Director Mark Banaszak Holl’s Message

Dear Alumni and Friends,

Can I take a moment to brag about the wonderful students here in the Macro program? It has been a great year filled with accomplishment, with four Ph.D and eight Master’s degrees conferred since the fall.

Our ACS POLY/PMSE student chapter was selected as student chapter of the year for 2016 by the American Chemical Society. Their exceptional commitment to outreach work with Detroit metro area schools contributed to this award. These efforts were also recognized by the University of Michigan’s Provost’s Office and the Center for Education Outreach, who have fully funded their efforts for next year. In addition they have provided support for an event bringing K-12 teachers to campus this summer. With over 2,000 students reached in their own schools over the last two years, our student section has much to be proud for their outreach.

The Macro students also excel by running our campus-wide polymer science and engineering lecture series, helping immensely with planning and running the annual Macro symposium, and creating an exciting and fun professional and social environment. We are fortunate to have them as colleagues here at Michigan! We have also recognized student leadership within the Macro program with Overberger Leadership Awards and Professor Albert & Mrs. Jessica Yee Student Leadership Awards. As always, many thanks to the alumni, faculty, and friends who have contributed to these funds.

While I was attending the spring ACS meeting in San Francisco I had the good fortune to see newly promoted Associate Professor Mark Roll (Macro Ph.D. 2010) and share in his good news regarding career progress. It is always wonderful to hear about our graduate’s successes and I thought “Why should I keep this good news to myself?” So, we have included updates from our younger faculty alumni so you can hear about the great scholarship they are pursuing. In addition, we have a highlight on Professor Seungpyo Hong (Macro Ph.D. 2006) and his translational work with Capio Biosciences. Seungpyo recently became Professor of Pharmacy at the University of Wisconsin.

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Director’s Message (CONTINUED FROM PAGE 1)

We are very excited about our new class of graduate students for the fall of 2017, which contains seven Ph.D. students and eight Master’s students. These new students have a great mix of experience in polymer science and engineering and will substantially add to the Macro program. Two of our new PhD students took advantage of our new summer research fellowship program and are already at Michigan pursuing research in the lab, which brings me to some really great news for the program.

This year we received a gift from the 3M Foundation for graduate student fellowship support. The gift will support three student’s research this summer and provide fall term support for one of our incoming graduate students.

This summer’s 3M fellows are Arushi Gupta (Sakamoto), Kelly Wang (Ma), and Nathan Jones (Lahann). In these times of uncertain and difficult to obtain federal support for science and engineering, these fellowships for our educational programs are immensely helpful.

Lastly, please join me in congratulating Professor Ellen Arruda for her election to the National Academy of Engineering. She joins Macro Professors Sharon Glotzer and Ronald Larson as members of the National Academy. This is a well-deserved honor for Ellen and her ground-breaking work in polymer mechanics.

Best wishes for an enjoyable summer!

Overberger Prize Awarded to Craig J. Hawker

Macro is pleased to announce that the 2017 Charles G. Overberger International Prize has been awarded to Craig J. Hawker, the Director of the California Nanosystems Institute (CNSI), Dow Materials Institute, and Co-Director of the Materials Research Lab at the University of California, Santa Barbara.

Dr. Hawker is the Clarke Professor within the CNSI and also has affiliations with the Materials Department and Department of Chemistry & Biochemistry at UCSB.

Nominees noted that Professor Hawker “has revolutionized almost every sub-field of polymer synthesis and his influence will continue to be felt by generations of scientists.” His impact has been felt through work including “a convergent approach to dendritic macromolecules, advances in nitroxide mediated polymerization, discovery and development of new polymer architectures, block copolymer lithography, click chemistry in polymer science, and photocontrolled radical polymerizations”.

Ellen Arruda Elected to National Academy of Engineering

In February Macro Professor Ellen Arruda was elected to the National Academy of Engineering, citing her “pioneering research in polymer and tissue mechanics and their application in innovative commercial products.”

Among current projects in the Arruda group is development of shock-absorbing technology that can more effectively diffuse force on impact. The material has particular value for protective gear including helmets.

41st Annual Macro Symposium
October 18th & 19th, 2017

The 41st Annual Macro Symposium, “Emergent Polymer Science & Engineering”, will be held on October 18th and 19th later this year. The event will feature a half-day series of career pathways short courses on Wednesday, followed by an industry networking dinner. The Thursday schedule includes invited research talks and student poster sessions. Confirmed speakers include:

- Craig J. Hawker, UCSB
- Jamie Garcia, IBM
- Oleg Gang, Columbia University
- Joerg Lahann, University of Michigan

More information, including registration, will be available later this summer at: macro.engin.umich.edu/events/symposium.
Macro Alumni Updates: Faculty Profiles

Since 1977 there have been 154 students that earned their Ph.D. with Macro. Currently 32 of those alumni hold faculty positions across the globe; here we’ve highlighted the work of some of our more recent graduates.

Sarah Calve (2006, Arruda)
Assistant Professor, Biomedical Engineering, Purdue University
Professor Calve is the principal investigator for the Musculoskeletal Extracellular Matrix Laboratory at Purdue, where she joined the faculty in 2012. The group’s focus is “to characterize the material properties of assembling tissues to establish design parameters for regenerative therapies.” Projects in the lab seek to determine the composition of the extracellular matrix (ECM), spatial organization of the ECM, and influence of ECM organization on mechanical properties.

