many of whom are now themselves well-seasoned and admirable mentors.

As for me, I'm only 45 years old, and I don't know what my next career steps may be, but it is reassuring to know that I have had, and continue to have, a mentor who considers it his responsibility and pleasure to lend an ear and advice. I hope to be that same type of mentor to the many undergraduates I come to know each year.

I came away from the meeting with a sense that, while one can be an adviser, teacher and role model, real friendship is earned through successful mentoring during transitions and over time. Being an engaged mentor takes commitment, deliberate action and willingness to provide the kind of stability that can lower the activation energy for transition states. While this type of personal engagement and long-term commitment may not be for everyone, I returned to my work with a new vigor to be an engaged mentor to my students, knowing that, like Guengerich, I can lower the activation energy for their career transitions and life transformations at age 20 and in every subsequent decade of their lives.

Laura Furge (Laura.Furge@kzoo.edu) is the Roger F. and Harriet G. Varney Professor and Chair in the chemistry department at Kalamazoo College.

Growing pains

By Paris Grey

After new undergrads reach certain benchmarks in the lab, their research supervisors often transition from the role of supervisor to that of a research mentor. Accompanying this change in roles is the growing responsibility of an undergrad to do tasks formerly completed by the research supervisor. This can be disconcerting for the undergrads, who quickly realize their success is now in their own hands. Long ago, one of my undergrads described this path to self-reliance as "growing pains," and it immediately became part of our lab's lingo.

The signs below may seem insignificant as they happen, but they are meaningful stepping stones for any new researcher working toward self-reliance.

You're put in charge of your to-do list

When you arrive at the lab and your mentor says, "Remind me what you're doing today," she probably already knows but wants you to start organizing your lab tasks without her help. This responsibility is often a critical step toward working on an independent research project rather than acting as an assistant to a labmate. Time-management skills in the lab are also essential to master if you plan to attend graduate school, so the more practice you have as an undergrad the better off you'll be.

You're instructed to 'choose whatever works'

I often tell my students that two scientists in a lab lead to three or more potential strategies on how to tackle a research question. In the beginning of your research experience, your mentor will tell you which approach to take. At some point, he will expect you to weigh the options and choose a strategy to follow. You might not pick the right one the first time, but it's important that you don't let that possibility stop you from making a decision and taking the leap.

Your mentor asks you to take the lead in analyzing results

Even though you'll find it frustrating at times and will wish she would just give you the answer, this mentoring tactic will help you build both analytical and creative-thinking skills. It will also help you make a more meaningful connection with your project and the science the lab does. I guarantee that this new role will be nerve-racking and the simplest questions will make your heart pound as you stumble through the answer. But the more practice you have interpreting and explaining results to your mentor, the easier it will become.

You're asked to make the stocks everyone uses

No researcher wants to redo an experiment because a lab stock was made incorrectly, so most won't use one if they question the ability of the person who prepared it. If you're asked to make stocks for your labmates, don't let your nerves get the best of you. Double-check your math, ask for help when needed and take the time to do it right. After you've made a few stocks, the fear of messing up everyone's experiment will fade.

IMAGE COURTESY OF PARIS GREY

Undergrads assuming new responsibilities in the lab, from making stocks to recycling pipette tip boxes, can experience growing pains.

You're asked to train another labmate

In addition to demonstrating solid research skills, being asked to train someone means that you work well with your labmates and are ready to take on a leadership role in the lab. You'll probably feel nervous and self-conscious the first few times you teach someone, but that is to be expected. Not every undergrad in the lab will be asked to step into this role, so it's particularly meaningful if you are asked to do this.

If the path to self-reliance is difficult for you as an undergrad researcher, rest assured that all new challenges will be temporary. With practice and the determination to excel, you'll move past the awkwardness as your research experience becomes more rewarding, and the growing pains will become significantly less painful.

Paris Grey (phgrey@ufl.edu) works as a molecular biologist and is co-creator of Undergrad in the Lab. She is also co-author of the new book "Getting In: The Insider's Guide to Finding the Perfect Undergraduate Research Experience."

