IGB NEWS

Upcoming Events

Monthly Profiles

Happenings at IGB

Image Of The Month

Research News

Department Announcements

Volume 13 Number 3

UPCOMING EVENTS

IGB Science Chat
Tue, 04/14/2020

Jessica Brinkworth, Anthropology
Chris Brooke,
Molecular & Cellular Biology
Colin Kieffer, Microbiology
Rebecca Smith, Pathobiology

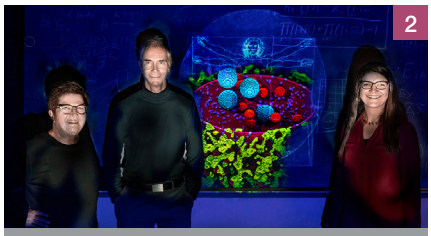
"A COVID-19 Primer: Virology, Immunology, Evolution, and Epidemic Modeling"

Join via Zoom: https://illinois.zoom.us/j/409255484?pwd=RjdReWlsNUx-NODgrZWltazhBd0Q1dz09

Join Professors Brinkworth, Brooke, Kieffer, and Smith, members of the Infection Genomics for One Health research theme at the Carl R. Woese Institute for Genomic Biology, for an interactive discussion in the first of our new series IGB Science Chats.

Free and open to the public

FEATURED NEWS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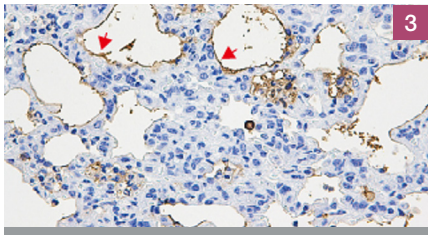
Computational human cell reveals new insights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Bacterial protein fragment kills lung cells in pulmonary fibrosis

