

Indispensable News

Minneceutics

University of Minnesota

Fall 2009

Department of Pharmaceutics

All the news that fits, we print

FROM THE DEPARTMENT HEAD

Dear Friends,

It is a great pleasure for me to greet you again after a short hiatus for the Pharmaceutics Newsletter. Since our last newsletter much has happened in the department. Professor Siegel has stepped down as department head, and I have assumed those duties. We all owe Ron Siegel a debt of gratitude for his long-standing efforts as our department head over the last decade. He has set the stage for continued success. We are fortunate to have three new faculty members, Jayanth Panyam, an expert in nanotechnology, Henning Schroeder, an authority in cardiovascular impact of antioxidants, and Calvin Sun, who studies critical manufacturing aspects of solid dosage forms. These great additions bring the department faculty to a total of ten. We will be looking to recruit two more faculty members in the next few years. This means the department will reach a size that can sustain many diverse research initiatives and our graduate program will continue to develop excellent, multi-talented pharmaceutical scientists for the future. Our outreach to the rest of the University and to the pharmaceutical industry continues, with the department faculty becoming strong collaborators in finding novel means to treat disease. I wish thank all of you who have helped us reach this point, and those that will help us continue to flourish. Please look over the many accomplishments listed in this newsletter. You will see that you can be proud of the Department of Pharmaceutics at the University of Minnesota.



With Kind Regards,

Bill Elmquist

A handwritten signature in black ink that reads "Will F. Elmquist".

Alumni and Friends!!!

Don't forget
**THE MINNESOTA BREAKFAST AT THE
AAPS ANNUAL MEETING**

Please join us for breakfast and to catch up with old friends and
to meet new ones!

Monday, November 9, 2009

7:00 - 8:15 a.m.

Room 303AB Los Angeles Convention Center

**PHARMACEUTICS
FACULTY:**

William F. Elmquist
Carolyn A. Fairbanks
Jayanth Panyam
Ronald J. Sawchuk
Henning Schroeder
Ronald A. Siegel
Calvin Changquan Sun
Raj G. Suryanarayanan
Timothy S. Wiedmann
Cheryl L. Zimmerman

**AFFILIATE GRADUATE
FACULTY:**

Walid Awni, Abbott
Laboratories, **Richard C.
Brundage**, Dept. of
Experimental and Clinical
Pharmacology, U. Minne-
sota. **Belinda W.Y.
Cheung**, Dept. of
Pharmaceutics, U.
Minnesota. **William H.
Frey, II**, Alzheimer's
Institute, Regions Hospital.
Z. Jane Li, Pfizer, Inc..
Gregory Rutkowski,
Department of Chemical
Engineering, UM-Duluth,
Evgenyi Y. Shalaev, Pfizer,
Inc. **Timothy S. Tracy**,
Dept. of Experimental &
Clinical Pharmacology, U.
Minnesota. **Chun Wang**,
Dept. of Biomedical
Engineering, U. Minnesota

FROM THE DIRECTOR OF GRADUATE STUDIES

Dear Friends and Colleagues:

It is my great privilege to be embarking on my second three-year term as Director of Graduate Studies in Pharmaceutics. We have had an eventful few years at the University of Minnesota. One recent event affecting us is the re-organization of the Graduate School. The Graduate School will be reconfigured from a free-standing administrative unit to an Office of Graduate Education, which will reside within the Provost's Office. This means that much of the oversight of our graduate programs will be "local", i.e., within the College of Pharmacy (COP). Our current Dean is clearly committed to graduate education, but I do have concerns about future COP administrations. In the short term, however, we are operating in "business as usual" mode, and wait to see whether this re-organization ultimately improves the lot of the individual graduate student.

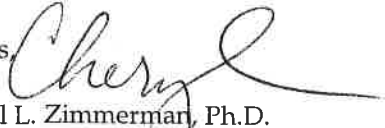


In February 2009, the Graduate Program in Pharmaceutics hosted our first "recruitment" weekend, in which we invited 12 applicants to campus. We had a Friday night poster session, hosted by the current graduate students and post-doctoral scientists, in the McNamara Alumni Center. Saturday was a full day of interviews, tours and faculty presentations, culminating with a banquet at the Campus Club. Both hosts and guests were enthusiastic about the program, and we hope to continue this event in the future. My ongoing concern for the graduate program is the balance between the size of our program and the financial support available for graduate training. Our present graduate student population is around 20 students. For each of the past several years, we have had 50-70 outstanding applicants for admission, and could only admit 4 or 5. As a graduate program we have made a commitment to admit only as many students as we are able to financially support at a stipend that is competitive with our peer programs.

May we ask you, our alumni and friends, for help? More than 90% of our Ph.D. graduates join the pharmaceutical industry, and even in this tough economy our graduates have all found positions. Our graduates are in high demand. We are exceedingly grateful to our industrial colleagues for supporting our students with summer internships and for donating to our many Fellowships. We especially thank Schering-Plough and Cima Laboratories for setting up their own fellowship awards in our program. We also have the three departmental fellowships established in the names of David Grant, Ronald Sawchuk, and Edward Rippie. These fellowships partially fund graduate students, but we hope that you will continue to contribute to the Sawchuk, Grant and Rippie Fellowships so that we can fully fund the fellowship recipients. We have many talented applicants to our graduate program and we wish to maintain the visibility and vibrancy of the program by insuring sustained growth.

Finally, I would to thank Dr. Tim Wiedmann, for carrying out my DGS duties this year when I was on my six-month sabbatical. And as usual, Ms. Candy McDermott, our DGS Assistant has made the job of the DGS run smoothly, and I'd like to thank her for her efforts.

Cheers,


Cheryl L. Zimmerman, Ph.D.

Professor and Director of Graduate Studies

FROM THE FORMER DEPARTMENT HEAD

Dear Colleagues,

Last year I decided, after ten years, to step down as Department Head, and I turned over the "keys" to Prof. Bill Elmquist on July 1, following a unanimous vote on his behalf from the faculty. My decision was based on the belief that just as experience and persistence are essential elements of leadership, so is the willingness to foster opportunities for others, and to realize when one's own passion for leading and managing an academic department has passed its peak. I am more than happy now to be a "regular" faculty member, with more time to devote to my research interests. Bill will bring new energy and ideas, and his own style of leadership. He will be a strong fighter for our department, and its values.