Four reasons we don't need 37 names for postdocs

By Gary McDowell

That which we call a postdoc by any other name might smell as sweet, but something smells off about the multitude of categories, titles and classifications that exist for postdocs. According to the National Postdoctoral Association 2014 Institutional Policy Report, the number of names for postdocs across institutions is 37.

Are postdocs "fellows" or "research associates"? Perhaps they are "scholars," or "trainees," or "research fellows," or "postdoctoral associates" or even "postdoctoral scholar employees"?

This situation has arisen because of the invisible nature of postdocs at institutions, a phenomenon that was written about as far back as 1969 in the National Research Council's commissioned report "The Invisible University." For nearly 50 years, postdocs have been slotted into various designations across departments and institutions depending on factors such as tax codes and grant requirements. Despite the long history of the postdoc in biomedical research, the administration of the job and title is dealt with in a piecemeal fashion.

At the American Society for Biochemistry and Molecular Biology's recent Sustainability Summit, attendees were charged with creating actionable items for implementing consensus recommendations for the biomedical enterprise. I co-chaired a working group on the biomedical workforce with Kay Lund, director of the National Institutes of Health's Division of Biomedical Research Workforce Programs. As part of this working group, I directed the subgroup that looked at postdocs in particular. A clear action item identified by the subgroup was consolidating the titles used for postdocs into a single designation at institutions.

Why would a single postdoc designation make a difference?

Data reporting

No one knows how many postdocs there are in the U.S. Estimates range from 40,000 to 80,000, and a major impediment to counting them correctly and establishing true statistical data, including postdoc employment prospects, is the number of titles assigned to them. Having one title at institutions would make reporting of postdoctoral data simpler for institutions and data-collection agencies.

Aligning benefits

Postdocs are often either "trainees" or "employees," depending on whether they are being paid from training fellowships or research grants. This leads to differences in benefits, even within the same lab. Postdocs may decline competitive fellowship offers because moving from employee to trainee status can mean losing benefits such as healthcare coverage from their institutions. Harmonizing benefits regardless of funding source is not only possible — some institutions already do it — but desirable.

CONTINUED ON PAGE 31

Research for all: a CURE for undergraduates

By Joseph Provost

The time that many of today's scientists spent in the lab as undergraduates, and the opportunity they had to experience the frustrations and joys of research alongside senior scientists, likely had a powerful impact on their career choices. The lab apprentice model remains an excellent approach to providing critical mentorship and research experiences for budding scientists. But these days undergraduate demand for research positions far exceeds supply.

A potential solution to this problem has arisen over the past several years in the form of course-based undergraduate research experiences, or CUREs. These classes have increased the number of students involved in original research while reducing the burden on faculty to provide one-on-one experiences for all students.

CUREs can take a variety of forms. They can be semester-long lab classes or contain a lab unit that lasts just a few weeks. However they're designed, all require that for some portion of the course students develop hypotheses, investigate unknown questions and participate in original research.

The influence and integration of CUREs have been growing for years. There are several very successful models and a growing body of scholarly research into the effectiveness of CUREs as a teaching pedagogy.

This fall, the American Society for Biochemistry and Molecular Biology put together a think tank meeting to discuss the state of CUREs in biochemistry and molecular biology. The meeting was a part of the society's National Science Foundation-funded Research Coordination Network-Undergraduate Biology Education grant. J. Ellis Bell, the project's principal investigator, led the meeting.

Participants included scientists who are involved in implementing CUREs at the institutional level; doing discipline-based educational research; or implementing CUREs at community colleges, primarily undergraduate institutions and research-intensive institutions. The participants discussed the following topics.

Definition of a CURE

Several elements are critical to ensuring a CURE provides a real research experience and is distinguishable from other laboratory experiences (1–3).

CUREnet is a network of people and programs creating CUREs. Based at the College of Natural Sciences at the University of Texas at Austin, they define a CURE as:

- The use of scientific practices (asking questions, building hypothesis, designing studies and communicating).
- The discovery of unknown questions, differing from inquiry where the answer is known to the instructor but not the student.
- Work that is broadly relevant or important to a community and could potentially become a research publication.
- Collaboration. Science is not conducted in a vacuum, so CURE students should work collaboratively to reflect the best practices of scientific research.
- Iteration to build upon earlier work and advance questions.