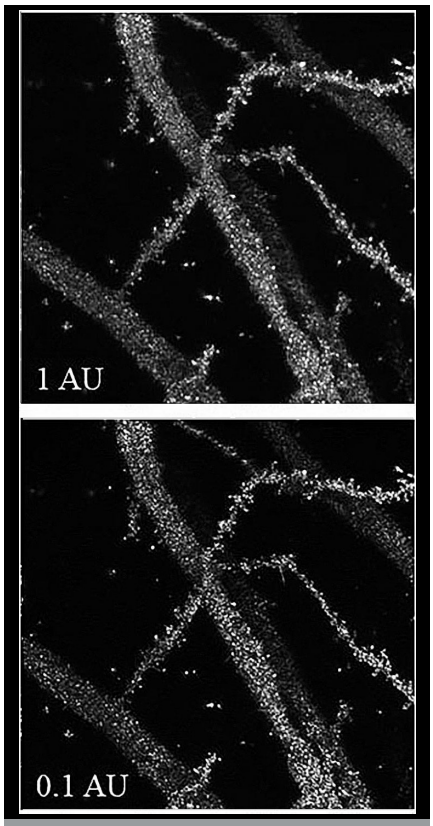

4

Monthly Profile: At-home activities for families and friends


5

On the Grid: Happenings at IGB

IMAGE OF THE MONTH

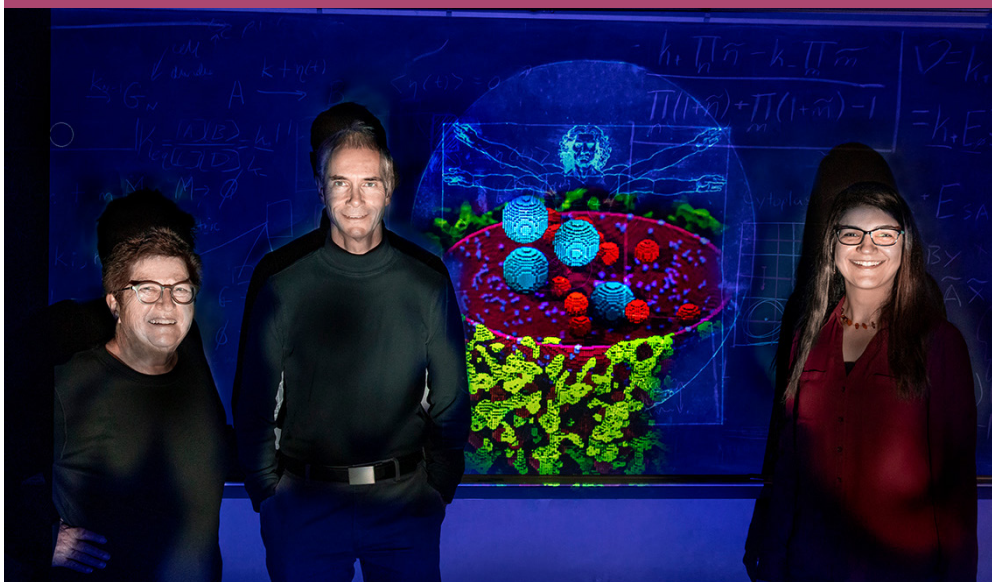


This month's image is a Confocal Reflection Super-Resolution imaging (CRSR) of Golgi-Cox impregnated murine hippocampal neurons, taken under the pinhole size condition of 0.1 Area unit (AU) in contrast to the conventional reflection imaging setting at 1 AU. The image was taken with the Zeiss LSM 880 with 63x magnification at 3.2 times zoom. Courtesy of Yee Ming Khaw of the Dr. Makoto Inoue Lab and Dr. Mayandi Sivaguru, Associate Director of the IGB Core Facilities.

IGB News

Share your news with the IGB. Send ideas on stories, articles, and features to *nvasi@illinois.edu*.

FEATURE



Computational human cell
reveals new insights

Researchers have developed the first computational model of a human cell and simulated its behavior for 15 minutes – the longest time achieved for a biological system of this complexity. In a new study, simulations reveal the effects of spatial organization within cells on some of the genetic processes that control the regulation and development of human traits and some human diseases.

The study, which produced a new computational platform that is available to any researcher, is published in the journal *PLoS Computational Biology*.

"This is the first program that allows researchers to set up a virtual human cell and change chemical reactions and geometries to observe cellular processes in real time," said Zhaleh Ghaemi, a research scientist at the University of Illinois at Urbana-Champaign and lead author of the study.

Working off the notion the insides of cells are packed with various organelles and molecules, the group, led by Chemistry Professor Zaida Luthey-Schulten (BCXT), focuses on how the movement of individual molecules around the many obstacles affects the chemical reactions inside cells.

To test the new model, the team performed simulations of a process called RNA splicing, which is one of the most complex cellular processes and a hallmark of human cellular biology, the researchers said.

"RNA splicing changes the messenger RNA molecules that carry information needed from DNA to form proteins," Ghaemi said. "The process uses a complex cellular machine – called a spliceosome – that requires the trafficking of precursor and mature components around the highly compartmentalized parts of a cell. This makes RNA splicing ideal for studying how spatial arrangement affects the various chemical reactions that take place in cells."

Chemistry professors Zaida Luthey-Schulten, left, Martin Gruebele and research scientist Zhaleh Ghaemi have developed the most complete computational model of a human cell to date.

The new simulations revealed a rationale for why precursors of the spliceosome move between the nucleus and cytoplasm compartments, the researchers said.

"Even though this movement seems somewhat inefficient and counterintuitive at first glance, our simulations indicate that they are essential to the proper RNA splicing, and therefore protein synthesis," said Martin Gruebele, a chemistry professor and study co-author. "When protein synthesis goes awry, it can lead to disease, including cancer,"

The researchers designed the computational platform to model a variety of cellular processes while being fully customizable by the researcher using it.

"For example, we could use this model to observe what types of proteins will form if the RNA-splicing process were to remove only two parts of a DNA sequence instead of three," Luthey-Schulten said. "This could provide insights into how different proteins form and influence the development of cancer cells."