I feel very proud of several accomplishments within our department over the past ten years. During this time, we hired Professors Fairbanks, Elmquist, Panyam, and Sun. Professors Sury, Zimmerman, Wiedmann and Elmquist were all promoted to Full Professor, and Prof. Fairbanks received tenure and promotion to Associate Professor. Professor Sawchuk, the only faculty member not mentioned so far, is undergoing a phased retirement from a successful career, and he is still very active in research and consulting. Our faculty have won several national and international awards for their research, and are highly active in international scholarship and governance related to Pharmaceutics.

Numerous graduate students and postdocs have passed through our department, and we have a remarkable success rate in placing our people in industry, academia, and government. Financial support for our program in the form of the David Grant, Ronald Sawchuk, and Edward Rippie fellowships, along with industrially sponsored fellowships (3M, CIMA Labs) has grown. Our graduate students routinely win travel and best poster awards to national and international conferences.

The saddest part of my tenure as department head was the untimely passing of Professor David Grant, whose program on solid state pharmaceuticals was world class. Numerous students and postdocs came specifically to work with him, and they are his permanent legacy, along with his prodigious research output. The death of an active colleague is something we don't expect, and there is no one to turn to for advice. It has taken about three years to recover from the loss of Dr. Grant, whose memory is now preserved in the David Grant Library. I thank the faculty, Dean Marilyn Speedie, and David's wife Marilyn and sister Gillian, who all showed tremendous resourcefulness in getting through this difficult time.

I thank Candy McDermott, who has stayed with the department through thick and thin, especially for the attention that she pays to the personal needs of the graduate students. Our office is a friendly place, and Candy has set the tone, along with the junior staff who have worked with her. Erica Flynn, our other administrative assistant, is also a joy to work with. I also thank Drs. Sury, Wiedmann, and Zimmerman for their work as DGS, which sometimes appears more difficult than being department head.

Please join me in wishing Bill Elmquist the best in his new leadership role!



Ron Siegel



ALUMNI NEWS

Swati Nagar is 2009 AAPS New Investigator in PPDM



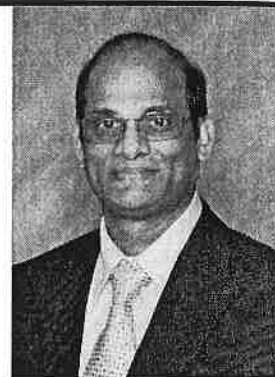
Dr. Swati Nagar will be named the 2009 AAPS New Investigator in Pharmacokinetics, Pharmacodynamics and Drug Metabolism (PPDM) at the Opening Session of the AAPS Annual Meeting in Los Angeles in November 2009.

Dr. Nagar received her B. Pharm. from the Bombay College of Pharmacy, Mumbai, India, in 1998. She received her Ph.D. in Pharmaceutics in 2003; her thesis advisor was Dr. Cheryl Zimmerman. Her thesis was on the metabolism of opioid analgesics in sickle cell transgenic mice. She then joined the laboratory of Dr. Rebecca Blanchard at Fox Chase Cancer Center in Philadelphia as a post-doctoral associate. At Fox Chase, Dr. Nagar was involved in characterizing sulfotransferase (SULT) 1A1 polymorphs *1, *2 and *3. In 2005, Dr. Nagar joined the faculty at the School of Pharmacy at Temple University in Philadelphia, where she is currently an Assistant Professor of Pharmaceutical Sciences. Her current work continues her interest in phase II metabolic processes, particularly with regards to metabolism of polyphenol compounds, including resveratrol. The polyphenols are natural products and are being actively pursued as cancer chemopreventive agents.

Dr. Nagar has a significant number of publications in the drug metabolism literature and is the principal investigator of a cancer prevention research grant from the National Institutes of Health. She was an invited plenary speaker at the 13th North American International Society for the Study of Xenobiotics (ISSX) in 2005, and in 2008 co-chaired a session at the 12th International Glucuronidation and UDP-Glucuronosyltransferases (UGT) Workshop. She is also actively involved in teaching professional Pharmacy students at Temple University, and training M.S. and Ph.D. students in Pharmaceutical Sciences.

The Pharmaceutics Department extends its hearty congratulations to Swati Nagar on this well-deserved honor.

Alekha Dash named to Endowed Chair at Creighton



Dr. Alekha K. Dash (Ph.D., 1990), Chair, Department of Pharmacy Sciences, Creighton University, Omaha, Nebraska was selected the Gilbert F. Taffe, Jr. Endowed Chair of Pharmacy Sciences. The Taffe Chair is a gift of the Gilbert Taffe estate and recognizes a prominent pharmaceutical scientist in the School and it is the only endowed chair at the School of Pharmacy at Creighton University.

Following his graduation from the Sury lab (first graduate student of Raj Sury), Alekha began his academic career in Creighton and rose to the rank of Professor in 2003. His research interests are in preformulation studies, design and evaluation of drug delivery systems including nutraceuticals and solid-state characterization of drugs and dosage forms. Dr. Dash has also received the Excellence in Teaching Award and the Scholarly Achievement Award in recognition of his outstanding teaching and scholarly contributions.

We are proud of you, Dr. Dash!

Drs. Robbie Thorne and Aparna Lakkaraju welcomed the birth of **Isha Lucia** on June 21, 2007.

Yan Song, Ph.D. and her husband welcomed the birth of a baby girl, **Katelyn Liu**, on June 25, 2007.

Bimal Malhotra, Ph.D. was named a Pfizer Global Health Fellow, and spent January- June 2007 in Mumbai, India as part of a collaborative effort between the American Cancer Society and the Indian Cooperative Oncology Network (ICON) to develop the capacity for clinical research for relatively remote semi-urban centers in India.

Zedong Dong, Ph.D. is currently working at the FDA in Rockville, MD. **Ping Ji, Ph.D.** accepted a position there in Summer, 2008. On May 25, 2007, they were blessed with a daughter, **Anna Jia-Xin**.

ALUMNI NEWS

Helen Hou, Ph.D. joined the Formulation Development group at Abbott Laboratories in 2008.

Chitra Telang, Ph.D. and her husband welcomed the birth of a baby girl, Esha, on October 8, 2008.

Luna Musib, Ph.D. accepted a position at Genentech in the San Francisco Bay area in July 2009. Luna joined her new husband, **Deepankar Das**.

Dr. John Roberts is at AstraZeneca-Wilmington focusing on psychiatric PK/PD. He works closely with discovery neuroscience teams to institute behavioral models, electrophysiological endpoints and other biomarkers with improved utility clinical translation. **Rissa Roberts** works in AstraZeneca legal assisting with patent law, in-licensing and e-learning opportunities.

Shekman Wong, Ph.D. is now an Associate Director at Nektar Therapeutics, in San Carlos CA.