Seungpyo Hong (2006, Banazak Holl)
Professor, Pharmaceutical Sciences, University of Wisconsin-Madison
Professor Hong recently joined the faculty at Wisconsin after several years at the University of Illinois-Chicago. His research joins biomimetics and nanotechnology, seeking to develop novel polymeric nanodevices for biological analysis, diagnostics, and therapeutics. More specifically, the group is “interested in understanding and controlling biological interactions of polymers with cells at the nano-scale.” His cancer diagnostic start-up, Capio Biosciences, is featured later in this issue.

Jennifer Lu (2006, Gulari)
Associate Professor, Materials Science & Engineering, University of California-Merced
Professor Lu was one of the first faculty to establish the Materials Science & Engineering program at Merced, where she oversees the Functional Materials Synthesis lab. The group’s core interest “is to develop functional material platforms for energy transduction, energy conversion, and energy storage.” Research advances can be used to create devices for green energy, artificial intelligence, and biomedical applications. Earlier in her career Professor Lu was a recipient of the DARPA Young Faculty Award for her work on a nanoscale power generator.

Diana Siberio-Perez (2006, Matzger)
Faculty Mentor & Coordinator, Empire State College, State University of New York
Dr. Siberio-Perez is a faculty mentor in science, mathematics, and technology at Empire State College (ESC). ESC is a unique part of the SUNY system that focuses on nontraditional teaching and learning, offering “flexible, innovative, and creative” environments for student learning. In her role Dr. Siberio-Perez works individually with students on their degree programs through mentored learning. In addition to her responsibilities as an instructor, Dr. Siberio-Perez is also the unit coordinator for operations of the Hudson Valley Region of ESC.

Carl McIntyre (2008, Filisko)
Assistant Professor, Chemical Engineering, University of Louisiana at Lafayette
Professor McIntyre oversees the Louisiana Engineering Activity in Rheology and Nanomaterials (LEARN) laboratory. His group investigates “the rheology and energy transport of nanoparticles in suspensions placed within electric and magnetic fields.” They seek “to create new field-controlled fluid systems containing nanofillers that previously have not been placed inside of these smart systems. The exploration of nanoparticles suspended in fluids but directed by fields of electromagnetic energy will lead to the creation of new fluid-based devices.”

Mark Roll (2010, Laine)
Associate Professor, Chemical & Materials Engineering, University of Idaho
Professor Roll’s work focuses within soft materials, organic/inorganic hybrid materials, and biologically relevant materials, particularly those for thin-film applications in the area of energy and photolithography. Some of his current projects focus on polyelectrolylates, silesiquoxane, and diamondoid and boron clusters. He is also affiliated with the Next Generation Microelectronics Research Center at Idaho.

Jiseok Lee (2011, Kim)
Assistant Professor, Energy & Chemical Engineering, Ulsan National Institute of Science & Technology
Professor Lee runs the Multi-functional Architecture Systems and Synthesis (MASS) lab at UNIST. The group has several active projects covering smart functional polymer synthesis, optofluiddics, and 3D smart functional structure fabrication. Their current work with optofluiddic microscope design offers a low-cost and highly compact imaging solution. “More functionalities, such as encoding microparticles and fluorescent biosassays, can also be adapted into industrial systems.” They anticipate that the “microparticle fabrication systems can address a range of biomedical and bioscience needs, and offer new microscope applications.”

Ed Palermo (2011, Kuroda)
Assistant Professor, Materials Science & Engineering, Rensselaer Polytechnic Institute
Professor Palermo began his current position at RPI in 2014. His work “focuses on the development of materials to combat infectious pathogens, inhibit biofilm formation, and act as components in new medical diagnostic tools.” Overall the group looks “to capture the essential design features of naturally occurring biological materials in order to design novel man-made materials.” Professor Palermo was recently awarded a Faculty Early Career Development Award from NSF for his project, “Biomimetic Macromolecules at the Materials-Microbes Interface.”
Macro Alumni Updates: Faculty Profiles

Hui Joon Park (2012, Guo)
Assistant Professor, Electrical & Computer Engineering and Energy Systems Research, Ajou University

Professor Park supervises the work of the Energy Materials & Devices Laboratory at Ajou. The group has many active projects covering photovoltaic cells, nanoelectronics, and display technology. Along with Professor Park a team of 6 graduate students is working on developing printed and flexible electronics, structural color filters and photovoltaic cells, and angle-insensitive structural color filters with photonic nanostructures. Professor Park began his position at Ajou in 2014 after working for two years as a Senior Research Engineer at Intel.

Sungbaek Seo (2014, Kim)
Assistant Professor, Biomaterials Science, Pusan National University

Professor Seo recently began his position at Pusan National University. After defending his dissertation in 2014 he completed two post-doctoral fellowships. The first was at the University of California Santa Barbara with Professor Herbert Waite. Since late 2015 Sungbaek worked in the lab of Craig Hawker, also at UCSB. His research interests are focused in the development of functional supramolecules based on block copolymers and bio-inspired macromolecular design.

