

# Indispensable News

# MinneCeutics

## PHARMACEUTICS FACULTY

William F. Elmquist

Carolyn A. Fairbanks

Karunya K. Kandimalla

Jayanth Panyam

Swayam Prabha

Ronald J. Sawchuk (emeritus)

Henning Schroeder

Ronald A. Siegel

Changquan Calvin Sun

Raj G. Suryanarayanan

Timothy S. Wiedmann

Cheryl L. Zimmerman

## AFFILIATE FACULTY

Walid M. Awni, AbbVie

Richard C. Brundage, Dept. of Experimental and Clinical Pharmacology, University of Minnesota

Lester R. Drewes, Dept. of Biochemistry and Molecular Biology, University of Minnesota-Duluth

Michael D. Karol, Synta Pharmaceuticals

David A. Largaespada, Genetics, Cell Biology, and Development, University of Minnesota

Z. Jane Li, Boehringer-Ingelheim Pharmaceuticals, Inc.

Theresa M. Reineke, Dept. of Chemistry, University of Minnesota

Jann N. Sarkaria, Dept. of Radiation Oncology, Mayo Clinic

Evgeniy Y. Shalaev, Allergan  
Chun Wang, Dept. of Biomedical Engineering, University of Minnesota

Joseph A. Zasadzinski, Dept. of Chemical Engineering and Materials Science, University of Minnesota

## From the Department Head

Dear Friends,

It is a great pleasure for me to greet you again this year. The department remains vibrant in all facets of its mission, including our research, teaching, and outreach to the pharmaceutical sciences community. The graduate program continues to flourish, and I want to thank Professor Wiedmann for his tireless efforts as the Director of Graduate Studies (DGS). Dr. Wiedmann stepped down as our DGS this past summer and turned the duties over to the very capable Professor Changquan Calvin Sun. Please see the DGS message for more details. Candy McDermott, our long-time assistant for the graduate program and department, retired from the University earlier in the year. I want to thank her as well for her many years of work that helped make the graduate program what it is today. In the spirit of the changing times, I also am stepping down as department head after six years. I really appreciate all the efforts of the faculty, staff, and students in keeping the department strong during my tenure as department head. After a brief internal search, the department welcomes Professor Jayanth Panyam as the new department head. I am sure he will bring a fresh vitality and the vision needed as we move forward during these times of change. Please join me in welcoming and supporting Jayanth in the months and years ahead. Finally, I want to thank all of you for the support you have given me and the department over the years. Best wishes to all for a safe and productive year ahead.



With kind regards,

*William F. Elmquist, Pharm.D., Ph.D.*

Professor (and former Department Head)

Dear Friends,

I am pleased to write this first letter to you as the new head of the Department of Pharmaceutics. I first wish to thank Professor Bill Elmquist for his excellent service over the last six years. My relationship with Bill goes back to my graduate school days at the University of Nebraska Medical Center where he was a faculty member. He has been, and continues to be, a wonderful mentor for me and a great source of pride for the department. I also thank Professor Tim Wiedmann for his outstanding service as the DGS over the last several years.

We have a number of exciting and challenging tasks ahead of us. We will be conducting a review of the department and the graduate program, where we plan to invite faculty members from other institutions to peer review our department to identify strengths and areas that need improvement. This will be followed by the development of a five-year strategic plan. The goal is to identify research priorities and develop an action plan to strengthen the department and the graduate program. Over the next year, we will be reaching out to you for your input on the department's strategic plan. As Professor Changquan Calvin Sun, our new DGS, mentions in his letter, these are difficult economic times. Funding support for research has been declining. We need to carefully plan for the future so the department and the graduate program continue to flourish.

I hope to see many of you at the AAPS annual meeting. Please plan to attend the annual UMN breakfast session on October 26th. It is a good time to connect with your old friends and make some new ones!

Thank you for your continued support of the department.

Best regards,

*Jayanth Panyam, Ph.D.*

Professor and Department Head



## Alumni News

**Agam Sheth**, Ph.D. [2004], was the winner of the University of Minnesota Alumni Association 2105 U40 Alumni Leader Award for his outstanding work in helping with maternal health in India.

**Ameya Kirtane**, Ph.D. [2015], has joined the laboratory of Professor Robert Langer in the Koch Institute of Integrative Cancer Research at the Massachusetts Institute of Technology in Boston as a postdoctoral associate.

**Frederick Osei-Yeboah**, Ph.D. [2015], has joined Biogen in Boston to set-up a material science function.

**Mohammed Muzakkir Naveed Shaik**, Ph.D. [2008], is an Associate Director at Pfizer in La Jolla, California and currently on assignment in Japan.

**Nagdeep Giri**, Ph.D. [2008], is enjoying spending time with his adorable son, Johan.

**Sagar Suresh Agarwal**, Ph.D. [2011], spent two weeks in Turkey and Greece taking in beautiful scenery and amazing culture.

**Ying Chen**, Ph.D. [2009], has been with Princeton Pharmaceutical, a promising small company that has been growing rapidly, for three years. Ying is responsible for leading pharmacokinetics activities for the company and enjoys bringing new generic and innovative pharmaceutical products to patients.

Send your alumni news and pictures to [pceuts@umn.edu](mailto:pceuts@umn.edu)!



Dr. Elmquist, Dr. Sury, Dr. Sheth, and Dr. Panyam at the 2015 Alumni Award Celebration



Naveed Shaik on assignment in Japan



Sagar Agarwal's hot air balloon view of Cappadocia, Turkey

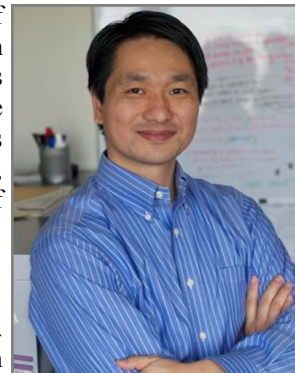


Nagdeep Giri and son, Johan

## From the Director of Graduate Studies

### A Change of Guards

With the trust of our faculty, I was elected the Director of Graduate Studies (DGS) of Pharmaceutics starting my service from July 1, 2015. In this critical role, Professor Tim Wiedmann has left big shoes for me to fill. Our students have routinely garnered prestigious awards, including the university-wide Doctoral Dissertation Fellowships, AAPS graduate student research awards, and IPEC student research awards. Winning these competitive awards speaks volumes about the caliber of our students and the quality of our graduate program, of which we can all be proud. The elite status of our program, developed under the leadership of DGSs before me, makes it a challenging task to protect and further elevate it.