DAVID J.W. GRANT MEMORIAL LIBRARY DEDICATED

On September 28, 2008 the Department of Pharmaceutics dedicated the **David J. W. Grant Memorial Library** in memory of the late Professor Grant. Two adjacent offices on the ninth floor of Weaver-Densford Hall were extensively remodeled for use as a library. Professor Grant's large collection of books and journals are housed there along with the collection of Ph.D. and M.S. theses from his many students, and other memorabilia from his distinguished career. Professor Grant's wife, **Marilyn Grant**, and his sister, **Gillian Grant**, attended the dedication ceremony along with many former students and College dignitaries. Professor Ron Siegel and Dean Marilyn Speedie welcomed guests and presented the Grants with mementos of the event. Following the ceremony, guests toured the new library and watched a short video of Dr. Grant's life that was created by Pharmaceutics graduate students and friends and was first aired at the 2006 PGSRM meeting hosted by Minnesota Pharmaceutics graduate students.

The design team for the library included **Candy McDermott** along with **Erica Flynn** and the Pharmaceutics graduate students, **Laura Maertens**, **Sagar Agarwal** and **Tanmoy Sadukha**. Funds for the renovation came from the College of Pharmacy, the Department of Pharmaceutics and the former Drug Delivery Center.

LOST ALUMNI!!

Do you have contact information for the following people? If so, please e-mail us at mcder002@umn.edu

Dorothy F. Elking, Ph.D. (1968)
Ashok K. Gumbhir, Ph.D. (M.S. 1968)
John H. Herath, M.S. (1964)
Hussein Goma Ibrahim, Ph.D. (1974)
Lih-Yang Wang Lin, Ph.D. (1979)
Lucy Tadros, M.S. (1974)
Warren (Yandong) Wen, Ph.D. (1996)
Zheng Wu, Ph.D. (2002)

DO YOU HAVE NEWS? CONTACT US!!

Send your news items to mcder002@umn.edu.

www.pharmacy.umn.edu/pharmaceutics
DEPARTMENT OF PHARMACEUTICS
College of Pharmacy
University of Minnesota
308 Harvard Street S.E.
Minneapolis, MN 55455, USA

GRADUATE STUDENT NEWS

DEGREES EARNED

Sisir Bhattacharya, Ph.D. in Pharmaceutics, 2008

Thesis: Molecular Mobility in Amorphous Pharmaceuticals-Implications of Heterogeneity (Advisor, Prof. Raj Suryanarayanan). Currently employed at Forest Laboratories, Commack, NY.

Amardeep Singh Bhalla, Ph.D. in Pharmaceutics, 2007

Thesis: Physicochemical Investigations of a Drug Delivery Oscillator (Advisor, Prof. Ron Siegel). Currently employed at Schering-Plough, Kenilworth NJ.

Dabing Chen, Ph.D. in Pharmaceutics, 2009

Thesis: Hygroscopicity of Pharmaceutical Crystals (Advisor, Prof. Raj Suryanarayanan). Currently employed at Boehringer-Ingelheim, Ridgefield CT

Ying Chen, Ph.D. in Pharmaceutics, 2009

Thesis: Active Transport and CNS Delivery of Novel Tyrosine Kinase Inhibitors (Advisor, Dr. Bill Elmquist). Currently employed at Pfizer-Wyeth, Pearl River, NY

Shyeilla Dhuria, Ph.D. in Pharmaceutics, 2009

Thesis: Intranasal Targeting of Neuropeptides to the Central Nervous System: Evaluation of Pharmacokinetics, Pharmacodynamics, and a Novel Vasoconstrictor Formulation (Advisor Dr. Bill Frey II). Currently employed at Novartis.

Nagdeep Giri, Ph.D. in Pharmaceutics, 2008

Thesis: Targeted Delivery of Anti-Retroviral Nucleosides: Role of Breast Cancer Resistance Protein (Advisor, Dr. Bill Elmquist). Currently employed at Astra-Zeneca, Waltham, MA

Cory Goracke-Postle, Ph.D. in Neuroscience, 2007

Advisor, Prof. Carolyn Fairbanks. Currently employed at the University of Minnesota, Office of the Vice-President for Research.

Ayman Khdair, Ph.D. in Pharmaceutical Sciences, 2008, Wayne State University

Thesis: Combination photodynamic therapy and chemotherapy to overcome drug resistance (Advisor, Dr. Jayanth Panyam). Currently employed as an Assistant Professor at the Applied Science University, Jordan

Jee Eun Lee, Ph.D. in Pharmaceutics, 2008

Thesis: Dynamic Pharmacodynamic Modeling Focused on the Protein Kinase A Signaling Pathway. (Advisor, Dr. Ron Siegel). Currently employed at the FDA, Rockville, MD

Zhihong Li, Ph.D. in Pharmaceutics, 2007

Thesis: The Possible Role of P-Glycoprotein in the Distribution of Clarithromycin to the Middle Ear. (Advisor, Dr. Ron Sawchuk). Currently employed at the FDA, Rockville, MD

Enxian Lu, Ph.D. in Pharmaceutics, 2008

Thesis: Stabilization of Amorphous Pharmaceuticals by Excipients (Advisor, Prof. Raj Suryanarayanan). Currently employed at Novartis, East Hanover NJ

Nael Mostafa, Ph.D. in Pharmaceutics, 2007

Thesis: Transtympanic Membrane Delivery of Antibiotics-Pharmacokinetic Studies in Chinchillas (Advisor, Dr. Ron Sawchuk). Currently employed at Abbott Labs, Chicago, IL

Siddhartha Mujumdar, Ph.D. in Biomedical Engineering, 2008

Thesis: Stimuli Sensitive Hydrogels for Controlled Drug Delivery and Sensing Applications (Advisor, Dr. Ron Siegel). Currently employed at Boehringer-Ingelheim, Ridgefield CT

Yogesh Patil, Ph.D. in Pharmaceutical Sciences, 2008, Wayne State University

Thesis: Dual-agent nanoparticles to overcome tumor drug resistance (Advisor, Prof. Jayanth Panyam). Currently employed at Impax Laboratories

John Roberts, Ph.D. in Pharmaceutics, 2007

Thesis: Pharmacokinetics, Pharmacodynamics and Transport of Agmatine in the Central Nervous System (Advisor, Dr. Carolyn Fairbanks). Currently employed at Astra-Zeneca, Wilmington, DE

Naveed Shaik, Ph.D. in Pharmaceutics, 2008

Thesis: Enhanced Delivery of Anti-Retroviral Agents to the CNS: Effect of Pluronics (Advisor, Dr. Bill Elmquist). Currently employed at Pfizer, La Jolla, CA

Komal Shahani, Ph.D. in Pharmaceutical Sciences, 2009, Wayne State University

Thesis: Sustained release curcumin microparticles for breast cancer chemoprevention (Advisor, Dr. Jayanth Panyam). Currently employed as a Research Associate, in the Department of Pharmaceutics, UM

Jon Urban Ph.D. in Biomedical Engineering, 2009

Thesis: Nonlinear Spatiotemporal Dynamics in Oscillatory Drug Release (Advisor, Dr. Ron Siegel). Currently employed at Medtronic, Twin Cities

GRADUATE STUDENT NEWS

DEGREES EARNED (CONT.)