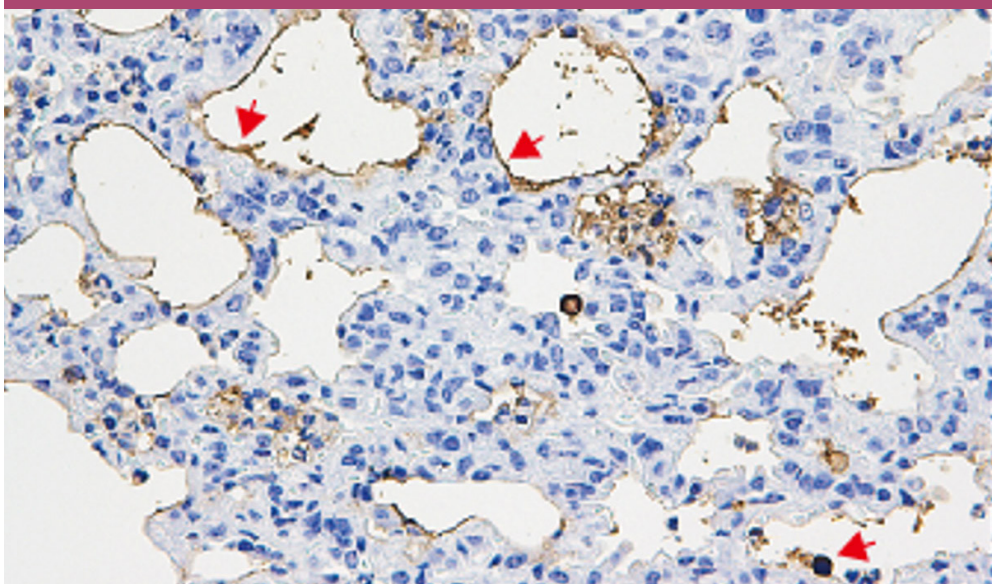
Although the most comprehensive human cell model to date, the computational model still has ample room for advancement and customization to study other cellular processes, the researchers said.

"This simulation allowed us to observe the RNA splicing for 15 minutes," Gruebele said. "Ultimately, we would like to be able to run the program for much longer and include all of the proteins that are required for gene replication, allowing us to observe cell division in real-time. The possibilities for our group – and others because the program is open access – are endless."

Luthey-Schulten also is affiliated with the physics department, the Beckman Institute for Advanced Science and Technology.

Gruebele heads the chemistry department and also is affiliated with physics, the Center for Advanced Study, the Beckman Institute and the Carle Illinois College of Medicine at Illinois. ■

Written by Lois Yoksoulian. Photo Fred Zwicky.



Bacterial protein fragment
kills lung cells in pulmonary fibrosis

A bacterial protein fragment instigates lung tissue death in pulmonary fibrosis, a mysterious disease affecting millions of people worldwide, according to a new study from researchers at the University of Illinois at Urbana-Champaign and Mie University in Japan.

Led by Illinois microbiology and animal sciences professor Isaac Cann (MME leader/BCXT) and Mie University immunology professor Dr. Esteban Gabazza (MME), the researchers published their findings in the journal *Nature Communications*.

"We discovered salt-loving bacteria in the lungs of patients with pulmonary fibrosis, and these bacteria secrete a peptide that marks the lung cells it touches for death," Cann said.

In people with pulmonary fibrosis, lung tissue becomes progressively more scarred and stiffened, with a prognosis of only three to five years of life after diagnosis. Certain environmental factors, infections or medications are linked to disease onset; however, the majority of cases are of unknown origin. These mysterious cases are called idiopathic pulmonary fibrosis. About 50,000 patients in the U.S. die of IPF every year – more than die from breast cancer, according to the IPF Foundation.

The disease progresses slowly until a point when a patient experiences a rapid worsening of breathing and loss of lung function, a phase called acute exacerbation. Yet doctors do not know what triggers acute exacerbation in a stable patient.

"More than half of the patients with IPF die because of acute exacerbation of the disease," Gabazza said. Of those who survive an acute exacerbation event, only 50% live more than four months, he said.

Previous studies found that certain bacteria, such as strains of Halomonas, Staphylococcus and Streptococcus, proliferate in the lungs of IPF patients, likely as a result of high amounts of salt in the lining of patients' lungs. The researchers wondered if the bacteria played a role in acute exacerbation, so they cultured bacteria associated with fibrotic lung tissue in a salty environment and studied what the bacteria secreted.

Lung tissue from mice with pulmonary fibrosis that were infected with corisin-secreting bacteria showed signs of acute exacerbation and lung tissue death.

They found a small peptide, secreted by Staphylococcus nepalensis, that rapidly kills lung cells. They named the peptide corisin.