Model CUREs

In addition to those educators who are independently developing CUREs, who are a part of CUREnet, or who are publishing in education journals, several institutions have developed unique means of providing CUREs to large numbers of students. For example, the Howard Hughes Medical Institute has a project called Science Education Alliance Phage Hunters Advancing Genomics and Evolutionary Science, which involves many

institutions and thousands of students. The University of Maryland at College Park also offers CUREs in many different disciplines to first-year students through their First-Year Innovation and Research Experience, or FIRE.

Barriers to broad implementation

The impressive growth and success of these projects have provided a stable and sustainable platform to broaden research access for many students. However, there are significant barriers for faculty and institutions to adopt or participate in CUREs.

One barrier is developing the support network critical to sustaining a CURE. Many biochemistry CUREs operate as silos. Sharing ideas, supporting projects and collaborating on authentic research for CUREs could help reduce the strain of independently adopting and maintaining CUREs.

While several large-scale CUREs for molecular biology and microbiology exist, there aren't enough well-supported, sustainable, protein-centered biochemistry/biophysical CURE projects. There also are not enough entry-level biochemistry and molecular biology CUREs that are adoptable for community colleges and freshman and sophomore classes.

Finally, institutions can feel challenged to implement CUREs because of the demands on time and funding. Some CURE developers have created easily adoptable kits that are available through commercial sources and that provide support to institutions and faculty. For example, A. Malcolm Campbell at Davidson College in Davidson, N. C., and Todd Eckdahl at Missouri Western State University in Saint Joseph, Mo., adapted their synthetic biology CURE into a kit available through Carolina Biological Supply Company.

Research for all

We have strong evidence of the motivational and learning gains made through CUREs. We know that conducting research in the teaching laboratory is much more involved than traditional lab experiences or inquiry labs. But it is also much more fun for the students and for the faculty! When we give CUREs a try, we give more students access to an important tool that can help them feel like true scientists.

REFERENCES

1. Auchincloss, L. C., *et al. CBE — Life Sciences Education* **13**, 29–40 (2014).
2. Spell, Rachelle M., *et al. CBE — Life Sciences Education* **13**, 102–110 (2014).
3. Lopatto, D. *CUR Quart.* **24**, 139–142 (2003).
4. https://curenet.cns.utexas.edu
5. Campbell, M. A. *CBE — Life Sciences Education* **13**, 285–296 (2014).

Joseph Provost is a professor in the chemistry and biochemistry department at the University of San Diego and a member of the ASBMB's Education and Professional Development Committee.

EDUCATION CONTINUED

CONTINUED FROM PAGE 29

This way competitive fellowships are not only awarded to those who can afford to take them.

Tracking their time

Postdocs are supposed to be in temporary training positions, but multiple titles or a change from one designation to another can allow circumvention of institutional policies on term limits or simply allow postdocs to disappear from data collection systems. Consolidating titles allows both tracking of the time periods for postdoctoral training — commonly five years — and monitoring of extension of training in cases where postdocs have taken breaks for health or family reasons. Since postdocs are meant to be temporary trainees and not permanent employees, this will facilitate institutional training practices and make sure they are not providing a cheap alternative to staff scientists.

Salary designation

A consensus recommendation at the summit was raising the salaries of postdocs and having a single designation that enables greater identification of postdoctoral populations. This could help institutions ensure that postdocs are receiving the same salary, which is a crucial first step toward raising the salary nationally.

Inertia is built into human resources policies at institutions, and consolidating postdoctoral titles into one title will require overcoming barriers to this reorganization. The outcome of the meeting was a proposal to develop a protocol for departments, institutions and human resources offices to classify postdocs into a single designation and harmonize benefits and salaries. We plan to work together with institutions who have already taken these steps to develop such a protocol.

Gary McDowell (gary.mcdowell@tufts.edu) is a postdoc at Tufts University and an organizer with the national Future of Research group.