Macro Moves to North Campus Research Complex

In January Macro moved its offices to the North Campus Research Complex (NCRC) after ten years in the Dow Building. The new space offers a dedicated conference area for Macro as well as offices for students and the Macro Coordinator. The space is big enough to host events for the program, including admitted student visits and meetings, with industrial partners. U-M purchased the complex from Pfizer in 2009, acquiring 2 million square feet in research and office space.

In recent years many of the Macro labs located on North Campus have moved to NCRC, notably groups that are part of the Biointerfaces Institute. Today, nearly half the Macro faculty and three-quarters of the Macro students work at NCRC. More Macro labs are scheduled to move into the complex in the coming years.

Currently there are over 2,500 U-M faculty, staff, and students who work at NCRC. It is a hub for medical and engineering research at Michigan and also houses the Business Engagement Center and Office of Technology Transfer. With more moves scheduled in the coming years, over 3,000 people will work at NCRC.

A Self-Healing, Water-Repellent, Ultra Durable Coating

Gabe Cherry, Michigan Engineering

A self-healing, water-repellent spray-on coating developed by the research group of Professor Anish Tuteja is hundreds of times more durable than its counterparts and could enable waterproofing of vehicles, clothing, rooftops and countless other surfaces for which current waterproofing treatments are too fragile. It could also lower the resistance of ship hulls, reducing the fuel consumption of the massive ships that transport ninety percent of the world’s cargo.

The new concoction is a major breakthrough in a field where decades of research have failed to produce a durable coating. “Thousands of superhydrophobic surfaces have been looked at over the past twenty or thirty years, but nobody has been able to figure out how to systematically design one that’s durable,” explains Professor Tuteja. “It’s going to open the door for other researchers to create cheaper, perhaps even better superhydrophobic coatings.”

The coating is made of a mix of a material called “fluorinated polyurethane elastomer” and a specialized water-repellent molecule known as “F-POSS.” It can be sprayed onto virtually any surface and has a slightly rubbery texture that makes it more resilient than its predecessors. If damaged, the coating can bounce back “even after being abraded, scratched, burned, plasma-cleaned, flattened, sonicated and chemically attacked,” the researchers note in a paper published March 29 in ACS Applied Materials & Interfaces.

In addition to recovering physically, the coating can heal itself chemically. If water-repellent F-POSS molecules are scraped from the surface, new molecules will naturally migrate to the surface to replace them. The discovery is being commercialized by HygraTek, a company founded by Professor Tuteja with assistance from the U-M Office for Technology Transfer.

The project produced what amounts to a recipe that researchers can use to optimize future coatings to a specific application’s requirements for cost, durability and other factors. So, while the coating detailed in the study is costly to produce, the team says their research should enable other makers to easily tweak the formula, for example to produce a version that’s only slightly less effective but far less costly.

Lead author and recent Ph.D. graduate Kevin Golovin explains, the team used a process radically different from previous research in the field. “Most researchers have focused on identifying one specific chemical system that’s as durable and water-repellent as possible. We approached the problem by measuring and mapping out the basic chemical properties that make a water-repellent coating durable.”

Most hydrophobic coatings are made of two main ingredients: an active molecule that provides the water-repellency and a binder. Generally, researchers have assumed that using more durable ingredients would make a more durable coating. But Tuteja’s team found that that’s not necessarily the case. They discovered that even more important than durability is a property called “partial miscibility,” or the ability of two substances to partially mix together. Chemicals that are more compatible with each other make a much more durable product, even if they’re less durable individually.

Tuteja estimates that the coatings will be available for use before the end of 2017 for applications including water-repellent fabrics and spray-on coatings that can be purchased directly by consumers.
Transparent Silver Films for Flexible Displays

Kate McAlpine, Michigan Engineering

The thinnest, smoothest layer of silver that can survive air exposure could change the way touchscreens and flat or flexible displays are made. It could also help improve computing power, affecting both the transfer of information within a silicon chip and the patterning of the chip itself through metamaterial “superlenses.”

By combining the silver with a little bit of aluminum, the team led by Professor L. Jay Guo found that it was possible to produce exceptionally thin, smooth layers of silver that are resistant to tarnishing. They applied an anti-reflective coating to make one thin metal layer up to 92.4 percent transparent.

In addition, the team showed that the silver coating could guide light about 10 times as far as other metal waveguides. And they layered the silver films into a metamaterial hyperlens that could create dense patterns with feature sizes a fraction of what is possible with ordinary ultraviolet methods, on silicon chips for instance.

Screens of all stripes need transparent electrodes to control which pixels are lit up, but touchscreens are particularly dependent on them. A modern touchscreen is made of a transparent conductive layer covered with a non-conductive layer. It senses electrical changes where a conductive object – such as a finger – is pressed against the screen.

“The transparent conductor market has been dominated to this day by one single material,” said Professor Guo. This material, indium tin oxide, is projected to become expensive as demand for touch screens grows. “Our proposed transparent conductor offers some interesting technical benefits, and may be less expensive than indium tin oxide in the future.”

The project started when Guo and his students were exploring how nanoparticles in silver can generate color by selectively reflecting light. Silver could produce red and green but not the shorter blue wavelengths. Aluminum could, but it absorbs too much light. So the team tried to get the best of both worlds.

Usually, it’s impossible to make a continuous layer of silver less than 15 nanometers thick. Silver has a tendency to cluster together in small islands rather than into an even coating, Guo explained.