Brian Willis, Ph.D. in Pharmaceutics, 2007

Thesis: Opioid Metabolism and Analgesia in a Murine Model of Sick Cell Anemia. (Advisor, Dr. Cheryl Zimmerman). Currently employed at Eli Lilly and Co., Indianapolis IN

Jie Xi, M.S. in Materials Science, 2008

Thesis: Living Synthesis and Phase Characterization of a pH and Temperature Sensitive Diblock Copolymer (Advisor, Dr. Ron Siegel) Currently employed at Proctor and Gamble, Beijing, China

Yuanyuan Xie, Ph.D. in Pharmaceutics, 2008

Thesis: Deposition of Magnetic Aerosol Particles. (Advisor, Prof. Tim Wiedmann) Currently employed at Astra-Zeneca, Waltham, MA

GRADUATE STUDENT ACTIVITIES and AWARDS

Tianli Wang, a student in Dr. Elmquist's group, married **Wei Zhong** on July 28, 2007.

Sisir Bhattacharya and his wife **Ananya** welcomed the arrival of a son, **Prattay**, in January 2007.

Daniel Schuster, a Ph.D. student in Neurosciences, joined Dr. Fairbanks' lab in Fall 2007. Dan is a 3M Fellow as well as a Pre-Doctoral Fellow of NINDS-NIH.

Tate Winter, a Ph.D. student in Pharmaceutics has been recognized for his leadership in the PharmacoNeuroImmunology Training Program (NIDA) where he is a Pre-Doctoral Fellow. Tate is a member of the Fairbanks lab.

Ayman Khdair, a Ph.D. student in Dr. Panyam's lab, received the 2007 AAPS Graduate Student Symposium Award in Biotechnology. His family was blessed with a baby boy (**Abdullah**) in March of 2008.

Komal Shahani, who was a Ph.D. student in Dr. Panyam's lab, received the 2009 AAPS Graduate Student Symposium Award in Biotechnology. Dr. Shahani is now a post-doctoral research associate in Dr. Panyam's group.

Yogesh Patil, who was a Ph.D. in Dr. Panyam's lab was blessed with a baby boy (**Arav**) in April of 2008.

Sagar Agarwal, a Ph.D. student in Dr. Elmquist's group, received the AAPS PPDM Section Travel Award for the 2008 AAPS Annual Meeting. This year he has received the Astra Zeneca Travel Award for 2009 AAPS Annual Meeting.

Prakash Sundaramurthi, a student in Dr. Sury's lab, will receive the 2009 AAPS Graduate Student Symposium Award from the Formulation Design and Development section at the AAPS Annual Meeting to be held in Los Angeles, CA in November. On the personal front, Prakash got married in August and his wife, **Sangeetha**, is doing her MS in Microbiology at Université Pierre et Marie CURIE in Paris.

Tanmoy Sadukha, a student in Dr. Panyam's group, announced the birth of **Pranjoli Sadhukha** on October 15th, 2009. Pranjoli weighed only 5 lbs 8 oz at birth, and she and her mother are both doing well.

NEW GRADUATE STUDENTS

The Department welcomed these new students in Fall 2007:

Sunny Bhardwaj received his B.S. in Pharmacy at University of Delhi (2005) and an M.S. in Pharmaceutical Analysis (2007) from NIPER, Punjab, India. His Ph.D. advisor is Dr. Raj Sury.

Alex Grill received his B.S. in Pharmaceutical Sciences (2007) from Drake University, Des Moines IA. His thesis advisor is Dr. Jayanth Panyam.

Tanmoy Sadhukha received his B.Pharm. in Pharmaceutical Technology (2005) from Jadavpur University, Kolkata, India. His Ph.D. advisor is Dr. Jayanth Panyam.

Jing Wang received a B.S. in Pharmaceutics (2004) from Shenyang Pharmaceutical University and his M.S. in Pharmaceutical Analysis (2007) from the Academy of Military Medical Sciences, Institute of Radiation Medicine, Beijing, P.R. China. His Ph.D. advisor is Dr. Cheryl Zimmerman.

GRADUATE STUDENT NEWS

NEW GRADUATE STUDENTS

The Department welcomed these new students in Fall 2008:

Syantant Chatteraj received his B.Pharm. (2006) from Jadavpur University, Kolkata, India, and ranked first in his graduating class. He received his M.S. in Pharmaceutics (2008) from the same University. His Ph.D. advisor is Dr. Calvin Sun.

Isha Koonar received her B.S. in Pharmacy (2008) from Panjab University, Chandigarh, India. Her Ph.D. advisor is Dr. Ron Siegel.

Ramola Sane received her B.Pharm. (2008) from the Bombay College of Pharmacy, Mumbai India. Her Ph.D. advisor is Dr. Bill Elmquist.

The Department welcomed these new students in Fall 2009:

Caroline (CeCe) Baum received her B.A. in Chemistry and Art History (2002) from St. Thomas University, St. Paul MN. Before joining the UM, she worked at Boston Scientific for several years.

Michael Burcusa received his B.A. in Chemistry (2001) from Carleton College, Northfield MN. Prior to entering the graduate program Mike worked at Cima Labs (2003-2009).

Lin Niu received his B.S. in Pharmacy (2007) and his M.S. in Immunology (2009) from the Huazhong University of Science and Technology, Tongji Medical College, Wuhan, P.R. China.

Khushboo Kothari received her B.S. in Pharmacy (2008) from the Bombay College of Pharmacy, Mumbai, India.

Jie Zhou received her B.S. in Biotechnology (2007) and her M.S. in Biomedical Engineering (2009) from Shanghai Jiao Tong University, P.R. China.