Blockbuster bio

Students learn to make science accessible through video production

By Alexandra Taylor

The shot opens on an American flag blowing in the wind. Suddenly the camera pulls back and rotates, and we realize the flag is attached to a Secret Service vehicle that is upside down and on fire. Smoke erupts from the United States Capitol in the background. A zombie emerges from the rubble and charges forward. We're not sure what we're watching, but we do know this is not your typical biology project.

Sarah Wetzel created her video exploring the potential for parasitic infections to cause zombielike symptoms as part of a course on teaching and learning biology at the University of Colorado, Boulder. Professor Michael Klymkowsky and colleagues introduced the video project to challenge students to solidify their own understanding of foundational concepts and to make these concepts accessible to people outside their field.

The course is required for all biology majors in the CU Teach program at UC Boulder. The program allows students to earn both a bachelor's degree and a teaching certificate in the STEM major of their choice. In addition to strengthening students' understanding of the concepts necessary to teach biology, the class is focused on techniques such as course design, course presentation and active versus passive learning.

Klymkowsky has taught an abridged version of the class at the Swiss Federal Institute of Technology in Zurich. Wherever he's teaching, his goal is to help students who are considering a teaching career to "realize that teaching and learning is more than just recognizing answers. It's being able to use and apply the information. What do you need to be able to use this information and make sense of it? How do you go from facts to scientific literacy?"

For the video project portion of the course, students are required to identify difficult concepts and explore what makes them challenging. They are free to choose anything related to biology that interests them. Past topics have included magnetic resonance, sauerkraut fermentation, proviruses, excessive sweating and the way reward pathways influence addiction.

Klymkowsky's former student Tim Vigers made a video about the chemical mechanisms that cause beer to go bad and take on a skunky flavor. "It was great that we were able to choose our own topic, because it meant that I was more motivated to make a worthwhile video," he says.

After choosing their topics, students must devise a hook — a way to pull viewers in in the first few frames and convince them that watching a five- to eight-minute video on a biology topic is well worth their time.

Klymkowsky is a professor and co-director of CU TEACH at the University of Colorado, Boulder.

(Klymkowsky's) goal is to help students who are considering a teaching career to "realize that teaching and learning is more than just recognizing answers. It's being able to use and apply the information. What do you need to be able to use this information and make sense of it? How do you go from facts to scientific literacy?"

Next comes the storyboarding phase, where students lay out the sequence of shots they'll be using, and finally production of the video itself.

The students can use any technique they like to produce their videos, and Klymkowsky has seen narrated PowerPoint presentations, video game-style animations and skits. Besides encouraging students to find a good microphone — "The first way you lose people is if they can't hear you," says Klymkowsky — he offers no technological guidance.

Students are encouraged to explore different options and decide which techniques best supports their concepts. In the past, some have taught

Former CU TEACH student Tim Vigers made a video about the chemical mechanisms that cause beer to go "skunky."

themselves stop-motion animation or used freeware available online to make cartoons. "It's a very creative process," says Klymkowsky. "You can really let go, which is not something you normally get to do in an average biology curriculum."

A significant amount of class time is dedicated to students presenting and discussing their progress at each phase and allowing them to bounce ideas around and get feedback from their audience. Klymkowsky says the biggest hurdle is thinking about why certain concepts are hard and what information is essential to understand them. Students must scrutinize their own knowledge and convey information in a way that makes it approachable and appealing to others. At first, "people tend to go in and just start rattling off facts, which are not useful or engaging," he says.

Vigers says the project helped him to grapple with the complexity of some of the concepts covered. "It was easy to feel like I had a good grasp of how systems work, but I usually found that I couldn't explain them to people," he says. "The video was a really great exercise in that and helped to pull the rest of class together."

There is no minimum requirement for time spent on these projects, although Klymkowsky estimates that they take an average of 20 to 40 hours. "They go off and do whatever they want, and they generally spend a very large amount of time," he says. "You can tell by looking at them — they're very cool."