### My Goals

Our department has long been recognized as among the best in pharmaceutics in the nation. My goal, through working with our faculty and students, is to make our great department even better by fostering a culture that bonds all of us like a family where we can always count on each other. This is now possible through social media. I have the full support from both my colleagues and students to reach this goal. I also ask support from you, the Pharmaceutics alumni. I want to hear your candid opinions on what has worked well and how we can make our program better.

### Challenges

Our graduate students are highly sought after by the pharmaceutical industry, as shown by the 100 percent job placement rate for our students. Many of our alumni have assumed leadership positions, both scientific and managerial, in the pharmaceutical industry. With access to the world-class research infrastructure at the University of Minnesota, our talented and enthusiastic faculty members have been actively advancing science, solving problems, and training students. Despite our success, a recent lack of research funding has presented a real threat to the future of our graduate program. We have had to cut back on the number of students we admit every year to cope with the shrinking funding. Currently, there are 21 Ph.D. students and six self-funded M.S. students in our program. With five Ph.D. and four M.S. students expected to graduate within the next twelve months, we may have less than 20 students in the department in the near future. Further downsizing may lead to the loss of the critical mass required for the success of our graduate program.

### What Can You Do to Help?

Establishing fellowships and endowments is a long-term solution to ensure the training of future students regardless of the funding climate. However, action needs to be taken now. The existing departmental fellowships need bigger monetary bases for providing sustainable support. You can help our program by working with your employers to identify opportunities for making charitable gifts to these departmental fellowships or by establishing new named fellowships. Making a personal donation, for example, during the annual United Way campaign, to these department fellowships can be very meaningful. Further information can be found at [give.umn.edu/giveto/DeptofPharmaceutics](http://give.umn.edu/giveto/DeptofPharmaceutics). You can also help by simply keeping in close touch with our department and being an advocate for your alma mater. If you need to fill a position, please contact us. We will be glad to recommend qualified graduate students. If you are visiting a place near the Twin Cities, please visit the department and meet with our graduate students and faculty. After all, the department is a family for us all.

Sincerely,

*Chanquan Calvin Sun, Ph.D.*

Associate Professor and Director of Graduate Studies

## Graduate Student News

### Degrees Earned in 2015

**Ameya Kirtane, Ph.D.** Thesis: *Overcoming transport barriers to nanoparticle-based chemotherapy*. Advisor: Dr. Jayanth Panyam.

**Frederick Osei-Yeboah, Ph.D.** Thesis: *Improving powder tableting performance through materials engineering*. Advisor: Dr. Changquan Calvin Sun.

**Shruthi Vaidhyathan, Ph.D.** Thesis: *Improving the delivery of molecularly-targeted agents to effectively treat melanoma brain metastases*. Advisor: Dr. William Elmquist.

### 2015-2016 Graduate Fellowship Recipients

The University of Minnesota Graduate School awards the **Doctoral Dissertation Fellowship** to top graduate students as they are preparing to defend their Ph.D. theses. One of these highly competitive fellowships was awarded to **Karen Parrish** (Advisor: Dr. William Elmquist).

The **3M Science and Technology Fellowship** is awarded to a promising student with interests in drug development. The recipient this year was **Davin Rautiola** (Advisor: Dr. Ronald Siegel).

The **David J.W. Grant and Marilyn J. Grant Fellowship in Physical Pharmacy** is awarded to students whose research is focused in physical pharmacy. **Wei-Jhe Sun** (Advisor: Dr. Changquan Calvin Sun) was this year's recipient.

The **Edward G. Rippie Fellowship in Pharmaceutics** is awarded to students with a consistent and outstanding academic record. It has been awarded to **Vidur Sarma** (Advisor: Dr. Karunya Kandimalla).

The **Ronald J. Sawchuk Fellowship in Pharmacokinetics** is awarded to a graduate student whose research is focused in pharmacokinetics. **Vidur Sarma** (Advisor: Dr. Karunya Kandimalla) received this year's award.

The **First Year Fellowship** is awarded to a Pharmaceutics Ph.D. student based on excellence in academic

performance in their first year. This year's fellowship was awarded to **Jiangnan Dun** (Advisor: Dr. Changquan Calvin Sun).

The Pharmaceutical Research and Manufactures of America (PhRMA) Foundation chose **Michelle Fung** (Advisor: Dr. Raj Suryanarayanan) as a recipient of a **Pre-Doctoral Fellowship in Pharmaceutics**.

### Pharmaceutics Welcomed New Students in Fall 2015

**Davin Rautiola**, B.S. in Professional Chemistry (Eastern Michigan University), M.S. in Chemistry (Portland State University), M.Eng. in Pharmaceutical Engineering (University of Michigan).

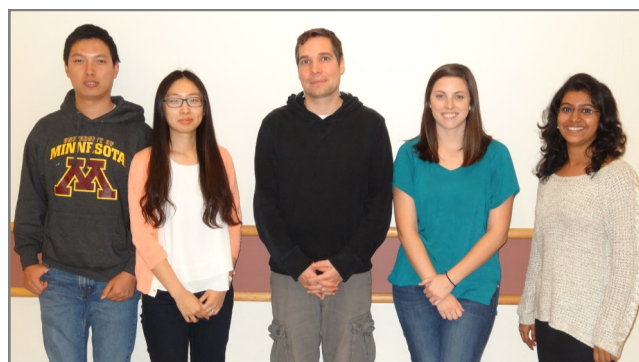
**Hongbo Chen**, B.S. in Pharmaceutical Science (Fudan University).

**Kelsey Pflepsen**, B.S. in Neuroscience (University of Minnesota-Twin Cities), M.S. in Biomedical Engineering (University of Minnesota-Twin Cities).

**Krutika Jain**, B.Pharm. in Pharmacy (Manipal University), M.S. in Pharmaceutical Sciences (University of Southern California).

**Kunlin Wang**, B.S. in Pre-Pharmacy (University of Iowa), B.S. in Chemistry (University of Minnesota-Twin Cities).

**Surabhi Talele**, B.Tech. in Pharmaceutical Sciences (Institute of Chemical Technology).



From left to right: Hongbo Chen, Kunlin Wang, Davin Rautiola, Kelsey Pflepsen, and Surabhi Talele (not pictured: Krutika Jain)

## Graduate Student Activities

**Hyunjoon Kim** won the University of Minnesota Clinical and Translational Science Institute Travel Award for 2015.

**Mehak Mehta** served as the founding chair of the 2015 Preclinical Form and Formulation in Drug Discovery Gordon Research Seminar, held on June 6 and 7 at the Waterville Valley Resort in Waterville Valley, New Hampshire. The meeting was attended by graduate students and post-doctorates from diverse programs across universities. The session topics addressed challenges in drug development of small molecules and proteins.

