

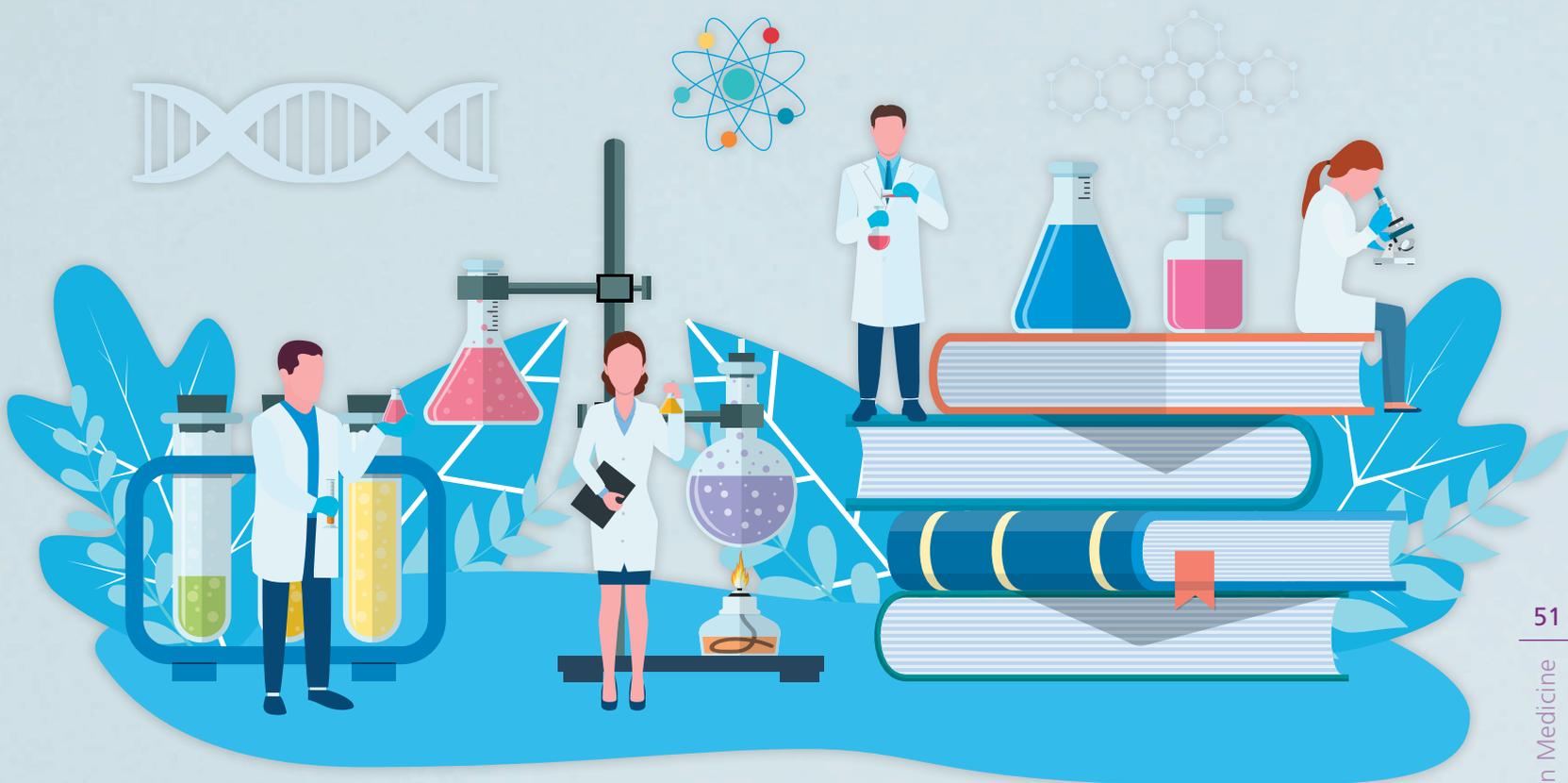
The Integration of Precision Medicine into a Medical School Curriculum

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The Journal of Precision Medicine





Introduction

The University of Arizona College of Medicine – Phoenix (COM-P) is a separately accredited medical school within the University of Arizona Health Sciences with a unique MD precision medicine curriculum tailored to the Phoenix community’s health needs and opportunities.* There are several curricular themes integrated vertically and horizontally across all four years.

For clinical practice, a major element of precision medicine is using *population* clinical data to aid a physician in ensuring that the patient gets an effective treatment at the right dose at the right time with minimum ill consequences based on that patient’s *individual* clinical profile. Despite these advances and the general acceptance of data-informed decisions by *patients*,¹ adoption by clinicians has been surprisingly slow.² To overcome any barriers in translating genetic laboratory test results into actionable prescribing decisions, the Clinical Pharmacogenetics Implementation Consortium (CPIC, <https://cpicpgx.org/>) was formed to evaluate evidence and recommend which drug use could be supported by individual genetic testing. In addition, they identified a number of impediments to adoption, including limitations in the electronic health record, cognitive barriers, lack of incentive to prevent adverse events, availability of preemptive testing, and privacy/legal concerns.^{3,4}

Solutions to these problems exist! And while the vast quantity of relevant clinical data and new genomic information may be very difficult for a physician to recall and utilize in the clinical setting, a computerized decision support system, built seamlessly into the electronic medical record and workflow, provides a solution. The COM-P is in a unique position with its primary clinical partner, Banner Health, to utilize a large healthcare system with an advanced electronic health record for education, research, and patient care in precision medicine.⁵ In addition, the COM-P is actively working to integrate decision support and precision medicine into both undergraduate and graduate medical education.