DOCTORAL DISSERTATION FELLOWSHIPS

The University of Minnesota Graduate School awards the *Doctoral Dissertation Fellowship* to graduate students in their final year, as they are preparing to defend their Ph.D. theses. These highly competitive fellowships were awarded to **Shyeilla Dhuria** (2007) and **Paroma Chakravarty** (2008).

FELLOWSHIPS AWARDED TO PHARMACEUTICS GRADUATE STUDENTS 2007-2009

The *Cima Labs Summer Graduate Fellowship* was awarded for the first time in 2009 to **Sunny Bhardwaj** and **Jing Wang**. The award was based on performance in the preliminary written exam.

The *David J.W. Grant and Marilyn J. Grant Fellowship in Physical Pharmacy* is awarded to students whose research is focused in physical pharmacy. It was awarded to **Enxian Lu** (2007), **Pengyun Zeng** (2008) and **Sunny Bhardwaj**, (2009).

The *Edward G. Rippie Fellowship* is awarded to students with a consistent and outstanding academic record. It has been awarded to **Laura Maertens** (2007), **Sagar Agarwal** (2008) and **Jing Wang** (2009).

The *Novartis Award* was awarded to a senior graduate student for the quality of his/her publications. **Dabing Chen** received the award in 2007. This award was re-named in 2008 to the *Pharmaceutics Achievement Award*, which was received by **Yuanyuan Xie**.

The *Ronald J. Sawchuk Fellowship in Pharmacokinetics* is awarded to a graduate student whose research is focused in pharmacokinetics. It has been awarded to **Ying Chen** (2007), **Li Li** (2008) and **Sagar Agarwal** (2009).

The *Schering-Plough Science and Innovation Award* is given to a graduate student who has demonstrated leadership capabilities and can articulate a vision of his/her future contributions to the pharmaceutical sciences. Recipients of the award were **Shyeilla Dhuria** (2007), **Laura Maertens** (2008) and **Paroma Chakravarty** (2009).

The College of Pharmacy awards the **Ted Rowell Graduate Fellowship** to a pharmaceutical sciences graduate student with an interest in nutrition or drug delivery systems. **Laura Maertens** (2007) and **Alex Grill** (2009) were recipients of this fellowship.

The University of Minnesota Graduate School awards the *3M Science and Technology Fellowship* to students from a large number of graduate programs in the Academic Health Center and the Institute of Technology. **Laura Maertens** held the fellowship from 2004-2008, and **Caroline Baum** received the award in 2009.

GRANT FELLOWSHIP BEQUEST

Gillian Grant, sister of the late Professor David J.W. Grant's, made an estate bequest to the College of Pharmacy. The \$1 million bequest will be earmarked for graduate fellowships in physical pharmacy in the name of Marilyn and David Grant.

SCHOLARS

Guoyu Pan, Ph.D., a post-doctoral scientist from Dr. Elmquist's group, joined Novartis in Cambridge MA in November 2008.

Caroline Baum, joined Dr. Fairbank's group in March 2008 as an bioanalytical chemist. She joined the Pharmaceutics Graduate Program in Fall 2009.

Dr. Patrick D. Braun, Research Associate, Dept. of Pharmaceutics, has received a Future Leaders in Pain Small Research Grant "Signaling mechanism of novel peptides in the pain pathway" from the American Pain Society.

Ion Dranca, Ph.D., was a visiting scientist in Dr. Sury's group in 2007-2008. Several other visiting scholars spent time in Dr. Sury's lab, including **Tamaki Miyazaki** (2007-08), **Ilaria Salvadeo** (2007-08) and **Sitaram Velaga** (2008). There have also been several post-doctoral scientists working in Dr. Sury's group. They include **Ajay Saxena** (2008/09), **Kannan Sivaprakasam** (2007-08) and **Venugopal Vangala** (2008-09). The current batch of post-doctoral scientists in Dr. Sury's lab are **Kapildeve Arora**, **Bakul Bhatnagar**, **Aditya Kaushal**, and **Nitin Tayade**.

André Eriksson, Ph.D., who worked in Dr. Cheryl Zimmerman's laboratory from 2005-2006 as a postdoctoral associate is currently employed at Bioneer: FARMA and Faculty of Pharmaceutical Sciences, University of Copenhagen, Denmark.

Dr. Limin Shi joined Dr. Calvin Sun's lab as a post-doctoral associate.

Manthana Varma, M.S., Ph.D., was a post-doctoral scientist in Dr. Cheryl Zimmerman's group from 2006-2008. He is currently employed at Pfizer Global Research and Development, Groton, CT.

Udaya Toti, Ph.D., a recent postdoc in the Panyam lab was blessed with a baby boy (**Abhinav**) in February of 2008. That was a good year for Dr. Toti, as he received the 2008 AAPS Outstanding Postdoctoral Award. Dr. Toti is currently a research associate at the University of Connecticut.

Benjamin Kett, a UM undergraduate student in Computer Sciences, has been working with Dr. Zimmerman to develop models to predict the effects of enzyme induction and inhibition on pharmacokinetics. Benjamin spent the summers of 2008 and 2009 at Boehringer-Ingelheim as an intern.

Several visiting scholars have spent time in Dr. Siegel's group over the past several years. They include **Kristof Ivan**, a visiting researcher from Budapest Institute of Engineering and Economics, **Tina Vermonden**, a visiting postdoc from University of Utrecht, the Netherlands and **Jesse Edwards**, a visiting professor from Florida A&M University. Dr. Siegel's group also profited from the efforts of Drs. **David Barriet** and **Marie Gaumet**, both post-doctoral associates, as well as Dr. Terry Davis, a research associate.

Kati Erdmann, Ph.D. joined Dr. Schroeder's lab as a post-doctoral associate in September 2007 and left in December 2008. She is currently working as a Scientist in Dresden, Germany.

Belinda Cheung, Ph.D. joined the Schroeder lab as Senior Research Associate in April, 2007.

Venugopal Vangala and his wife **Sushma** welcomed a baby girl, **Sragvini** on May 3, 2008.

Reena Kartha, Ph.D. joined Dr. Schoeder's lab as a post-doctoral associate in March, 2008 and was promoted to Research Associate in March, 2009.

Dora Babu Madhura, Ph.D. was a post-doctoral associate in Dr. Sawchuk's lab from in January 2008 to August 2009. He recently accepted a post-doctoral position at the University of North Carolina, Chapel Hill.

Guifang Zhang, Ph.D. was a post-doctoral fellow in Dr. Tim Wiedmann's lab from 2004-2008.

Osman Güldan from Coburg (Bavaria, Germany), University of Applied Science in Giessen (Hesse, Germany) carried out his BS Thesis research in the field of Biopharmaceutical Technology, under the direction of Dr. Wiedmann in 2008.