By adding about six percent aluminum, they coaxed the metal into a film of less than half that thickness – seven nanometers. What’s more, when they exposed it to air, it didn’t immediately tarnish as pure silver films do. After several months, the film maintained its conductive properties and transparency.

The team believes that the aluminum is responsible for these improvements. It attaches strongly to the oxygen in glass, anchoring the silver. Once the film is exposed to air, extra aluminum migrates toward the surface to bind with oxygen there. Guo believes that the oxidized aluminum forms a network over the silver surface, blocking more oxygen from binding to the silver. The network also keeps the silver from clumping up when exposed to heat.

The plasmonic capability of the silver film can also be harnessed in metamaterials, which handle light in ways that break the usual rules of optics. Because the light travels with a much shorter wavelength as it moves along the metal surface, the films alone acts as a superlens. To make out even smaller features, the thin silver layers can be alternated with a dielectric material such as glass to make a hyperlens.

Such lenses can image objects that are smaller than the wavelength of light, which would blur in an optical microscope. It can also enable laser patterning – such as is used to etch transistors into silicon chips today – to achieve smaller and smaller features.

A Crystal Ball for Crystal Formation

Kate McAlpine, Michigan Engineering

Jet turbine stability, chocolate smoothness and drug purity all rely on crystallization – transforming fluids into a highly ordered solid. Despite the ubiquity of this process, researchers are still trying to uncover exactly how molecular particles assemble to form a crystalline unit and the factors that drive how that template grows and repeats uniformly. With 100 million hours on Titan, a Cray XK7 supercomputer at the Oak Ridge Leadership Computing Facility, the University of Michigan’s Sharon Glotzer and colleagues are expanding their earlier simulations to explore these important questions. “The emergence of complexity out of simple building blocks has been something that’s always been interesting to me,” Glotzer says.

When chemists think about what prompts small molecules and nanoparticles to self-organize, they gravitate toward intermolecular forces. Positively charged structures glom onto negatively charged ones through electrostatic attraction. Greasy substances clump together in water under sway of weak forces known as van der Waals interactions. Much of water’s behavior results from intermolecular forces known as hydrogen bonds.

But beneath those interactions, each particle has a basic shape, whether round, oblong or a polygon. That fundamental structure serves as a template for these other interactions, Glotzer says, changing their strength and tuning their influence on self-assembly.

Studying the role of shape in self-assembly came up accidentally, Glotzer says, as she and her colleagues were studying the properties of semiconducting nanoparticles their University of Michigan colleagues produced. Small changes in molecules on the surface of the nanoparticles led to big structural changes.

“Every time they changed that, they got a completely different self-assembled structure from what they had before,” she says. So her team decided to strip such systems down to their basics, removing all the interactions to look at the role of shape alone in crystallization. By focusing on shape, their workzeroed in on the contribution of a single, fundamental thermodynamic property: entropy. Many people associate the idea of entropy with disorder, Glotzer notes. But more precisely, entropy pushes atoms and molecules to seek greater options in their vibrations and rotations.

In wide-open spaces, entropy can drive molecules to move in ways that appear random and chaotic. But in relatively confined spaces, an ordered-looking arrangement can provide that greater flexibility in scenarios that depend on particle shape. Theoretical physicists had played with this idea in the past, for instance showing that tiny balls that half-fill a box will choose to pack together to optimize entropy. Glotzer offers another example: pushing pencils into a pile on a table. The pencils naturally align parallel to each other, increasing the ways they can arrange without butting neighbors.

In recent years, as chemists and materials scientists have synthesized new complex molecules and nanoparticles, understanding packing and crystallization behavior has become increasingly important, Glotzer says.

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A Crystal Ball for Crystal Formation (CONTINUED FROM PAGE 9)

Two of the 2016 Nobel laureates in physics, J. Michael Kosterlitz and David J. Thouless, made fundamental contributions to understanding the complex process of crystallization and its relationship to exotic states of matter such as superconductivity. Working with others, they came up with a theoretical model known as KTHNY theory that looked at the behavior of two-dimensional disks. Unlike water that forms a direct, or first order, transition to ice crystals, KTHNY theory proposed that these disks would gradually form a new precrystalline, or hexatic, phase, followed by a second transition to their true crystalline form.

But the only way to test the idea was to run computer simulations, and such calculations required using large sample sizes (millions of particles) and running them many times to get a meaningful result amid random noise. Until recently such calculations were unwieldy, even on the largest supercomputers. “We could not have done the work if not on Titan,” Glotzer says.

In their first computing time allotment at Oak Ridge in 2015 — work supported through the INCITE (Innovative and Novel Computational Impact on Theory and Experiment) program — Glotzer joined Joshua Anderson, a Michigan research scientist, to perform simulations on Titan examining shape behavior. To simulate large enough systems on reasonable timescales, they developed a fast graphics processing unit implementation of the Monte Carlo simulations algorithm, building on what’s called the Monte Carlo checkerboarding technique. After the team’s first Titan project confirmed the hexatic phase in 2-D systems of disks, it set out to explore the role of shape on the KTHNY predictions.