Once the videos are completed, students share them with the public by posting them to YouTube (klymkowskylab.colorado.edu/Learning-Videos.htm). This way they each end the semester with product: something to show a future employer to demonstrate creativity and clarity of thought.

Klymkowsky sees other potential uses for the types of videos his students are producing. For example, after a paper is published, an accompanying video could help explain its significance, potentially broadening the paper's audience in the process. "The key is to make them engaging," Klymkowsky says, "to really think about who your audience is without just going through the figures of a paper."

Vigers, who is now a clinical research coordinator at Children's Hospital Colorado working on cystic fibrosis-related diabetes, says, "Dr. Klymkowsky's class made me realize that there are lots of things that you can do with a biology degree aside from bench research. I realized that I love educating people about biology, which is a big part of my job now."

Alexandra Taylor is a master's candidate in science and medical writing at Johns Hopkins University.

New minors policies affect outreach activities

By James T. Hazzard, Melissa Harnois & Erica Siebrasse

Many science outreach groups are discovering that their institutions have implemented policies regulating engagement with minors. The policies have been developed and enacted in no small part due to concerns originating from the infamous case of Jerry Sandusky, a former assistant coach at Pennsylvania State University who was convicted of molesting boys whom he was meant to be mentoring.

Though the details of these engagement policies may vary by institution, they likely will have a significant effect on outreach efforts. Each adult scientist who visits a K–12 classroom, judges a science fair, hosts a campus workshop with minors or participates in a science camp may soon need to comply with these policies.

We offer our experience as an example of how an outreach group can manage and comply with minors policies. At the University of Arizona, our ASBMB Student Chapter runs a weeklong summer science camp called BlastOff! The university developed minor policies in the spring of 2015, and we hosted BlastOff! in June, unaware of the changes. In August, administrators informed us that the camp was in violation of the university's policies and could not run again until we were in compliance.

After our initial "What policy?" response, we discovered that the main issue the policy was meant to address was one-on-one contact between a minor student and an adult who had not undergone an approved verification process. At our university, this verification includes a background check with fingerprinting as well as a two-hour online training video related

ALL IMAGES COURTESY OF MELISSA HARNOIS

Fifteen campers and BlastOff! staff gather under the Koffler building sculpture, which depicts the work of chemists and biologists, at the University of Arizona.

to child abuse.

Our chapter was concerned about the cost of verifying 30 camp volunteers at $95 each. The total cost would have been $2,850, which is almost twice the cost of running the camp. We communicated our financial concerns to university administrators, who responded that all volunteers must complete the training or we would have to cancel the camp.

After speaking with leaders of our university's Society of Women Engineers, which hosts a similar outreach activity, it became clear that the policies were evolving as the administration realized the deleterious effect the costs would have on university outreach activities. Fortunately, the university appointed an administrator who was very familiar with undergraduate-sponsored outreach events and sympathetic to the financial burden of these policies.

Administrators recently informed our student chapter that only three camp leaders will need to undergo background checks and participate in the training video — drastically decreasing the cost. To be in compliance with the policies, only these undergraduates will be allowed to have one-on-one contact with minors. No other undergraduates can be alone with a minor.

We offer our story to illustrate how a student chapter successfully worked with an administration to develop a policy that protected students while still managing the financial burden on the project. This process was not easy for us, and we hope the following tips will help others avoid difficulty:

BlastOff! organizers initially were surprised to learn of their university's new minors policy, which stipulated that every adult working one-on-one with minors must undergo a verification process.

1. Start early and be proactive. As soon as you start planning your outreach activity, determine if your university has an established policy for working with minors.

2. Be aware that many university policies govern both on- and off-campus activities. In addition, some K–12 schools may have their own policies, which may require background checks by local or state law-enforcement agencies.

3. Determine the cost of compliance. Many grants will support the cost of background checks. If you are writing a new grant, be sure to include this cost.

4. Do not assume the administration is unwilling to work with you if compliance will be overly burdensome to your project.

5. Protect your students. If there are no established minor policies, we advise developing your own. Adult volunteers who have not had background checks should not be alone with minors. This also applies to one-on-one communication over the phone or email. This type of policy protects both the minors and volunteers.