Rabkwan Chealee, a PhD student in the Department of Pharmaceutical Sciences, Prince of Songkla University, Hat Yai, Thailand, worked with Dr. Wiedmann from 2006-2009.

SCHOLARS (CONT.)

Suresh Swaminathan, Ph.D., joined the Panyam lab in 2008 and **Bharath Raja Guru, Ph.D.** joined the lab in 2009.

Sajeda Abdo joined Dr. Zimmerman's lab as a research assistant in September 2009. Sajeda received her B. S. in Pharmaceutical Sciences from the University of Jordan, Amman in 2006. She is working on bioanalytical methods development.

STAFF

Erica Flynn purchased a house in July 2007 in Richfield, MN. She also adopted a dog named Maybelle from an animal rescue in April 2008.

Sarah Sexton joined the Pharmaceutics staff in June 2007 as Dr. Sury's assistant. She graduated from the University of Minnesota, and has worked in several University departments. Prior to joining Pharmaceutics, Sarah worked for a journal in the School of Statistics. Sarah is married, with a twelve-year-old son and two dogs.

FACULTY NEWS AND ACTIVITIES

PROFESSOR WILLIAM F. ELMQUIST presented *Challenges and Opportunities in Pharmacokinetic Modeling of Intrathecal and Intracerebral Drug Administration* at the CNS Drug Delivery: Theory to Practice: Satellite to Society for Neuroscience meeting in San Diego, CA in November 2007.

Dr. Elmquist presented *In vivo microdialysis: pharmacology in animals, Advancing Blood-Brain Barrier Translational Research* at the Fourteenth Annual Blood-Brain Barrier Consortium Meeting, Skamania Lodge, Stevenson, WA in March 2008. In November 2008 Dr. Elmquist presented *CNS Delivery of "Molecularly-Targeted" Tyrosine Kinase Inhibitors*, at the Division of Pharmaceutical Sciences, The Ohio State University.

Closer to home Dr. Elmquist gave several seminars at the University of Minnesota. In January 2009, he presented *Improving Delivery of "Molecularly-Targeted" Therapy to Glioma Stem Cells* to the Brain Tumor Program, at the Masonic Cancer Center. In February 2009, he presented *Drug Targeting: A Systems Approach* to the Tumor Biology and Progression Program, at the Masonic Cancer Center. In May 2009 he presented *Hide and Seek in the Brain: Glioma 'Stem' Cells Dodge the Magic Bullets* to the PharmacoNeuroImmunology Program.

PROFESSOR CAROLYN A. FAIRBANKS received promotion to Associate Professor with Tenure on May 10th, 2008. She was recruited to become the Vice Chair of Biomedical Sciences of the IACUC for the University of Minnesota in August 2008. She was also elected to the Board of Directors of the American Pain Society. Her research program is currently focused on targeted delivery of gene therapeutics to specific CNS neuronal subpopulations and continues to focus on delineating divergent and convergent mechanisms underlying the development of chronic pain and of addiction.

Dr. Fairbanks and members and alumni of her laboratory have been engaged in a Human Genome Project program. Eight babies were born to lab members and alumni since February 2007. **Kathryn Vianne Kereakos-Fairbanks** arrived on Feb 23rd, 2007 to Dr. Fairbanks and Nick Kereakos. **Zachary Ryan Postle** arrived to Dr. Cory Goracke-Postle and Roman Postle on April 5th, 2007 followed by sister **Claire Kathleen** on August 14th, 2008. Twins **Charles Quang-Loc and Vincent Quang-Viet Anderson** were born to Oanh Nguyen and Peter Anderson on July 20th, 2007 followed by brother **Morgan Bao-Minh** on March 5th, 2009. **Johann Patrick** was born to Caroline and Juergen Baum on May 20th, 2007. **Marco David** was born to Dr. John and Rissa Roberts on June 19th, 2009.

PROFESSOR JAYANTH PANYAM joined the UM Department of Pharmaceutics in August 2007. He received his Ph.D. in Pharmaceutical Sciences from the University of Nebraska in 2003, and was an Assistant Professor of Pharmaceutics at Wayne State University from 2003-2007.

Dr. Panyam presented *Surface-engineered nanoparticles for targeted drug delivery* at the MnNano Briefing, St. Paul, MN in January 2008, and at the Design of Medical Devices Conference, Minneapolis, MN in April 2008. In March 2008, he presented *Surface-engineered nanoparticles for tumor targeted drug delivery and imaging* at the Masonic Cancer Center, University of Minnesota.

Dr. Panyam presented *Nanotechnology-Based Approaches to Overcome Tumor Drug Resistance* to the Women's Interest Group, Masonic Cancer Center, University of Minnesota in April 2008. In November 2008 he presented *Targeted dual agent nanoparticles to overcome p-glycoprotein mediated tumor drug resistance*, at the Institute of Therapeutic Drug Discovery and Development, University of Minnesota, Minneapolis, MN. Also in November 2008 Dr. Panyam presented *Polymeric nanoparticles for targeted drug delivery and imaging*, at the 4th Annual Minnesota Nanotechnology Conference, Minneapolis, MN.

In February 2009 Dr. Panyam was an invited symposium speaker at the Chemistry in Cancer Research: A Vital Partnership in Cancer Drug Discovery and Development conference in New Orleans, LA. His topic was *Surface-functionalization of nanoparticles for multi-targeted drug delivery*.

PROFESSOR RONALD J SAWCHUK was issued US Patent 7,220,431 on May, 22, 2007. The patent was entitled Methods and compositions for applying pharmacologic agents to the ear and R.J. Sawchuk and B.W. Cheung are listed as the inventors.

Dr. Sawchuk received the 2007 American Pharmacists Association Academy of Pharmaceutical Research and Sciences (APhA-APRS) Research Achievement Award for his career-long work in the development and application of pharmacokinetics.

Dr. Sawchuk presented the keynote address at the Fifth International Symposium on Microdialysis in Drug Research and Development in Leiden, The Netherlands on April 2007. His talk was entitled *Future Perspectives on the Contributions of Microdialysis in Drug Research and Development*. In June 2007, Dr. Sawchuk presented *Drug Delivery to the Middle Ear across the Tympanic Membrane for Therapy of Acute Otitis Media* at the Global Gators 6th Symposium on Clinical Pharmacy and Clinical Pharmacology in Munich, Germany. This was followed soon after by a presentation of *The Pharmacokinetics of Hydrophilic Drugs during Intrathecal Infusion: the Concept of a Targeted Delivery Advantage* at Novartis Pharma AG, Basel, Switzerland.