The simulations showed that KTHNY theory was generally right, with a few unexpected modifications. For example, small hexagonal disks behave exactly as KTHNY predicted. Objects with greater numbers of sides all behave like round disks, making a direct transition to the hexatic phase followed by a slower transition to the crystalline form. Pentagons avoid the intermediate phase entirely and make a water-like transition from fluid to crystal. Glotzer and colleagues are moving beyond shape alone, collaborating with experimentalists to study systems’ behavior. For example, the team recently worked with Chad Mirkin’s group at Northwestern University to model and predict the self-assembly behavior of nanoparticles decorated with DNA oligonucleotides — short molecules of genetic material — part of a DOE Energy Frontier Research Center (EFRC).

In their latest INCITE allotment, Glotzer’s team has explored shape in 3-D while adding back the contributions from other types of intermolecular interactions. They want to examine the assembly process frame by frame to understand exactly how and when atoms, molecules and nanoparticles unite as organized solids from fluids and the relative contributions of individual forces.

This information could be critical for many applications. For instance, jet engine turbines rely on materials that are highly resistant to fracture — properties fundamentally tied to the controlled growth of uniform crystals. In addition, pharmaceutical purity and efficacy rely on the reliable crystallization of active drug compounds. Problems in crystallization can lead to poor quality and ineffective or even harmful isomers in compounds. The quality and mouth feel of fine chocolate also relies on crystal quality, Glotzer adds.

Glotzer says crystals can be far more complicated than those in table salt. Instead of having just one or two atoms in a repeating unit cell, some can have 16 or 83 particles in the unit cell, and some intermetallic species can have more than 20,000 atoms in a unit cell. “How do they form?” She wonders. “How in the world do they figure out that they’ve reached their unit cell and repeat? That’s amazing.”

Coating Method Could Improve Temporary Implants

Kate McAlpine, Michigan Engineering

A strategy for coating complicated surfaces with biodegradable polymers has been pioneered by a team of researchers led by Joerg Lahann, a professor of chemical engineering and director of the Biointerfaces Institute at U-M. It could enable coatings for implants that dissolve in the body, such as drugs to improve healing.

Permanent polymer coatings are already used on medical equipment that does not biodegrade, such as metal stents that hold blocked arteries open. The drug prevents cells from growing over the webbed metal structure and narrowing the artery again. It can be applied with a technique called chemical vapor deposition—a process that puts the drug into a gas phase and lays it down in an even coating, like fog turning into frost.

“What you couldn’t do until we published this paper is take a suture that biodegrades and coat with a vapor-based coating that would provide similar benefits,” said Lahann. A suture or biodegradable bone screw might benefit from a coating of growth factors to promote healing, he added.

Other ways of coating include dissolving the drug into a solvent and then spraying it onto the structure. However, the solvents are often toxic, and the spray technique can bridge gaps in open structures or result in one part of a structure blocking the spray from reaching another.

Still, chemical vapor deposition is very tricky with polymers, or chemicals built in a chain—and a biodegradable coating would need to be made out of polymers. Polymers tend to break up when they are vaporized, so they must be built piece by piece onto a surface.

The researchers demonstrated this using two different monomers, or types of links in the polymer chain. By controlling the ratio between the two monomers, and the chemical groups hanging off the sides of the monomers, the team could control how quickly water could get into the polymer and begin breaking up the chain into its nontoxic elements.

In the lab, Lahann’s group is testing out the coating technique with biodegradable scaffolds that they use for implanting stem cells to help heal wounds involving gaps in tissue. They are also beginning a project with the lab of William Giannobile, the Najjar Professor of Dentistry and Biomedical Engineering, to coat biodegradable dental implants with growth factors to speed healing.

Other members of the research team hailed from Northwestern Polytechnical University in Xi’an, China, and the Karlsruhe Institute of Technology in Eggzenstein-Leopoldshafen, Germany.
Synthetic Tooth Enamel May Lead to More Resilient Structures
Kate McAlpine, Michigan Engineering

Unavoidable vibrations, such as those on airplanes, cause rigid structures to age and crack, but researchers may have an answer for that: Design them more like tooth enamel. It could lead to more resilient flight computers, for instance. Most materials that effectively absorb vibration are soft, so they don’t make good structural components such as beams, chassis or motherboards. For inspiration on how to make hard materials that survive repeated shocks, the researchers looked to nature. “Artificial enamel is better than solid commercial and experimental materials that are aimed at the same vibration damping,” said Professor Nicholas Kotov. “It’s lighter, more effective and, perhaps, less expensive.”

He and his team didn’t settle on enamel immediately. They examined bones, shells, carapaces and teeth. Under an electron microscope, tooth enamel shared a similar structure whether it came from a Tyrannosaurus, a walrus, a sea urchin or Kotov himself. (He contributed his own wisdom tooth to the effort.) “To me, this is opposite to what’s happening with every other tissue in the process of evolution. Their structures diversified tremendously but not the structure of enamel,” said Kotov.

Evolution had hit on a design that worked for pretty much everyone with teeth. And unlike bone, which can be repaired, enamel had to last the lifetime of the tooth – years, decades or longer still. It must withstand repeated stresses and general vibrations without cracking. Enamel is made of columns of ceramic crystals infiltrated with a matrix of proteins, set into a hard protective coating. This layer is sometimes repeated, made thicker in the teeth that have to be tougher.