6. We also recommend developing and communicating guidelines on appropriate conduct for undergraduate volunteers. Many have not worked with K–12 students before and may be unsure about appropriate behavior.

BlastOff! sixth and seventh grade campers come from multiple schools in low-income areas of Tucson, Ariz.

James T. Hazzard (jhazzard@email.arizona.edu) is a senior lecturer at the University of Arizona and a member of the ASBMB Student Chapters Steering Committee.

Melissa Harnois (Melissaharnois@email.arizona.edu) is a senior at the University of Arizona and president of the school's ASBMB Student Chapter.

Erica Siebrasse (esiebrasse@asbmb.org) is the education and professional development manager for the ASBMB. Follow her on Twitter at twitter.com/ericaseib.

Bacterial girl

By Manju Hingorani

I like writing song parodies, and I guess you could say Bonnie Bassler at Princeton University, who is known for her work on quorum sensing in bacteria, and Madonna were the muses for this one. I had just read one of Bassler's review articles, and an image from Madonna's "Material Girl" video came to mind (you know, when she's channeling Marilyn Monroe and the men in tuxes are all over her). Then the words just wrote themselves.

Manju Hingorani (mhingorani@wesleyan.edu) is a professor at Wesleyan University, where her research group studies DNA repair. She is also a program director at the National Science Foundation.

Some bugs on me, some bugs in me
I think they are swell
If they just make me vitamin K
I won't take a pill

They're in poop and even pee
But some won't see the light (that's right)
'Cause they're bugs that "colon"ize
In anaerobic night, 'cause we are

Living in a bacterial world
And I am a bacterial girl
You know that we are living in a bacterial world
And I am a bacterial girl

Some bugs romance, some bugs slow dance
That's all right with me
If they can kick the bad ones out, I'll
Surely let them be

Some commensal and some mutual
I just let them play (all day)
'Cause those critters outnumber me
And can make me pay, 'cause they are

Living in a bacterial world
And I am a bacterial girl
You know that we are living in a bacterial world
And I am a bacterial girl

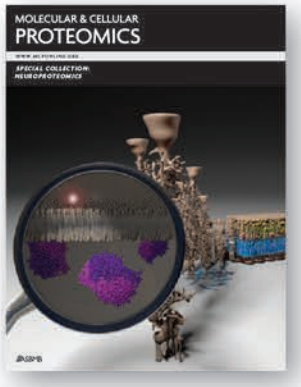
Living in a bacterial world (bacterial)
Living in a bacterial world

Bugs may come and bugs may go
And that's all right, you see
Symbiosis made us rich, now
They're all over me, 'cause everybody's

Living in a bacterial world
And I am a bacterial girl
You know that we are living in a bacterial world
And I am a bacterial girl

A bacterial, a bacterial, a bacterial, a bacterial world

Living in a bacterial world (bacterial)
Living in a bacterial world



ASBMB
American Society for Biochemistry and Molecular Biology

www.asbmb.org/publications

ASBMB JOURNALS

When you submit to an ASBMB journal you can expect:

- No submission fees
- Fair, thorough, constructive peer review by scientists
- Immediate and freely available publication upon acceptance

ASBMB member benefits:

- Discounted page charges and free color figures*
- Complimentary online subscriptions to JBC, JLR and MCP

**ASBMB has eliminated color figure fees for regular members publishing as corresponding authors.*

The American Society for Biochemistry And Molecular Biology

You have the drive and we have the resources to help you take your career to the next level.

ASBMB Member Benefits:

- Career resources, including an online job board, job blog and workshops
- Reduced publication fees and FREE color in all ASBMB journals*
- Online access to all ASBMB journals:
    - Journal of Biological Chemistry
    - Molecular & Cellular Proteomics
    - Journal of Lipid Research
- Print and online subscription to ASBMB Today, the member magazine
- Travel awards
- Discounts on registration for ASBMB meetings
- A voice on Capitol Hill

*Must be a regular member publishing as the corresponding author.

www.asbmb.org/memberbenefits

ASBMB
American Society for Biochemistry and Molecular Biology