To confirm that corisin was the exacerbating culprit, Gabazza's group ran an experiment on mice with IPF. They compared mice given corisin itself, those infected with corisin-secreting Staphylococcus nepalensis, those infected with a Staph strain that did not secrete corisin, and an untreated control group. They found that the mice given corisin or the bacterium that secretes it showed much greater signs of acute exacerbation.

They also looked at lung tissue samples from human patients and found that those who had undergone acute exacerbation had higher levels of corisin in their lungs.

Cann's group then searched the genome of Staphylococcus nepalensis to figure out where corisin comes from. They found that it is a fragment cut from a larger protein. They tested the larger protein on lung tissue and found it did not have the destructive properties of the fragment.

"It's like a Trojan horse," Cann said. "Anybody trying to characterize the large protein to find what it does would never know it has this destructive element hidden inside it. The microbe makes the polypeptide and then it cuts out that small piece of it, the corisin, and that is very deadly."

Next, the researchers hope to identify the enzyme that cuts corisin out of its larger protein. They aim to create agents to block it – effectively bolting shut the door of the Trojan horse. They also plan to identify which other strains of bacteria produce corisin or similar peptides, and to study other types of fibrosis, such as in the kidneys and liver, to see if corisin or other bacterial agents play a role in those diseases.

"Knowing that a cause of the acute exacerbation is a bacteria-derived factor gives us a fightable enemy," Gabazza said. "On the patient side, this new discovery could mitigate the psychological stress of fighting against an 'unknown intruder,' while on the physician side, this can stimulate the development of strategies for treatment and drug discovery."

The findings also may have important implications for the current coronavirus pandemic, as some patients may develop pulmonary fibrosis after recovering from COVID-19, in similarity to the fibrosis seen in some patients after the outbreak of the SARS coronavirus, Cann and Gabazza said.

The Ministry of Education, Culture, Sports, Science, and Technology of Japan, the Carl R. Woese Institute for Genomic Biology and the College of Agricultural, Consumer and Environmental Sciences Office of International Programs at Illinois supported this work. ■

Written by Liz Ahlberg Touchstone. Photo courtesy of Esteban Gabazza/Nature Communications.

MONTHLY PROFILE

At-home activities
for families and friends

As we all adjust to new health recommendations and wellness practices we may be finding ourselves at home much more than ever before. Here at the IGB we want to connect with communities both locally in Urbana-Champaign and across the globe. We are posting fun and educational activities or suggestions to help enjoy this time together and to engage with each other, and to provide some opportunities to learn something new, experiment with a fresh idea, or just be curious.

Below you can find a selection of activities from our daily post, see the full list here.

Build a Flower

Plants with flowers depend on certain types of animals, called pollinators, to help spread their pollen from flower to flower. These can be bees, butterflies, birds, all types are attracted to those new Springtime flowers. We're going to design a flower and think about the kinds of pollinators that might visit us!

Crack the Code

A tricky activity about DNA, RNA, and proteins, where you'll play the part of a biological deciphering machine called a ribosome. Read through our special codon wheel and decipher a secret message about coronavirus. Download a packetthat has instructions, background info on the science, and the code to be cracked. The answer is on the last page so no skipping ahead!

Crossword Puzzle

Here's your chance to use all the new words you've been learning about when we talk about COVID-19, and the ways we can help keep the disease from spreading. You can download a copy to print and fill out. If you're really stumped you can also get a copy of all the answers here, but do you really need it? We don't think you do.

DNA Coloring Sheet

Want to bring some color into this DNA drawing? Download a PDF of our DNA coloring sheet. To learn more about DNA and genomics, check out our video from the World of Genomics at the bottom of this page.

DNA Origami

Here's a fun and challenging paper folding activity - fold a DNA structure! There are two templates available, a color version and a black and white if you'd like to color everything in, with instructions. DNA not included but you absolutely have some at home.

How Do I Compare To A Bat?

For activity leaders, a detailed lesson plan for a suite of activities called "How Do I Compare to a Bat?" that has several options to try out over time, or even in a small group.

I Spy DNA

Anything that is alive, or was once alive, or was a part of a living thing, has some DNA in it. Do you think you could spot all the items in a picture that have DNA? Download a copy of our I Spy DNA activity and give it a try! There are bonus challenges too, but stay away from the last page until you're ready for answers.