Mehak will also be receiving a travel award from the Physical Pharmacy and Biopharmaceutics section of AAPS for her poster abstract *Correlation between molecular mobility and physical stability in glassy pharmaceuticals* (poster #M1238) at the 2015 AAPS Annual Meeting.

**Nidhi Sharda** received travelship awards from the University of Minnesota Council of Graduate Students (COGS) and the Cold Spring Harbor Laboratory (CSHL) to present her research work at the CSHL-Blood Brain Barrier meeting. Her poster presentation was titled *Kinetics of amyloid beta trafficking at the blood brain barrier in Alzheimer's disease*. Nidhi also presented her work at the 2014 AAPS Annual Meeting in San Diego, California.

Nidhi is also the recipient of the Pharmacokinetics, Pharmacodynamics, and Drug Metabolism (PPDM) section travelship award to attend the 2015 AAPS Annual Meeting and a graduate student research award in pharmaceutical sciences from the American Association of Indian Pharmaceutical Scientists (AAiPS) for 2015.

She also gave a podium talk at the annual Pharmaceutics Graduate Student Research Meeting (PGSRM) at the University of Kentucky.

**Pinal Mistry** was selected to receive the 2015 Graduate Student Research Award in Physical Pharmacy and Biopharmaceutics section of AAPS for her poster abstract titled *Strength of drug-polymer interactions: implications on the molecular mobility, physical stability, and dissolution behavior of amorphous solid dispersions*. This award is designed to recognize excellence in graduate

education in the fields of physical pharmacy and biopharmaceutics.

She also participated in a summer internship at Genentech in California under the guidance of Dr. Paroma Chakravarty and Dr. Joe Lubach in the Small Molecule Pharmaceutical Sciences Department. Her research project involved investigating the heterogeneous water distribution in solid dosage form by solid state NMR.

Pinal was invited to present her thesis research at:

- AAPS Graduate Student Research Award in Analysis and Pharmaceutical Quality Podium Presentation, San Diego, California (November 2014).
- Centre for Pharmaceutical Engineering Science, University of Bradford, Bradford, England (May 2015).
- Gordon Research Seminar (GRS) Preclinical Form and Formulation for Drug Discovery, Waterville Valley, New Hampshire (June 2015).
- AAPS Excipient Focus Group Webinar (September 2015).

**Sampada Koranne** has been selected for the 2015 Graduate Student Research Award in Analysis and Pharmaceutical Quality section of AAPS for her poster abstract titled *Salt disproportionation in the solid state: characterization by thermal, spectroscopic, and diffractometric techniques*. This award is designed to recognize excellence in graduate education in the fields of pharmaceuticals, bioanalytical chemistry, and pharmaceutical analysis. She will present her poster at the 2015 AAPS Annual Meeting.

**Shail Panchamia** attended the Pharmaceutics Graduate Student Research Meeting (PGSRM) at the University of Kentucky.

**Shao-yu Chang** presented his work titled *Relationship between stability of hydrates and true density measured by helium pycnometry* to Upsher-Smith in August 2015.

**Wei-jhe Sun** presented his work titled *Elucidating sources of fines generated in dry granulation* to Upsher-Smith in August 2015.

## Graduate Student Organizations

### AAPS Student Chapter News

The AAPS Student Chapter organized both educational and social activities last year. The chapter held workshops that focused on leadership, networking, and career development. In addition to these workshops, the student chapter was fortunate to host Joseph Polli, Ph.D., in May 2015. Dr. Polli visited the University of Minnesota as part of the Pharmacokinetics, Pharmacodynamics, and Drug Metabolism Education Initiative and gave three lectures to students and faculty members covering a career in the pharmaceutical sciences, the breast cancer resistance protein transporter, and a discussion on drug-drug interactions at the blood-brain barrier. In addition to these talks, there were numerous opportunities for students to meet with Dr. Polli in small groups. In addition to hosting Dr. Polli, the AAPS chapter partnered with the ISOPR chapter to host the dean of the College of Pharmacy, Marilyn Speedie, to share career-learned lessons with the students.

The student chapter also continued the tradition of Bowling Night at Goldy's Gameroom and volunteered with Habitat for Humanity.



### 2015 Fall Picnic Hosted by the 2013-2014 Pharmaceutics Graduate Student Representatives Sampada Koranne and Hyunjoon Kim

Students prepared great food for the entire Pharmaceutics Department and their families on the banks of the Mississippi River near the medical science buildings. It was a beautiful afternoon and everyone had a great time!



## Graduate Student Organizations (cont.)

### AAPS Student Chapter Officers 2015-2016

Chair: **Youssef Roman** (Experimental and Clinical Pharmacology)

Chair-Elect: **Sampada Koranne** (Pharmaceutics)

Treasurer: **Gautham Gampa** (Pharmaceutics)

Secretary: **Drishti Sehgal** (Pharmaceutics)

Web and Social Media Coordinator: **Sam Callisto**  
(Experimental and Clinical Pharmacology)

Student Outreach Officer: **Irene Vuu** (Experimental and Clinical Pharmacology)

### Pharmaceutics Graduate Student Representatives 2015-2016

**Janice Laramy**

**Saif Rahman**

### Council of Graduate Students (COGS) Pharmaceutics Representative 2015-2016

**Vidur Sarma**

## People

**Allison Siehr** is a graduate student in Biomedical Engineering working in Dr. Siegel's laboratory on self-assembling nanoparticles for antiviral treatments.

**Caroline Rath**, an undergraduate student from Duke University in Durham, North Carolina, worked in Dr. Siegel's lab during the summer of 2015.

**Chenguang Wang**, a Ph.D. student from China's Huazhong University of Science and Technology, visited Dr. Sun's lab from December 2014 to October 2015.

**Dan Jung**, a graduate student in Biomedical Engineering, completed his Plan B Master's degree under Dr. Siegel's supervision.

**Haiqing Dai** recently joined EMD Serono in the Greater Boston area in their clinical pharmacology to support immuno-oncology program.

**Hana Sacic**, an undergraduate student from Ohio State University, worked in Dr. Siegel's lab during the summer of 2015.

**Karlis Berzins** recently joined Dr. Suryanarayanan's group and will be conducting research there through June 2016. He obtained his M.S. degree (magna cum laude) in

Physical Chemistry of Pharmaceuticals from the University of Latvia. For the past four years, while working as a researcher at University of Latvia Department of Physical Chemistry, he has been focusing on API polymorphism, solid state crystallography, and modeling of phase transition kinetics. He is the recipient of the BAFF (Baltic-American Freedom Foundation) fellowship. The main goal of this program is to enrich the ties between the United States and Baltic countries.