In October 2008, Dr. Sawchuk presented *Trans-tympanic Membrane Delivery of Antibiotics into Chinchilla Middle Ear* at Alcon Laboratories, Fort Worth TX. In April 2009, he traveled to Poitiers, France to present *A Phase I Study to Investigate the Safety and Pharmacokinetics of Intrathecal Gabapentin Injection in Individuals with Chronic Pain* at the University of Poitiers.

PROFESSOR HENNING SCHROEDER joined the UM Department of Pharmaceutics in August 2007. He received his Ph.D. in Pharmacology (1985) from Düsseldorf University in Germany. Immediately prior to joining the UM he was Professor and Chair, Department of Pharmacology, Martin Luther University School of Pharmacy, Halle, Germany, and a Visiting Professor, Division of Neonatology, Stanford University School of Medicine in California. Besides his faculty appointment in Pharmaceutics, he is also the Associate Dean for Research and Graduate Studies, in the UM College of Pharmacy.

Dr. Schroeder presented a lecture on *Heme oxygenase-1 as a therapeutic target in oxidative stress-related diseases* at the 3rd International Symposium of the Collaborative Research Center (SFB) 553 and 12th NO Forum of the German-speaking Countries, Mainz, Germany, October 5th, 2007. He also served as a Session Chair at the same symposium.

Dr. Schroeder is a member of the Scientific Advisory Board for the World Congress on Heart Disease, held annually. In this capacity he participated in the:

- 13th Annual Scientific Sessions of the International Academy of Cardiology, Vancouver, B.C., Canada, July 28-31, 2007
- 14th Annual Scientific Sessions of the International Academy of Cardiology, Toronto, ON, Canada, July 26-29, 2008

He will also participate in the 15th Annual Scientific Sessions of the International Academy of Cardiology Vancouver, BC, Canada, July 24-27, 2010.

Dr. Schroeder served as reviewer of the Austrian Genome Research Programme GEN-AU, Austrian Ministry of Education, Science and Culture.

PROFESSOR RONALD A. SIEGEL stepped down as Department Head on July 1, 2009.

Dr Siegel's invited lectures at Universities include: *Gels, MEMS, and Microfluidics in Sensor and Drug Delivery System Design*, University of Santiago de Compostela, Santiago de Compostela, Spain, February 2007.

Novel Applications of Hydrogels in Drug Delivery and Microfluidics, IPRIME midyear workshop, University of Minnesota, May 2007.

Novel Methods to Measure Interstitial Glucose: Hydrogels, Microfabrication, and Nanoassembly, Diabetes Breakthrough 2007, University of Minnesota, October 2007.

Microfabrication with Hydrogels: Sensing and Hormone Delivery, Dept. of Molecular Pharmaceutics, U. North Carolina (Student AAPS lecture), Chapel Hill, NC, April 2008.

Dr. Siegel presented two seminars at the NATO Workshop on Morphogenesis through the Interplay of Nonlinear Chemical Instabilities and Elastic Active Media, Carghese, Corsica, July 2007. The seminars were

- *Use of Nonlinear Phenomena in Biosensing and Drug Delivery: Hard and Soft Materials* and
- *Biochemomechanical Hormone Delivery: Theory and Experiments*

Dr. Siegel's invited lectures at conferences include:

- Polymers as Functional Excipients, Plenary Lecture, Pharmaceutical Polymers – Bridging Properties with Product Quality and Performance, 4th Ann. Int. Industrial Pharmaceutical Research and Development Conference (Land O' Lakes), Merrimac, WI, June 2007.*
- Responsive and Autonomous Pulsing Hydrogels: Sensing, Drug Delivery, and Microfabrication, AAPS National Biotechnology Conference, San Diego, CA, June 2007.*
- Recent Results on a Hydrogel-Enzyme Oscillator and on Microfabricated Hydrogel Constructs, 7th International Gel Symposium, Tokyo, Japan, August 2007.*
- Novel Hydrogels for Rhythmic, Pulsatile Drug Delivery, Reactive Polymers 2007, Dresden, Germany, September 2007.*
- Identification of Factors Affecting Performance of an Enzyme/Hydrogel Oscillator, Materials Research Society, Boston, MA, November 2007.*
- Dynamic Pharmacodynamics, American College of Pharmacometrics, First Annual Meeting, Tucson AZ, March 2008.*
- Hard/Soft Material Based Sensing and Delivery Systems: Top-Down and Bottom-Up Fabrication Technique," Japan Society for the Promotion of Science Winter School on Nanophotonics, U. North Texas, Denton TX, February 2008.*
- Two sessions, *Top-Down, Bottom-Up Fabrication of a Structurally Asymmetric Membrane, and Factors Governing Glucose-Driven pH Oscillations in a Hydrogel-Enzyme-Marble Reactor,"* at the American Chemical Society, New Orleans, LA, April 2008.
- Top-Down and Bottom-Up Fabrication of Novel Biosensors and Drug Delivery Devices Containing Hydrogels, International Medical Device Society Plenary Lecture. October 2008.*
- Novel Devices for Drug and Hormone Delivery Using Micro/Nanofabrication, and Hard/Soft Materials, Life Sciences Alley 7th Annual Conference and Expo, December 2008.*

PROFESSOR CALVIN SUN joined the Department of Pharmaceutics in July 2008 as an Assistant Professor. Dr. Sun received his Ph.D. in Pharmaceutics at the University of Minnesota in 2000, under the direction of Dr. David Grant. Prior to re-joining the Department, Dr. Sun had been employed at Amgen.

Dr. Sun received the 2008 New Investigator Grant in Pharmaceutics and Drug Delivery and Pharmaceutical Technologies, sponsored by Pfizer. He received the award at the 2008 AAPS Annual Meeting.

Dr. Sun was recognized as one of 21 top reviewers in 2009 by the *Journal of Pharmaceutical Sciences*.

Dr Sun's invited lectures at Universities include:
Materials Science in Tablet Product Development, Rutgers University December 2008.