IGB Stations Coloring Sheets

Sometimes the IGB travels to another city and puts on a big show called the World of Genomics, that has different interactive stations where people can learn about DNA, or medicine, or bees! We took the best cartoons from those stations and made them into coloring sheets, so let your imagination go wild ....

Make a Tiny Zine

Zines are small-circulation self-published booklets. They allow for voices of all volumes to publish and share their experiences! So why not share your experience with your own tiny zine, instructions and a photo guide available.

Observing Like a Scientist and an Artist

Sometimes there is a whole world to explore right in front of us, ways to stimulate our brain and examine our surroundings that we've never thought about before. With that idea in mind, let's make new discoveries by observing like a scientist and an artist! Go outside in your backyard and find a leaf and follow our directions.

Pollen Coloring Sheet

We had so much fun with the DNA coloring sheet that we decided to post a new one - and this is all about pollen! Download a copy and get creative with those colors.

Social Squares

We can do our own investigation into how an infection, like COVID-19, can be spread among people. Scientists use powerful computers and special software to make predictions just like this, but we can do our own experiment with objects already in your house. Download our Social Squares activity and get started!

Strawberry DNA Extraction

Extract actual DNA from a strawberry ... this is definitely a group activity that you'll need some help and supervision from an older family member or friend, so find a science partner, download a copy of the activity, and get that DNA! ■

ON THE GRID
HAPPENINGS AT THE IGB

AWARDS

BRIAN ALLAN

Brian Allan, Associate Professor of Entomology (CGRH/IGOH), was identified through the Chancellor's Senior Survey as a faculty or staff member who has made a positive impact on graduating seniors at Illinois. The survey, administered to all graduating seniors as a way to better understand their experiences at Illinois, identified over 900 faculty and staff, of which 38 were chosen for this recognition.

IAN TRANIELLO

Ian Traniello, Graduate Student in the Neuroscience Program (Robinson Lab), was selected as an award recipient for the NIH Outstanding Scholars in Neuroscience Award Program (OSNAP), a national program that recognizes those who are conducting exceptional research and have great academic potential within their discipline.

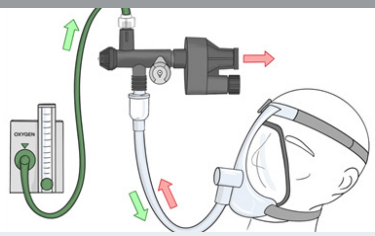
AMY WAGONER JOHNSON

Amy Wagoner Johnson, Professor of Mechanical Science and Engineering (CGRH/RBTE) was appointed a 2020 Andersen Faculty Scholar, and received the Outstanding Advisor Award by the Engineering Council from The Grainger College of Engineering, recognizing the top 10 percent of advisors across all the engineering departments.

TANDY WARNOW

Professor Wenyan Mei has joined the IGB as an affiliate member in the Microbiome Metabolic Engineering (MME) Research Theme. Dr. Mei is a Research Assistant Professor in the Department of Comparative Biosciences in the College of Veterinary Medicine. She received her PhD from the Shanghai Institute of Biochemistry and Cell Biology, and was a postdoctoral research associate at the University of Pennsylvania School of Medicine. Her lab is interested in understanding how stem cells control their self-renewal and differentiation, and how their disregulation causes diseases.

PROTOTYPE



WORKING PROTOTYPE OF EMERGENCY VENTILATOR FOR COVID-19 PATIENTS

A team led by the University of Illinois at Urbana-Champaign's Grainger College of Engineering and Carle Health has produced a prototype emergency ventilator to help address the expected surge in the need for respiratory care associated with the COVID-19 pandemic.

The Illinois RapidVent, as the emergency ventilator is known, would plug into the oxygen source available in most hospital rooms or could plug into a tank of oxygen. The prototype has run for more than 75 hours, which is more than 125,000 breathing cycles. Learn more at the RapidVent site: https://rapidvent.grainger.illinois.edu/index.asp.