**Katie James** joined the Pharmaceutics departmental office in July 2015. She has a Bachelor's degree in Business Administration and over 14 years of experience in providing post-secondary education administrative support. She enjoys books, movies, games, art, music, and parks, and spending time with her husband, two children, and three cats.

**Lili Liu**, a Ph.D. student visiting from the Chinese University of Hong Kong, visited Dr. Sun's lab from August to September 2015.

**Limin Shi**, Ph.D., joined Upsher-Smith Laboratories in Minnesota in October 2015. He was a postdoctoral associate and a scientist in Dr. Sun's research group.

## People (cont.)

**Naveen K. Thakral**, Ph.D., a postdoctoral associate for Dr. Suryanarayanan, is the recipient of a Lilly Innovation Fellowship Award (LIFA), for the third consecutive year. The award, totaling over \$110,000 per year, was created by Eli Lilly and Company with the goal of identifying and fostering exceptional postdoctoral scientists pursuing ground-breaking research projects. The program pairs the postdoctoral scientist with an academic mentor (Dr. Suryanarayanan, University of Minnesota) and a Lilly scientist (Dr. Greg Stephenson), who serves as an industry mentor, to advance a research project titled *Design space of manufacturing processes: potential for phase transformation and development of control strategy*. The postdoctoral fellow will typically work at both the academic institution and at a Lilly research site with access to Lilly scientists and technologies.

**Rafael Castro** is a visiting Master's student from the Autonomous University of Baja California, working in Dr. Siegel's lab on bioinert hydrophobic surfaces and on intranasal delivery of benzodiazepine drugs for rescue from seizure emergencies.

**Raymond Twumasi**, an undergraduate student from St. John's University in Collegeville, Minnesota, worked in Dr. Siegel's lab during the summer of 2015. He was supported by a MRSEC summer program fellowship.

**Ruolin Lu**, a B.S. student in Chemistry, started a UROP project in Dr. Sun's lab during the summer of 2015.

**Seema Thakral**, Ph.D., received a Deane K. Smith Fellowship from the International Center for Diffraction Data (ICDD) to attend the XRD Fundamentals of X-ray

Powder Diffraction Clinic at the ICDD headquarters in Philadelphia, Pennsylvania in June 2015.

Seema also presented a poster at the International Society for Lyophilization and Freeze Drying, Midwest Chapter, in Chicago, Illinois, titled *In situ salt formation during freeze-drying: a strategy to enhance indomethacin dissolution*.

She was invited to deliver a presentation on freeze drying fundamentals at Upsher-Smith, Maple Grove, Minnesota, in June 2015.

**Shuangling Zhang**, Ph.D., joined Dr. Elmquist's lab in January 2014 as a postdoctoral associate after graduating from Texas Tech University Health Science Center in Amarillo, Texas. She investigated the influence of anti-angiogenic therapy on drug delivery to brain tumors and biodistribution of D-luciferin. She plans to return to China with her two-year-old son, Yongbin K. Ai, at the end of September 2015 to seek new opportunities near her hometown of Yibin, China.

**Tanmoy Sadhukha**, Ph.D., a research associate for Dr. Prabha, was selected as one of the Baxter Young Investigator award winners among 100 applicants for his project titled *Nanoengineered MSCs as therapeutic carriers*. Tanmoy is presenting two posters at the AAPS Annual Meeting 2015; please visit him in front of his posters, #T2138 and #T3115.

**Xin He**, a visiting professor from the Agricultural University of Hebei, China, joined Dr. Sun's lab in February 2015.





## Faculty News & Activities

### Professor Carolyn A. Fairbanks



In 2014 and 2015, Dr. Fairbanks and her research team continued to contribute their expertise in intrathecal and epidural drug delivery for translational research collaborations with industry and other academic groups (e.g., the University of Minnesota Center for Translational Medicine). Her research interests focus on targeted delivery of gene therapeutics to specific CNS neuronal subpopulations. This research is supported in part by the National Institute on Drug Abuse (NCCAM) to investigate mechanisms of inhibition of opioid-induced tolerance. Her program also includes a strategy to develop gene therapeutics for the treatment of opioid addiction, an effort generously supported by a gift from the Noble family to the College of Pharmacy.

Additionally, in September 2015, Dr. Fairbanks received a three year Neurosensory and Rehabilitation Research Award from the Department of Defense for her study titled *Controlling neuropathic pain by novel non-opioid pharmacological and gene therapeutic approaches*. Collaborators include Professor R. Scott McIvor (Genetics, Cell Biology, and Development), Professor Lucy Vulchanova (Neuroscience), and Professor Herb Nagasawa (Medicinal Chemistry).

One of Dr. Fairbanks's team members, Dr. Caroline Churchill, defended her thesis in 2014 and has since joined Medtronic.

In 2015 Dr. Fairbanks has welcomed several new members to her laboratory including Daniel Bruce (graduate program in Pharmacology) and Kelsey Pfllepsen (graduate program in Pharmaceutics).



### Professor Chanquan Calvin Sun



Dr. Sun returned in July 2015 from his sabbatical at the University of Copenhagen Department of Pharmacy in Denmark. He was appointed the Director of Graduate Studies of Pharmaceutics for a term of three years. He served on the AAPS Award Committee as a member, the AAPS MSE Award Committee as a chair, and on the AAPS Foundation Committee on Grants and Fellowships (inaugural). He also served as the chair of the Compaction Simulation Forum held at the University of Copenhagen in June 2015.

Dr. Sun was invited to give several presentations this year:

- *Solving tablet manufacturing problems through particle and crystal engineering*. Biogen, Cambridge, Massachusetts (September 2015).
- *Improving tabletability of drugs through crystal engineering*. Compaction Simulation Forum, University of Copenhagen, Copenhagen, Denmark (June 2015).
- *Tablet mechanical strength, brittleness, and friability*. Novo Nordisk, Copenhagen, Denmark (June 2015).
- *Powder flowability: fundamentals, characterization, and enhancement strategies*. AstraZeneca, Mölndal, Sweden (May 2015).
- *Strategies for improving powder tabletability*. AstraZeneca, Mölndal, Sweden (May 2015).
- *Solving problems in tablet manufacturing through crystal and particle engineering*. Department of Pharmaceutical and Pharmacological Sciences, University of Leuven, Leuven, Belgium (March 2015).
- *Materials science tetrahedron: a useful tool in pharmaceutical research*. University of Wolverhampton, Wolverhampton, England (February 2015).
- *Crystal and particle engineering for solving problems in tablet manufacturing*. University of Birmingham, Birmingham, England (February 2015).