The reason why this structure is effective at absorbing vibrations, Kotov explained, is that the stiff nanoscale columns bending under stress from above create a lot of friction with the softer polymer surrounding them within the enamel. The large contact area between the ceramic and protein components further increases the dissipative forces, thereby otherwise damage it. Bongjun Yeom, a post-doctoral researcher in Kotov’s lab, recreated the enamel structure by growing zinc oxide nanowires on a chip. Then he layered two polymers over the nanowires, spinning the chip to spread out the liquid and baking it to cure the plastic between coats.

It took 40 layers to build up a single micrometer, or one thousandth of a millimeter, of enamel-like structure. Then, they laid down another layer of zinc oxide nanowires and filled it in with 40 layers of polymer, repeating the whole process up to 20 times. Even molecular or nanoscale gaps between the polymer and ceramic would dissipate the energy that might otherwise damage it. Bongjun Yeom, a post-doctoral researcher in Kotov’s lab, recreated the enamel structure by growing zinc oxide nanowires on a chip. Then he layered two polymers over the nanowires, spinning the chip to spread out the liquid and baking it to cure the plastic between coats.

In certain patients who are being treated for cancer, it’s possible for cells to detach from the tumors inside their bodies and begin moving through the bloodstream. These circulating tumor cells, or CTCs, can help oncologists and other clinicians determine how a disease is progressing, and how effective treatments given to that patient have been.

But getting this information requires capturing CTCs, which is not an easy task, in part because CTCs are so rare. That’s according to Seungpyo Hong, a professor at the University of Wisconsin-Madison School of Pharmacy. He is also the co-founder of Capio Biosciences, a startup seeking to commercialize a device that he says could help researchers and healthcare workers capture greater numbers of CTCs than they are able to with the one system that has been cleared for clinical use to date.

Hong joined the faculty at UW-Madison from the University of Illinois at Chicago last month. Capio, which gets its name from the Latin word for “capture,” also changed addresses as part of the move. The startup, which was launched in 2013 by Hong and Andy Wang, an associate professor of radiation oncology at the University of North Carolina at Chapel Hill, recently raised $2.9 million in equity financing from investors.

Hong says that China-based Betta Pharmaceuticals was the “major investor” in the Series A funding round. It could top out at $4.5 million, he says, provided Capio is able to hit certain milestones. Hong declined to provide specifics on what those are.
“It’s a little too early to tell,” he says. “We don’t have that [much data] yet, but based on the patients we’ve seen so far, their CTC trend has been really well coordinated with the clinical outcome.” So far, Capio has conducted three clinical studies that together have involved 60-plus patients, Hong says. Many of them receive care at UNC Health Care in Chapel Hill, NC, near where Wang works.

Hong says that a typical patient is recruited upon receiving a cancer diagnosis, then undergoes a liquid biopsy, a minimally invasive blood test to look for cancer cells. Additional blood samples are collected after each round of treatment, he adds. “If the CTC numbers go down, their response is typically good,” Hong says. “If the CTC numbers go back up, their response is not really good. That’s how we read their cancer progress.”

Capio, which only has two full-time employees but gets help from postdoctoral researchers who work in the co-founders’ labs, has looked at several different types of cancer; the list includes head and neck, renal, prostate, and lung. Currently, CellSearch is intended for use in patients with breast, prostate, or colorectal cancer, according to Janssen Diagnostics’ website.

Capio established a joint venture with Betta Pharmaceuticals that specifically targets lung cancer, in part because that disease is so prevalent in China, Hong says. “The joint venture is to develop this technology in China for the Chinese market,” he says. “Betta has strong interest in non-small cell lung cancer targeted therapies. We see some synergy there.”

Capio also still has yet to determine which cancer OncoSense CTC will target first, but he says that after receiving its first FDA clearance in a cancer, regulatory nods for other forms of the disease would likely follow. “But our technology is a platform technology, so we can expand to other types of diseases as well,” Hong says.

Ellen Arruda - Professor Arruda was elected to the National Academy of Engineering, citing her “pioneering research in polymer and tissue mechanics and their application in innovative commercial products.” Professor Arruda was also a recipient of the 2017 Harold R. Johnson Diversity Service Award.

Sharon Glotzer - In February Professor Glotzer was elected a Fellow of the Materials Research Society for her “groundbreaking work on computational description of nanoparticle self-organization phenomena leading to new classes of advanced materials.”

Peter Ma - Professor Ma was elected to the Council for the Tissue Engineering and Regenerative Medicine International Society. In collaboration with Dr. Eugene Chen, his group was awarded a $3 million grant from NIH to study blood vessel regeneration.

Geeta Mehta - Professor Mehta was named the Dow Corning Assistant Professor in Materials Science & Engineering. This award is given every three years and alternates among MSE and CHE faculty.

Shuichi Takayama - This summer Professor Takayama will begin a new position in the Wallace H. Coulter Department of Biomedical Engineering, a joint endeavor between Georgia Tech and Emory University. He will be a Professor and the Price Gilbert Jr. Chair in Regenerative Engineering and Medicine.

Siu on Tung (Nicholas Kotov & Levi Thompson) - Siu on defended his dissertation, “Aramid Nanofiber Composites for Energy Storage Applications” this spring. He will continue work as Chief Technology Officer at Elegus Technologies a company he co-founded in 2014. The company seeks to commercialize a “lithium-ion battery separator that allows battery manufacturers to increase energy density without compromising safety.”