FAREWELL

LISA STUBBS TO DEPART THE UNIVERSITY OF ILLINOIS

Professor of Cell and Developmental Biology Lisa Stubbs, a pioneer in mammalian regulatory machinery, will be departing the IGB after serving for eight years as theme leader of the Gene Networks in Neural & Developmental Plasticity (GNDP) research theme to assume a vital new role as Senior Investigator at Pacific Northwest Research Institute in Seattle, Washington.

"I visited UIUC for the first time 13 years ago, and the IGB really caught me by surprise," recalled Stubbs. "As soon as I saw and met the people at the IGB, I knew I would be coming back, as I was drawn to the interdisciplinary opportunities and collaborations. I had not seen that kind of true team-science focus anywhere else I had been in the country."

"We are very sorry to see Lisa leave, but we are happy that she can return to her roots in Seattle," said IGB director Gene Robinson (GNDP). "Lisa has been a stalwart member of the IGB and has served with distinction for eight years as leader of the Gene Networks in Neural & Developmental Plasticity Research Theme."

We thank Lisa for her excellent work and leadership over the years and wish her the best in her new position

RECENT PUBLICATIONS

Please include your connection to the IGB in your author byline when submitting publications, as it will greatly help track potential newsworthy items and increase the possibility of coverage.

Traniello, I. M., Bukhari, S. A., Kevill, J., Ahmed, A. C., Hamilton, A. R., Naeger, N. L., Schroeder, D. C., & Robinson, G. E. (2020). Meta-analysis of honey bee neurogenomic response links Deformed wing virus type A to precocious behavioral maturation. *Scientific reports*, 10(1), [3101]. https://doi.org/10.1038/s41598-020-59808-4

Wen, Y., Mirji, N., & Irudayaraj, J. (2020). Epigenetic toxicity of PFOA and GenX in HepG2 cells and their role in lipid metabolism. *Toxicology in Vitro*, 65, [104797]. https://doi.org/10.1016/j.tiv.2020.104797

Uprety, S., Dangol, B., Nakarmi, P., Dhakal, I., Sherchan, S. P., Shisler, J. L., Jutla, A., Amarasiri, M., Sano, D., & Nguyen, T. H. (2020). Assessment of microbial risks by characterization of *Escherichia coli* presence to analyze the public health risks from poor water quality in Nepal. *International Journal of Hygiene and Environmental Health*, 226, [113484]. https://doi.org/10.1016/j.ijheh.2020.113484

Caetano, T., van der Donk, W., & Mendo, S. (2020). Bacteroidetes can be a rich source of novel lanthipeptides: The case study of *Pedobacter lusitanus*. *Microbiological Research*, 235, [126441]. https://doi.org/10.1016/j.micres.2020.126441

Parker, C. G., Dailey, M. J., Phillips, H., & Davis, E. A. (2020). Central sensory-motor crosstalk in the neural gut-brain axis. *Autonomic Neuroscience: Basic and Clinical*, 225, [102656]. https://doi.org/10.1016/j.autneu.2020.102656

DeAngelis, R., Dodd, L., & Rhodes, J. (2020). Nonapeptides mediate trade-offs in parental care strategy. *Hormones and Behavior*, 121, [104717]. https://doi.org/10.1016/j.yhbeh.2020.104717

Sun, J., Chen, J., Mohagheghian, E., & Wang, N. (2020). Force-induced gene up-regulation does not follow the weak power law but depends on H3K9 demethylation. *Science Advances*, 6(14). https://doi.org/10.1126/sciadv.aay9095

Huang, C., Shen, Y., Smith, R. L., Dong, S., & Nguyen, T. H. (2020). Effect of disinfectant residuals on infection risks from *Legionella pneumophila* released by biofilms grown under simulated premise plumbing conditions. *Environment International*, 137, [105561]. https://doi.org/10.1016/j.envint.2020.105561

Huang, X., Cao, M., & Zhao, H. (2020). Integrating biocatalysis with chemocatalysis for selective transformations. *Current Opinion in Chemical Biology*, 55, 161-170. https://doi.org/10.1016/j.cbpa.2020.02.004

Li, K., Liszka, M., Zhou, C., Brehm, E., Flaws, J. A., & Nowak, R. A. (2020). Prenatal exposure to a phthalate mixture leads to multigenerational and transgenerational effects on uterine morphology and function in mice. *Reproductive Toxicology*, 93, 178-190. https://doi.org/10.1016/j.reprotox.2020.02.012