- Three seminars at NIPER, India, February 2009:
- *Critical Roles of Solid Fraction in Tablet Formulation Development*
- *Improving Powder Processibility by Particle Surfaces Nano Coating*
- *Materials Science Tetrahedron in Tablet Product Development*
- Challenges and Opportunities in Tablet Product Development* Purdue University, February 2009
- Pharmaceutical Tablet Product Development Enabled by Materials Science, Chinese University of Hong Kong, June 2009.*
- Materials Science and Engineering in Tablet Formulation Development* University of Kentucky, October 2009.
- Materials Science in Tablet Product Development, Rutgers University December 2008.*

- Dr. Sun's invited lectures for the industry include:
Xenoport Inc., *Integrating Materials Science with Tablet Product Development, October 2008*
- Eli Lilly, *A New Tool in Tablet Product Development - Materials Science Tetrahedron, November 2008*
- Pfizer, *High Quality Tablet Products Enabled by Materials Science, May 2009.*
- Boehringer-Ingelheim
- *Decoding Powder Tableability* April 2009
- *Expediting formulation development using material-sparing and predictive tools, August 2009.*
- Abbott, *Relationship between Crystal Structure and Powder Compaction, July 2009.*
- Two seminars at Medtronic, October 2009:
- *The Past and Future of Pharmaceutical Materials Science and Engineering*
- *Fundamental Aspects of Powder Flow*

PROFESSOR RAJ G. SURYANARAYANAN was appointed to the William and Mildred Peters Endowed Chair in 2006. This position had previously been occupied by the late Professor David J.W. Grant. Dr. Sury received the 2007 Distinguished Alumnus Award from Banaras Hindu University, Department of Pharmaceutics, Institute of Technology, India.

- Dr. Sury's invited lectures at conferences include:
American Association of Pharmaceutical Scientists
- Short course, roundtable, & symposium, Annual Meeting, TX, 2006
- *Innovations in Excipient Selection, National Biotechnology Conference, CA*
- Pharmaceutical Powder X-ray Diffraction*
Somerset, NJ (2006), Barcelona, Spain (2007), Glasgow, Scotland (2009)

Geotechnical & Environmental Associates, National University of Singapore, 10th Anniversary Commemorative Pharmaceutical Conference, Singapore, 2007

Dr. Sury's invited lectures at Universities and the pharmaceutical industry include visits in:

- 2006 Human Genome Sciences; Andrx Pharmaceuticals; North Dakota State University; Merck & Co.; Pfizer
- 2007 Cephalon; Panalytical; Katholieke Universiteit Leuven; Human Genome Sciences; Duquesne University; Surmodics; Ranbaxy Laboratories Ltd; National Institute of Pharmaceutical Education & Research (NIPER)
- 2008 TA Instruments Users Meeting; Argonne Laboratory Users Week; Bay Area Discussion Group; Smiths Detection Scientific; Ecolab
- 2009 Lupin Ltd.; Janssen-Cilag, Johnson & Johnson

Dr. Sury's contributions to Short Courses include:

- 4th Annual Nassau Inn Meeting, NJ (2007) and 5th Annual Nassau Inn Meeting, NJ (2008)
- 59th IPC, Banaras Hindu University, India (2007)
- Zydus Cadila, India (2008)
- Pfizer, MO (2008)
- IPrime Annual Meeting, MN(2008)
- Indo-US Bilateral Workshop, India NIPER, India (2009)
- Roundtable, CRS 35th Annual Meeting & Exposition, Denmark (2009)

PROFESSOR TIMOTHY WIEDMANN was recognized as one of the top reviewers in 2007 by the *Journal of Pharmaceutical Sciences*.

Dr. Wiedmann's invited presentations include:
Rodent aerosol exposure system at the British Columbia Fox Cancer Center, British Columbia, Canada (2007).

Intraocular aerosol delivery during vitrectomy, Design of Medical Devices, Minneapolis, MN (2007)

Inhalation delivery systems. Oxygen Plus, Inc., Mahtomedi, MN (2007)

Aerosol Delivery: Deposition, Targeting, and Drug Release, Center for Lung Science, University of Minnesota, Minneapolis, MN (2008)

Preclinical assessment of lung cancer: Chemoprevention and therapy, Respiratory Drug Delivery Conference, Scottsboro, AZ (2008).

Magnetic targeted drug delivery, The Second Thailand Nanotechnology Conference, Nanomaterials for Health, Energy and Environment, Phuket, Thailand (2008)

The challenges of inhaled chemotherapy, International Conference on Inhaled Drug Delivery, London, England (2008)

Magnetic targeted drug delivery, Department of Pharmacy, King's College London, England (2008).

PROFESSOR CHERYL L. ZIMMERMAN gave the keynote address at the Pharmaceutical Sciences Graduate Research Symposium, held August 7-8, 2008 at South Dakota State University, Brookings SD. Her talk was entitled *Stereoselective Biological Disposition of Tobacco-Specific Nitrosamines*. She spoke on a similar topic at Virginia Commonwealth University, October 23, 2007 and at the University of Toronto, October 17, 2008.

Dr. Zimmerman was recognized as one of the top reviewers in 2007 by the *Journal of Pharmaceutical Sciences*.

Dr. Zimmerman and Dr. Bill Elmquist presented a short course entitled, *Basic Pharmacokinetic Concepts for the Pharmaceutical Scientist* at Paddock Labs, November 2007-June 2008.

Dr. Zimmerman was on sabbatical from March 1-September 1, 2009. She spent 3 months at Eli Lilly and Company evaluating strategies for animal to human scaling of pharmacokinetics and pharmacodynamics.

Dr. Zimmerman will be inducted as an AAPS Fellow during the Opening Session of the AAPS Annual Meeting on November 8, 2009.

RECENT PUBLICATIONS

BOOK CHAPTERS

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R. K. Cavatur, N. Murthi Vemuri and R. Suryanarayanan, "Preformulation Studies for Tablet Formulation Development". In *Pharmaceutical Dosage Forms: Tablets*, L. L. Augsburger, S. W. Hoag (eds.), Informa Healthcare, New York, 2008

R. Govindarajan and R. Suryanarayanan, "Processing-induced phase transformations and their implications on pharmaceutical product quality". In *Polymorphism*, R. Hilfiker (ed.), Wiley-VCH Verlag GmbH & Co., Weinheim, Germany (2006).

R. J. Sawchuk and B.W.Y. Cheung, "Application of Microdialysis in Pharmacokinetic Studies." in *Handbook of Microdialysis: Methods, Applications and Clinical Aspects*, B.H.C. Westerink and T.I.F.H. Cremers (Editors), Academic Press, Amsterdam, 2007.

Siegel, R.A., "Autonomous Rhythmic Drug Delivery Systems Based on Chemical and Biochemical Oscillators," in *Chemomechanical Instabilities in Responsive Materials* (P. Borckmans, S. Metens and P. DeKepper, A. Khokhlov and S. Mètens and eds.), Springer, Dordrecht (Netherlands), pp. 175-201 (2009).

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