## Faculty News & Activities (cont.)

- *Particle and powder engineering for successful tablet manufacturing*. IPROC Seminar, Department of Chemical and Process Engineering, University of Surrey, Guildford, England (January 2015).
- *Engineering strategies for improving powder flowability and tableability*. Department of Chemical Engineering, Imperial College, London, England (January 2015).
- *Powder flow fundamentals, characterization, and pharmaceutical applications*. Danish Technological Institute, Copenhagen, Denmark (January 2015).
- *Powders and particles: flow properties of powder and particle characterization*. Danish Technological Institute, Copenhagen, Denmark (January 2015).
- *Improving tablet manufacturability through crystal and particle engineering*. Department of Pharmaceutical Sciences, University of Milan, Milan, Italy (January 2015).
- *Strategies to expand solid-state landscape of drugs*. Department of Pharmaceutical Sciences, University of Milan, Milan, Italy (January 2015).
- *Roles of materials science tetrahedron in dosage form design*. Eli Lilly, Indianapolis, Indiana (October 2015).

### Professor Cheryl L. Zimmerman



In March 2015, Dr. Zimmerman accompanied eleven Pharm.D. students on a medical mission to Haiti. Dr. Zimmerman and another pharmacist functioned as the pharmacy preceptors in a rural primary care and immunization clinic, which the group set up in a church on the site of an elementary school. The team worked with a nurse and Haitian physicians to treat the students, parents, and people from the surrounding countryside. The four-day clinic treated 465 patients and dispensed approximately 1,800 prescriptions. The student-run organization, CARE for Haiti (Clinics and Relief Efforts for Haiti) is planning annual medical missions and plans to continue to treat the community of Chabin for acute conditions. The next trip is planned for March 2016.

Please see their Facebook page at [www.facebook.com/CareForHaitiClinicsAndReliefEfforts](http://www.facebook.com/CareForHaitiClinicsAndReliefEfforts) which contains more information and photos.

### Professor Jayanth Panyam



Dr. Panyam gave the following presentations this year:

- Kirtane A, Panyam J. *Improving the tumor penetration of drug delivery systems*. American Association of pharmaceutical Scientists (AAPS) Annual Meeting, San Diego, California (November 2014).
- Sadhukha T, Wiedmann TS, Panyam J. *Inhalable magnetic nanoparticles for targeted hyperthermia in lung cancer therapy*. American Association of Pharmaceutical Scientists (AAPS) Annual Meeting, San Diego, California, (November 2014).
- Niu L, Chu L, Hansen K, Panyam J. *Intradermal Delivery of polymeric nanoparticle based vaccine formulation using a hollow microneedle system*. Tumor Immunology and Immunotherapy: A New Chapter, Orlando, Florida (December 2014).
- Kalscheuer S, Panyam J. *Phage display derived antibodies for the detection of mesenchymal CTCs in TNBC*. The 106th Annual Meeting of AACR, Philadelphia, Pennsylvania (April 2015).

Dr. Panyam was also invited to give the following talks:

- *Nanoparticles for tumor-targeted drug delivery: challenges and opportunities*. Department of Chemistry and Biochemistry, University of Minnesota-Duluth, Duluth, Minnesota (March 2015).
- *Targeting circulating tumor cells and metastases in breast cancer*. 6th Annual American Drug Delivery and Formulation Summit, Orange County, California (April 2015).

Dr. Panyam also completed the Twin Cities Marathon in October 2015.

## Faculty News & Activities (cont.)

### Professor Karunya Kandimalla



Dr. Kandimalla's lab investigates pathophysiological mechanisms that mediate toxic amyloid accumulation and trigger cognitive decline in Alzheimer's disease (AD) and cerebral amyloid angiopathy (CAA). Critical findings from these studies are being

employed in developing early detection and treatment strategies for AD and CAA. His research group is also developing novel drug delivery systems to disrupt microbial biofilms and inhibit quorum-sensing circuitry, which promotes antibiotic resistance in bacterial biofilms. In collaboration with the Microbiome Program at the Mayo Clinic in Rochester, Minnesota, Dr. Kandimalla's lab is investigating the impact of human microbiota on the oral drug absorption and metabolism.

Dr. Kandimalla's lab submitted several publications this year. Partnering with their Mayo Clinic collaborators, they also developed a research database that harbors salient features of the blood-brain barrier genomic landscape: <http://bioinformaticstools.mayo.edu/bbbomics/>.

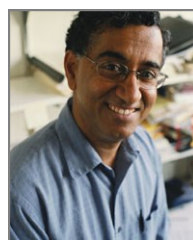
Dr. Kandimalla received a U01 grant from the Food and Drug Administration (FDA) to investigate the fentanyl and scopolamine transdermal drug delivery systems. He is also a co-investigator on the grant *ApoJ/Clusterin peptide as a novel therapeutic agent for Alzheimer's disease* funded by the Alzheimer's Drug Discovery Foundation (ADDF).

Dr. Kandimalla gave the following invited presentations:

- *Vascular contributions to neurodegenerative diseases*. Mayo Clinic College of Medicine Regenerative Neurobiology Meeting, Rochester, Minnesota (October 2014).
- *Development of nanovehicle platform for the diagnosis and treatment of cerebral amyloid angiopathy*. Center for Orphan Drug Research Seminar, University of Minnesota, Minneapolis, Minnesota (October 2014).

- Special academic invitee, Precision Medicine Congress, London, England (September 2015).

### Professor Raj G. Suryanarayanan



Dr. Suryanarayanan is the recipient of the 2015 IPEC Foundation Ralph Shangraw Memorial Award, to be presented at the awards ceremony at AAPS 2015 in Orlando, Florida on Sunday, October 25, 2015. Dr. Suryanarayanan's goal of research

work is to develop a fundamental understanding of the material science properties of pharmaceuticals (both drugs and excipients) to prepare dosage forms with reproducible and predictable properties.

Dr. Suryanarayanan has been appointed as an associate editor of *Molecular Pharmaceutics*, an ACS publication that encourages contributions describing research at the interface of drug discovery and drug development. The journal strives to improve the molecular mechanistic understanding of drug delivery and drug delivery systems.

Dr. Suryanarayanan serves as the chair of Faculty Committee for the National Institute for Pharmaceutical Technology and Education (NIPTE). NIPTE, Inc. is a unique not-for-profit organization dedicated to fundamental research and education in pharmaceutical product development and manufacturing. NIPTE's goal is to increase science- and engineering-based understanding of this area such that novel state-of-the-art technologies can be developed and science-based regulations can be implemented. These technologies will also enable new drug discoveries to be brought to market faster with less variability, higher predictability of performance, and at a significantly lower cost.