Lawson, S. L., Enos, J. K., Mendes, N. C., Gill, S. A., & Hauber, M. E. (2020). Heterospecific eavesdropping on an anti-parasitic referential alarm call. *Communications biology*, 3(1). https://doi.org/10.1038/s42003-020-0875-7

Ghaemi, Z., Peterson, J. R., Gruebele, M., & Luthey-schulten, Z. (2020). An in-silico human cell model reveals the influence of spatial organization on RNA splicing. *PLoS computational biology*, 16(3), e1007717. https://doi.org/10.1371/journal.pcbi.1007717

D'alessandro-gabazza, C. N., Kobayashi, T., Yasuma, T., Toda, M., Kim, H., Fujimoto, H., Hataji, O., Takeshita, A., Nishihama, K., Okano, T., Okano, Y., Nishii, Y., Tomaru, A., Fujiwara, K., D'alessandro, V. F., Abdel-hamid, A. M., Ren, Y., Pereira, G. V., Wright, C. L., ... Gabazza, E. C. (2020). A *Staphylococcus* pro-apoptotic peptide induces acute exacerbation of pulmonary fibrosis. *Nature Communications*, 11(1), [1539]. https://doi.org/10.1038/s41467-020-15344-3

Hwang, M. T., Heiranian, M., Kim, Y., You, S., Leem, J., Taqieddin, A., Faramarzi, V., Jing, Y., Park, I., Van Der Zande, A. M., Nam, S., Aluru, N. R., & Bashir, R. (2020). Ultrasensitive detection of nucleic acids using deformed graphene channel field effect biosensors. *Nature communications*, 11(1), [1543]. https://doi.org/10.1038/s41467-020-15330-9

Di Pietro, V., Yakoub, K. M., Caruso, G., Lazzarino, G., Signoretti, S., Barbey, A. K., Tavazzi, B., Lazzarino, G., Belli, A., & Amorini, A. M. (2020). Antioxidant Therapies in Traumatic Brain Injury. *Antioxidants*, 9(3), [260]. https://doi.org/10.3390/antiox9030260

Kerns, K., Sharif, M., Zigo, M., Xu, W., Hamilton, L. E., Sutovsky, M., Ellersieck, M., Drobnis, E. Z., Bovin, N., Oko, R., Miller, D., & Sutovsky, P. (2020). Sperm cohort-specific zinc signature acquisition and capacitation-induced zinc flux regulate sperm-oviduct and sperm-zona pellucida interactions. *International journal of molecular sciences*, 21(6), [2121]. https://doi.org/10.3390/ijms21062121

Tillmaand, E. G., Anapindi, K. D. B., De La Toba, E. A., Guo, C. J., Krebs, J., Lenhart, A. E., Liu, Q., & Sweedler, J. V. (2020). Quantitative Characterization of the Neuropeptide Level Changes in Dorsal Horn and Dorsal Root Ganglia Regions of the Murine Itch Models. *Journal of Proteome Research*, 19(3), 1248-1257. https://doi.org/10.1021/acs.jproteome.9b00758

Louder, M. I. M., Lafayette, M., Louder, A. A., Uy, F. M. K., Balakrishnan, C. N., Yasukawa, K., & Hauber, M. E. (2020). Shared transcriptional responses to con- and heterospecific behavioral antagonists in a wild songbird. *Scientific reports*, 10(1), [4092]. https://doi.org/10.1038/s41598-020-60231-y

Massalha, N., Plewa, M. J., Nguyen, T. H., & Dong, S. (2020). Influence of Anaerobic Mesophilic and Thermophilic Digestion on Cytotoxicity of Swine Wastewaters. *Environmental Science and Technology*, 54(5), 3032-3038. https://doi.org/10.1021/acs.est.9b07066

Song, Z., Tan, Z., Zheng, X., Fu, Z., Ponnusamy, E., & Cheng, J. (2020). Manipulating the helix-coil transition profile of synthetic polypeptides by leveraging side-chain molecular interactions. *Polymer Chemistry*, 11(8), 1445-1449. https://doi.org/10.1039/c9py01857c ■

ILLINOIS

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