Apoorv Shanker (Jinsang Kim) - In April Apoorv defended his dissertation, “Rational Designing of Polymeric Materials for Engineering and Biomedical Applications”. This capped an impressive year for Apoorv in which he received a MRS Silver Award and was selected as the Best Oral Presentation at the ACS Excellence in Graduate Polymer Research Symposium.

Master’s Graduates

Arushi Gupta (Jeff Sakamoto) - Arushi will continue her work on solid state batteries at Michigan this fall in the Macro Ph.D. program.

Omkar Gpnte (Anish Tuteja) - Omkar graduated in December and is now a researcher at the 3D Systems Packaging Research Center at Georgia Tech.

Dan Li (Timothy Scott) - During her Master’s study Dan worked with Prof. Scott’s group to develop novel shape-memory polymers for better performance as medical stents. She spent last summer working with P&G.

Huanghe Li (Jinsang Kim) - In September Huanghe will begin his Ph.D. in Chemical and Biological Engineering at Rensselaer Polytechnic Institute.

Yanliang Liu (Michael Solomon) - In Prof. Solomon’s group Yanliang’s work focused on self-assembly and fieldassisted assembly of micro-sized polystyrene particles.

Midori Maeda (Shuichi Takayama) - Midori will join Professor Takayama and this fall will begin her Ph.D. in Biomedical Engineering at Georgia Tech. In January Midori was named a national runner-up in ‘The Search for Hidden Figures’ contest that aimed to recognize emerging female visionaries in STEM fields.

Xiangyun Meng (Joerg Lahann) - Xiangyun’s work in the Lahann lab focused on macrophage-targeted drug delivery particles.

Nathan Wood (Timothy Scott) - Last month Nathan began a position as an associate scientist at BASF in Wyandotte, MI, working in the 3D printing applications group.
Fall 2017 New Students

Shang-Chun (Andrew) Chiang (Ph.D) - Andrew recently completed his Bachelor’s in Chemical Engineering from the University of California, San Diego. His research interest is in characterization of mechanical properties of materials for flexible electronic applications and tissue engineering.

Zhihe Gao (Master’s) - Zhihe joins Macro after completing her Bachelor’s in Macromolecular Science & Engineering at Sichuan University. She has had several industrial and academic research experiences.

Yanan (Candy) Gong (Ph.D) - Candy earned both her Bachelor’s and Master’s degrees in Chemical Engineering from Xi’an Jiaotong University. She has worked for ExxonMobil Asia Pacific R&D since 2013, and will be a part of the Tauber Institute for Global Operations at Michigan.

Shamalee Goonetilleke (Ph.D) - This spring Shamalee finished her Bachelor’s in Materials Engineering at the University of Illinois. She is interested in conducting research on drug localization and delivery, biomimetics, polymerization, and new ways to treat antibiotic resistance.

Arushi Gupta (Ph.D) - In April Arushi completed her Master’s degree with Macro. Prior to that she earned her Bachelor’s in Plastics Technology from Uttar Pradesh Technical University. She plans to continue work with Professor Jeff Sakamoto on polymer electrolytes and hybrid electrolytes for solid state batteries. She was one of three students selected as a Summer 3M Fellow.

Bryce Kriegman (Master’s) - Bryce just completed his Bachelor’s in Materials Science & Engineering at Michigan, and will continue on to earn his Macro Master’s. As an undergraduate he worked with both Professor Jinsang Kim and Geeta Mehta.

Wang Li (Master’s) - In the spring Wang completed his Bachelor’s in Macromolecular Science & Engineering from Sichuan University. He is interested in research on polymer nanocomposites and also completing coursework with the Center for Entrepreneurship or Ross Business School.

Ting Lin (Master’s) - Ting studied Materials Science as an undergraduate at Southwest Jiaotong University. He is interested in work on polymeric composites, functional polymer electronics, and nanostructured materials.

Violet Sheffey (Ph.D) - Violet recently earned her Bachelor’s in Chemical Engineering from the University of New Mexico. She has had experiences in industry and national labs, and her research interests revolve around polymers for sustainability applications. This summer she will be working at P&G in Cincinnati.

Rachel Shifman (Master’s) - Rachel finished her Bachelor’s in Materials Science & Engineering at Michigan this spring. In addition to conducting research in the Ma group, she served as President of the Michigan Materials Society.

Rishabh Tennankore (Master’s) - Rishabh will begin in Macro following the completion of his Bachelor’s in Polymers from Delhi Technological University. He has had a wide range of industrial and academic experiences, and is interested work on polymer nanocomposites and interfacial science.

Kelly Wang (Ph.D) - Kelly graduated from Purdue University last December with her Bachelor’s in Chemical Engineering. Since then she has worked in the Ma group, where she will be a Summer 3M Fellow.

Fall 2017 New Students

Mengjie Yu (Master’s) - Mengjie recently earned her Bachelor’s in Materials Engineering from Qingdao University. Her past research experience has covered areas of polymer liquid crystals, electrospun fibers, and polymer gels.

Shuqing Zhang (Master’s) - Shuqing completed her Bachelor’s in Macromolecular Science & Engineering this year from Sichuan University. She aims to focus on practical utilization of novel biomaterials.