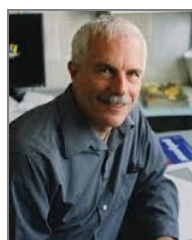
Dr. Suryanarayanan attended the Pharmaceutical Critical Path Manufacturing Research Conference in Rockville, Maryland where he moderated a panel session on quality metrics along with Ajaz Hussain, James Drennen, Lawrence Yu, and Tara Goen Bizjak.

## Faculty News & Activities (cont.)

Dr. Suryanarayanan was invited to give several presentations this year:

- *Molecular mobility in amorphous state: implications on physical stability (roundtable)*. AAPS Annual Meeting, Orlando, Florida (October 2015).
- *Thermal analysis to design freeze-dried pharmaceuticals*. North American Thermal Analysis Society (NATAS) Annual Meeting, Montreal, Quebec, Canada (August 2015).
- *Unique role of XRD in the characterization and quantification of crystalline phases*. Denver X-Ray Conference (DXC), Denver, Colorado (August 2015).
- *Pharmaceutical materials science unique role of XRD in the characterization and quantification of crystalline phases*. 2015 Annual Meeting of the American Crystallographic Association (ACA), Philadelphia, Pennsylvania (July 2015).
- *Advanced characterization of complex dosage forms to demonstrate product equivalence*. Generic Drug User Fee Amendments of 2012 Regulatory Science Initiatives: Request for User Input for FY 2015 Generic Drug Research Part 15 Public Hearing, FDA, White Oak Campus, Silver Spring, Maryland (July 2015).
- *Evaluation of polymorphic changes during tablet manufacturing and storage*. Pharmaceutical Critical Path Manufacturing Research Conference 2015, Rockville, Maryland (April/May 2015) with Eric Munson.
- *Predicting the physical stability of amorphous systems*. AAPS Webinar organized by the AAPS Preformulation group (March 2015).
- *Predicting the physical stability of amorphous systems from molecular mobility*. Genentech, South San Francisco, California (January 2015).
- *Transitions during pharmaceutical processing and product storage*. Bay Area Discussion Group, Foster City, California (January 2015).
- *Monitoring phase transitions during freeze-drying: potential implications on product performance*. Bay Area Discussion Group, Foster City, California (January 2015).
- *Transitions during pharmaceutical processing and product storage*. Materials Science Approaches for Solving Drug Formulation Challenges, a One-Day Symposium-Discussion sponsored by UKIERI at the School of Chemistry, University of Hyderabad, Hyderabad, India (December 2014).
- *Stabilization of amorphous phases*. Dane O. Kildsig Center for Pharmaceutical Processing Research (CPPR) Webinar (October 2014).

### Professor Ronald A. Siegel



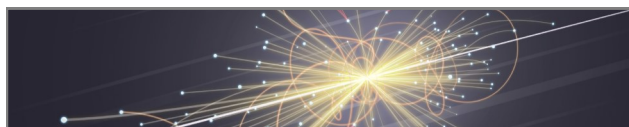
Dr. Siegel received grants from the Academic Health Center and the Institute for Engineering in Medicine to support his work on self-assembling antiviral nanoparticles, in collaboration with Professor Wei Shen (Biomedical Engineering) and Professor Louis

Mansky (Institute of Molecular Virology).

Dr. Siegel continues to direct the Biomaterials and Pharmaceutical Materials Program for IPRIME (Industrial Partners for Research in Interfacial and Materials Engineering) at the University of Minnesota. He is also on the International Scientific Advisory Board for SuMo, a consortium of Swedish universities and companies, funded by the Swedish government, which focuses its research on biomaterials and other soft materials.

To expand his scientific horizons, Dr. Siegel visited his former postdoctoral associate, Marie Pourtier Gaumet, who lives near Geneva, Switzerland. As part of a larger group, they toured CERN and the Large Hadron Collider, where the Higgs boson was discovered in 2012.

Dr. Siegel presented invited lectures at the University of Toronto, Oregon State University, the Universidad Autónoma de Baja California, and the Instituto Tecnológico de Tijuana.



## Faculty News & Activities (cont.)

### Professor Swayam Prabha



Dr. Prabha received the 2015 Minnesota Ovarian Cancer Alliance Grant for her project titled *Glycoengineered mesenchymal stem cells as theranostic agents*.

The Center for Translational Drug Delivery (CTDD) established a research partnership with the Center for Translation Medicine (CTM) and the Department of Neuroscience at the University of Minnesota focusing on the improvement of the delivery of target drugs for clinical use.

Dr. Prabha gave the following presentations this year:

- Sadhukha T, O'Brien T, Prabha S. *Nanoengineered mesenchymal stem cells as targeted therapeutic carriers*. 5th Annual Masonic Cancer Center Research Symposium, Minneapolis, Minnesota (2014).
- Sadhukha T, Prabha S. *Encapsulation in nanoparticles improves anti-cancer efficacy of carboplatin*. Center for Pharmaceutical Processing Research Industrial Advisory Board Meeting, Minneapolis, Minnesota (2014).
- Layek B, Sadhukha T, O'Brien T, Prabha S. *Glycoengineered mesenchymal stem cells as potential theranostic agents: process optimization*. ASME 4th Global Congress on NanoEngineering for Medicine and Biology, Minneapolis, Minnesota (April 2015).
- Sadhukha T, Layek B, O'Brien T, Prabha S. *Glycoengineered mesenchymal stem cells as potential theranostic agents: therapeutic nanoparticle conjugation*. ASME 4th Global Congress on NanoEngineering for Medicine and Biology, Minneapolis, Minnesota (April 2015).
- Layek B, Rahman S, Prabha S. *Design and optimization of multilayered polymeric films for combination therapy*. Chicagoland Pharmaceutical Discussion Group, Chicago, Illinois (2015).

- Layek B, Rahman S, Prabha S. *Design and optimization of multilayered polymeric films for combination therapy*. 47th Annual PGSRM Meeting, Lexington, Kentucky (2015).

She was also invited to give the following presentation:

- *Glycoengineered MSCs as theranostics*. Gynecology Oncology Translational Working Group, University of Minnesota, Minneapolis, Minnesota (May 2015).

Dr. Prabha also completed the Minneapolis Marathon in May 2015.

### Professor Timothy S. Wiedmann



Dr. Wiedmann is presently on a single semester leave at Shenyang Pharmaceutical University, Shenyang, Liaoning Province, in the northwest part of China. He is currently lecturing and assisting in the teaching of biopharmaceutics to students in the

five-year B.S. program (the extra year is for English instruction).

Dr. Wiedmann attended the Inhalation Asia 2015 conference in Shenyang, China and gave an invited talk titled *Targeted magnetic hyperthermia for lung cancer*. He is also pursuing collaborations in the area of inhalation drug delivery with Professor Shirui Mao and Professor Dongmei Cun.

The College of Pharmacy and Shenyang Pharmaceutical University have signed a Memorandum of Agreement for the purpose of advancing interactions between the two institutions with inter alia the exchange of faculty and students.

Dr. Wiedmann and Dr. Lisa Peterson received a grant for their study titled *Interactions between tobacco smoke constituents in rodent tumor models*. Their studies will provide critical information for the assessment of the human safety of new and emerging tobacco products.

## Faculty News & Activities (cont.)

### Professor William F. Elmquist



Dr. Elmquist was invited to give the following talks this year:

- *Efflux transporters in the BBB: role of Pgp and BCRP in CNS drug delivery.* Keynote Address, Solvo Meet the Experts Transporter Conference, San Francisco, California (October 2014).
- *Blood-brain barrier transporters in the treatment of primary and secondary brain tumors.* Graduate Program in Neuroscience Colloquium, University of Minnesota, Minneapolis, Minnesota (October 2014).
- *Drug delivery factors that influence the treatment of primary and secondary brain tumors.* Joint JSSX/ISSX Annual Meeting, San Francisco, California (October 2014).
- *Impact of endothelial efflux pumps and cellular protective mechanisms on drugs.* CNS Anticancer Drug Discovery and Development Conference, Society for Neuro-oncology, Miami, Florida (November 2014).

- *Delivery and efficacy of targeted agents in the treatment of brain tumors.* Genentech, South San Francisco, California (May 2015).
- *Transporters in cancer chemotherapy ADME: targeted bioavailability.* 5th Kuwait International Pharmacy Conference, Kuwait University, Kuwait City, Kuwait (February 2015).
- *Role of transporters in the treatment of primary and metastatic brain tumors.* 5th Kuwait International Pharmacy Conference, Kuwait University, Kuwait City, Kuwait (February 2015).
- *The rough road to a brain tumor: a story of active transporters, tight junctions, and narrow tunnels.* Cerebral Vascular Biology Conference, Cite' Internationale Universitaire, Paris, France (July 2015).



## Recent Publications

Arora K, Bhardwaj S, Mistry P, Suryanarayanan R. 2015. Modulating the dehydration conditions of adefovir dipivoxil dihydrate to obtain different physical forms of anhydrate. *J. Pharm. Sci.* 104(3), 1056-1064. DOI: 10.1002/jps.24296. PMID 25545839.

Becker CM, Oberoi RK, McFarren SJ, Muldoon DM, Pafundi DH, Pokorny JL, Brinkmann DH, Ohlfest JR, Sarkaria JN, Largaespada DA, Elmquist WF. 2015. Decreased affinity for efflux transporters increases brain penetrance and molecular targeting of a PI3K/mTOR inhibitor in a mouse model of glioblastoma. *Neuro Oncol.* 2015 May 12. pii: nov081. (Epub ahead of print)

Bhalla AS, Siegel RA. 2014. Mechanistic studies of an autonomously pulsing hydrogel/enzyme system for rhythmic hormone delivery *J. Control. Rel.* 196, 261-271 (2014). NIHMS640330. DOI: 10.1016/j.jconrel.2014.10.019. PMID: 25450402. (PubMed - in process)

Bhardwaj S, Arora K, Kwong E, Templeton A, Clas S, Suryanarayanan R. 2014. Mechanism of amorphous itraconazole stabilization in polymer solid dispersions: role of molecular mobility. *Mol. Pharm.* 11(11), 4228-4237. PMID: 25325389.

## Recent Publications (cont.)

- Chow SF, Wan KY, Cheng KK, Wong KW, Sun CC, Baum L, Chow AHL. 2015. Development of highly stabilized curcumin nanoparticles by flash nanoprecipitation and lyophilization. *Eur. J. Pharm. Biopharm.* 94:436-449.
- Drees J, Mertensotto M, Liu G, Panyam J, Leonard A, Augustin L, Schottel J, Saltzman D. 2015. Attenuated Salmonella enterica Typhimurium reduces tumor burden in an autochthonous breast cancer model. *Anticancer Res.* 35(2):843-9.
- Fernández-Gallardo J, Elie BT, Sadhukha T, Prabha S, Sanaú M, Rotenberg SA, Ramos JW, Contel M. 2015. Heterometallic titanium-gold complexes inhibit renal cancer cells in vitro and in vivo. *Chem. Sci.* 6, 5269-5283.
- Frik M, Martínez A, Elie BT, Gonzalo O, Ramírez de Mingo D, Sanaú M, Sánchez-Delgado R, Sadhukha T, Prabha S, Ramos JW, Marzo I, Contel M. 2014. In vitro and in vivo evaluation of water-soluble iminophosphorane ruthenium(II) compounds: a potential chemotherapeutic agent for triple negative breast cancer. *J. Med. Chem.* 57(23): 9995-10012.
- Gong X, Chang S-Y, Osei-Yeboah F, Paul S, Perumalla SR, Shi L, Sun W-J, Zhou Q, Sun CC. 2015. Dependence of tablet brittleness on tensile strength and porosity. *Int. J. Pharm.* 493: 208-213.
- Gong X, Sun CC. A new tablet brittleness index. 2015. *Eur. J. Pharm. Biopharm.* 93:260-266.
- Govindarajan R, Landis M, Hancock B, Gatlin L, Suryanarayanan R, Shalaev E. 2015. Surface acidity and solid-state compatibility of excipients with an acid-sensitive API: case study of atorvastatin calcium. *AAPS Pharm. Sci. Tech.* 16(2), 354-363. PMID: 25319055.
- Gummadi T, Zhang BY, Valpione S, Kim C, Kottschade LA, Mittapalli RK, Chiarion-Sileni V, Pigozzo J, Elmquist WF, Dudek AZ. 2015. Impact of BRAF mutation and BRAF inhibition on melanoma brain metastases. *Melanoma Res.* 2015 Feb; 25(1):75-9. DOI: 10.1097/CMR.000000000000133.
- Khorasani M, Amigo J, Sun CC, Bertelsen P, Rantanen J. 2015. Near-infrared chemical imaging (NIR-CI) as a process monitoring solution for a production line of roll compaction and tableting. *Eur. J. Pharm. Biopharm.* 93:293-302.
- Kirtane AR, Lis L, Georg G, Gurvich V, Panyam J. 2015. Reformulating tylocrebrine in EGFR targeted polymeric nanoparticles improves its therapeutic index. *Mol. Pharmaceutics.* 12(8):2912-23.
- Kirtane AR, Siegel RA, Panyam J. 2015. A pharmacokinetic model for quantifying the effect of vascular permeability on the choice of drug carrier: a framework for personalized nanomedicine. *J. Pharm. Sci.* 1174-1186. DOI: 10.1002/jps.24302. PMID: 25583443. (PubMed in process)
- Kothari K, Ragoonanan V, Suryanarayanan R. 2014. Dielectric spectroscopy of small molecule pharmaceuticals: effect of sample configuration. *J. Pharm. Sci.* 103(10), 3190-3196. PMID: 25176641.
- Kothari K, Ragoonanan V, Suryanarayanan R. 2015. The role of drug-polymer hydrogen bonding interactions on the molecular mobility and physical stability of nifedipine solid dispersions. *Mol. Pharm.* 12(1), 162-170. PMID: 25426538.
- Kothari K, Ragoonanan V, Suryanarayanan R. 2015. The role of polymer concentration on the molecular mobility and physical stability of nifedipine solid dispersions. *Mol. Pharm.* 12(5), 1477-1484. DOI: 10.1021/mp500800c. PMID: 25894099.
- Krishna GR, Bag PP, Shi L, Sun CC, Reddy CM. 2015. Correlation among crystal structure, mechanical behavior, and tableting in the co-crystals of vanillin isomers. *Cryst Growth Des.*, 15: 1827-1832.