Muru Zhou (Ph.D) - This year Muru finished her Bachelor’s in Pharmaceutical Science from Fudan University. As a Ph.D student she intends to focus on design and synthesis of polymers for drug delivery and medical applications such as biosensors and therapeutics.

Student News

Ted Ahn (Mark Banaszak Holl) - Ted advanced to candidacy in the Winter 2017 term and during the coming school year will work as the Peer Mentorship Coordinator for Macro.


Rosy Cersonsky (Sharon Glotzer) - Rosy continued involvement with outreach work and presented on those efforts at ACS San Francisco in April. Her presentation was titled, “Augmenting Primary and Secondary Education with Polymer Science and Engineering”. Rosy also presented on her own research, “Distinguishing Packing and Assembly Behavior via Phase Transitions in Shape Space” at the spring meetings of APS and MRS.

Ming Dang (Peter Ma) - Ming’s 2016 publication “Local Pulsatile PTH Delivery Regenerates Bone Defects Via Enhanced Bone Remodeling in a Cell-free Scaffold” was selected as Editor’s Choice of Science Translational Medicine.

Yasmine Doleyres (Peter Ma) - Yasmine was inducted into the Michigan chapter of the Edward Alexander Bouchet Graduate Honor Society. At right, Yasmine and Leanna accept the award for ACS/POLY PMSE 2017 best chapter.

Leanna Foster (Kenichi Karoda) - As Peer Mentorship Coordinator during the 2016-17 school year Leanna made important contributions to the Macro community, ensuring a smooth transition for all new students. For the 2017-18 school year she received the competitive Rackham Predoctoral Fellowship. In April at the ACS meeting she gave an oral presentation, “Host-defense peptide-mimetic polymers to target the solution state of bacteria for modulation of biofilm formation”.

Ryan Hall (Ronald Larson) - Ryan was elected as the ACS POLY/PMSE Chapter President for the 2017-18 year.

Jiajun Lin (Henry Sodano) - Jiajun advanced to candidacy for the Winter 2017 term.
**Student News**

**Ayse Muniz (Joerg Lahann)** - This year Ayse was an active leader in the ACS POLY/PMSE chapter outreach efforts. At right, Ayse is pictured with Director Banaszak Holl at the Fall 2016 SACNAS conference.

**Sunghyun Nam (L. Jay Guo)** - Sunghyun advanced to candidacy in Winter 2017.

**Sam Navarro (Peter Ma)** - Sam received a pre-doctoral fellowship award from the NIH Tissue Engineering training grant (T32) for the 2017-18 school year.


**Apoorv Shanker (Jinsang Kim)** - Apoorv was given the Best Oral Presentation Award at the Graduate Polymer Research Symposium at the Spring ACS meeting. His talk was titled, “Molecular Engineering of Polymers to Realize High Thermal Conductivity in Amorphous Systems”. Earlier in the term he received the Richard F. and Eleanor A. Towner Prize for Distinguished Academic Achievement from the College of Engineering.


**Harry van der Laan (Timothy Scott)** - Harry worked throughout the year as President for the ACS POLY/PMSE Chapter. He oversaw the chapter’s seminar series, co-authored funding proposals to the College of Engineering and Rackham, co-authored a paper on the chapter’s outreach efforts, and networked with industry partners to generate opportunities for Macro students. At right, Harry and Matt Boban at an adventure park outing the ACS POLY/PMSE chapter organized last summer.

**Lisha Zhang (Henry Sodano)** - Lisha advanced to candidacy for the Winter 2017 term.

The **ACS POLY/PMSE Student Chapter** organized a plant visit to BASF in Wyandotte, MI for 14 students from Macro and ChE. The visit also included a poster and networking session with BASF research scientists.

**Macro students celebrating the end of the school year. From left to right: Abhishek Dhyan, Nisha Hollingsworth, Ying Liu, Leanna Foster, Nathan Wood, Laura Saunders, Taesu Kim, Alyssa Travitz.**

**Overberger and Yee Leadership Awards**

This year the Macro program again awarded Overberger and Yee Leadership awards to recognize outstanding student commitment to the ACS POLY/PMSE Chapter and Macro program. Students are able to use these awards for professional or research travel.

**Macro students Rosy Cersonsky, Ayse Muniz, and Harry van der Laan each received $700 Overberger Leadership Awards. Rosy and Ayse were key leaders for the ACS POLY/PMSE outreach initiative, and Harry worked extensively throughout the year as chapter president and a member of the Macro Symposium committee.**

The following students (Macro unless noted) received Yee Leadership Awards for their commitment to going on many outreach visits: Abhishek Dhyani, Heather Fairbairn (ChE), Leanna Foster, Ryan Hall, Nathan Jones, Laura Saunders, Ben Swerdlow (MSE), and Alyssa Travitz.

**2017-18 Chapter Leadership**

The chapter recently held elections and appointed the following students to the chapter leadership: Ryan Hall (President), Abhishek Dhyani (Vice President), Ying Liu (Treasurer), Nisha Hollingsworth (Social Chair).
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Macro has several endowed scholarships and awards that are given in honor of Macro founder Charles G. Overberger, former Director Frank E. Filisko, and longtime Macro Coordinator Nonna Hamilton.

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