## Recent Publications (cont.)

- Lou B, Perumalla SR, Sun CC. 2015. From molecular salt to pseudo CAB cocrystal: expanding solid-state landscape of carboxylic acids based on charge-assisted COOH $\cdots$ COO $^-$  hydrogen bonds. *J. Mol. Struct.* 1099:516-522.
- Mistry P, Mohapatra S, Gopinath T, Vogt FG, Suryanarayanan R. 2015. Role of the strength of drug-polymer interactions on the molecular mobility and crystallization inhibition in ketoconazole solid dispersions. *Mol. Pharm.* 12(9), 3339-3350. PMID: 26070543.
- Osei-Yeboah F, Sun CC. 2015. Tabletability modulation through surface engineering. *J. Pharm. Sci.* 104:2645–2648.
- Osei-Yeboah F, Sun CC. 2015. Validation and applications of an expedited tablet friability method. *Int. J. Pharm.*, 484:146-155.
- Parrish KE, Sarkaria JN, Elmquist WF. 2015. Improving drug delivery to primary and metastatic brain tumors: strategies to overcome the blood-brain barrier. *Clin Pharmacol Ther.* Apr; 97(4):336-46.
- Pokorny JL, Calligaris D, Gupta SK, Iykegbe DO Jr, Mueller D, Bakken KK, Carlson BL, Schroeder MA, Evans DL, Lou Z, Decker PA, Eckel-Passow JE, Pucci V, Ma B, Shumway SD, Elmquist WF, Agar NY, Sarkaria JN. 2015. The efficacy of the weel1 inhibitor MK-1775 combined with temozolomide is limited by heterogeneous distribution across the blood-brain barrier in glioblastoma. *Clin Cancer Res.* Apr 15; 21(8):1916-24.
- Puhalla S, Elmquist W, Freyer D, Kleinberg L, Adkins C, Lockman P, McGregor J, Muldoon L, Nesbit G, Peereboom D, Smith Q, Walker S, Neuwelt E. 2015. Unsanctifying the sanctuary: challenges and opportunities with brain metastases. *Neuro Oncol.* 2015 May; 17(5):639-51. DOI: 10.1093/neuonc/nov023. (review)
- Sarafoglou K, Zimmerman CL, Gonzalez-Bolanos MT, Willis BA, Brundage R. 2015. Interrelationships among cortisol, 17 $\alpha$ -hydroxyprogesterone, and androstenedione exposures in the management of children with congenital adrenal hyperplasia. *J. Investig. Med.* 63 (1): 35-41.
- Siegel RA, Kapoor M, Cheryala N, Georg G, Cloyd JC. 2015. Water soluble benzodiazepine prodrug/enzyme combinations for intranasal rescue therapies. *Epilepsy and Behavior.* 49, 303-306. DOI: 10.1016/j.yebeh.2015.04.0267.
- Song J\*, Kirtane AR\*, Upadhyaya P\*, Qian X, Balbo S, Panyam J, Kassie F. 2014. Intranasal delivery of liposomal indole-3-carbinol: a promising strategy for lung cancer chemoprevention. *Int. J. Pharm.* 9:2933-42. (\*equal contributions)
- Sun CC. 2015. Dependence of ejection force on tableting speed: a compaction simulation study. *Powder Technol.* 279:123-126.
- Sun CC, Shargel L, Yu ABC. 2015. Biopharmaceutical aspects of the active pharmaceutical ingredient and pharmaceutical equivalence. *Applied Biopharmaceutics and Pharmacokinetics, 7th ed.* Shargel L, editor; Yu ABC, editor. McGraw-Hill.
- Sundaramurthi P, Suryanarayanan R. 2014. Azithromycin hydrates: implications of processing-induced phase transformations. *J. Pharm. Sci.* 103(10), 3095-3106. PMID: 25139082.
- Thakral NK, Mohapatra S, Stephenson G, Suryanarayanan R. 2015. Compression-induced crystallization of amorphous indomethacin in tablets: characterization of spatial heterogeneity by two-dimensional X-ray diffractometry. *Mol. Pharm.* 12 (1), 253-263. PMID: 25438193.
- Thakral NK, Hiroyuki Y, Stephenson G, Suryanarayanan R. 2015. Spatial distribution of trehalose dihydrate crystallization in tablets by X-Ray diffractometry. *Mol. Pharm.*



## Recent Publications (cont.)

- Thakral S, Suryanarayanan R. 2015. Salt formation during freeze-drying: an approach to enhance indomethacin dissolution. *Pharm. Res.* June 1. DOI: 10.1007/s11095-015-1732-0. PMID: 26063046. (Epub ahead of print)
- Tian Y, Shi C, Sun Y, Zhu C, Sun CC, Mao S. 2015. Design micellar nanocarriers with improved drug loading and stability based on solubility parameter. *Mol. Pharm.* 12: 816–825.
- Ullah M, Hussain I, Sun CC. 2015. The development of carbamazepine-succinic acid cocrystal tablet formulations with improved in vitro and in vivo performance. *Drug Dev. Ind. Pharm.* (accepted)

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