The assimilation of precision medicine into the curriculum requires a paradigm shift similar to that which led to adopting and adapting to evidence-based medicine 20 years ago. While improvements in individualized efforts toward disease prevention, medication effectiveness, and medication safety were deemed more likely, the precision medicine paradigm had to be developed, implemented and tested.

Curriculum Prior to the Launch of Precision Medicine Theme

In order to establish a baseline and evaluate the inclusion of precision medicine in the pre-clerkship curriculum, pre-clerkship block

directors identified where precision medicine was currently taught in their block and completed a comprehensive query of the curriculum topics. Most blocks included material which briefly mentioned concepts related to genomic or precision medicine. These materials, however, were nebulous and thereby lacked a unified goal; furthermore, this information was commonly presented to medical students as “for the future.” A small amount of teaching time was dedicated to interdisciplinary patient care in genomic medicine, including interdisciplinary education by genetic counsellors, but this has not always been perceived as useful by the students. A recent national survey suggested that students lack insight into the possibility of careers in medical genetics, biomedical informatics, or medical toxicology.⁶

Evaluation of the initial clinical curriculum revealed that little teaching or role modeling of precision medicine was available during the clinical learning years. Instruction that was done in this discipline was limited to a few individual preceptors, rather than any concerted efforts on focused, longitudinally integrated teaching and mentoring that would inculcate this approach in the students. National surveys indicate many preceptors may not feel comfortable integrating and teaching precision medicine.⁷ No specific elective rotation is yet available. ➤

OBJECTIVES



Figure 1: Objectives of the COM-P Precision Medicine Theme

Intervention of Precision Medicine Theme

In order to facilitate the teaching of precision medicine, faculty who were interested in the integration of precision medicine into their clinical practice, teaching, and research were identified and encouraged; those faculty members who expressed interest were invited to a series of workshops that focused on genomic medicine topics relevant to the medical practice.

Several specialty areas with the highest level of expressed interest were targeted. These included the areas of toxicology, neuro-psychiatry, oncology, cardiovascular health, infectious disease and transplantation medicine. We highlighted how precision medicine can combine with biomedical informatics for healthcare delivery and discovery research. These faculty workshops cultivated collaborations among faculty to initiate research and add didactic methods in teaching precision medicine. The importance of offering meaningful

continuing medical education (CME) offerings and career development in these sessions was evaluated and identified as valuable by faculty.

Revision of the pre-clerkship curriculum did not add class hours but involved revision of current teaching sessions to highlights concepts of precision diagnostics and pharmacogenetics (see steps to revise the curriculum for our program are enumerated in **Figure 1**). We employed both informal discussion with each block director and a formal audit of the pre-clerkship curriculum for relevant sessions and faculty development for session leaders. The COM-P has set a goal of increasing the number of “flipped classroom” or active learning sessions. Thus, the changes implemented included the development of independent learning modules, simulation sessions, and learning studios with active participation. *Interdisciplinary education in this area, in particular genetics counsellors and pharmacists, was key.* Students noted this information was helpful,

engaging and well-designed in course evaluations. In fact, these sessions received an average score of 4.9/5 in student evaluations in the first two years. Student comments included:

- “Awesome and engaging session and I loved learning about this!”
- “This session allowed us to interact directly with the resources that help clinicians answer pharmacogenetics questions,” and
- “It is very relevant to consider how different genetic profiles affect drug activity.”

During the clinical rotations in the curriculum, a series of intercession learning studios that are immediately applicable to the content of the clinical rotations has been developed. A short overview document will be created to provide each clinical rotation director recommendations for how best to teach precision medicine that is specific to their area of expertise. An elective rotation will begin during the next academic year, starting in the Section for Precision and Genomic Medicine in the Department of Medical Toxicology at our primary clinical partner, Banner – University Medical Center Phoenix. In addition, we plan to add a rotation to our local VA hospital in conjunction with the clinical PHASER (Pharmacogenomic Testing for Veterans) and research Million Veterans’ Program (see <https://www.cancer.va.gov/phaser.asp>).

Each year, the Precision Medicine Theme provides a report to our institution’s curriculum committee for review and comment from scientists, physicians and staff. At this time the theme is updated to include advancing science, new material, added clinical adaptations and feedback. Sessions may be added and have been entirely revised.

At our affiliated graduate medical education training sites, presentations review current relevant recommendations for implementing precision medicine and explore opportunities for collaboration in research. One major goal will be to familiarize trainees with the best available educational resources for learning consensus practice guidelines and results of up-to-date outcomes research.

Discussion

The goal of the Precision Medicine theme was integration into the curriculum and ensuring every physician trained at the COM-P is proficient in the use of pharmacogenomic data and advanced clinical decision support systems. We want to prepare physicians to effectively integrate future advancements into their patients’ care as well as educate and guide patients. **OPM**



Kenneth S. Ramos, MD, PhD

Kenneth S. Ramos, M.D., Ph.D., is the Alkek Chair of Medical Genetics at Texas A&M University Institute of Biosciences and Technology. He also serves as Assistant

Vice Chancellor for Health Services and Associate Vice President for Texas A&M Health. A member of the National Academy of Medicine, Dr. Ramos has worked closely with colleagues throughout the world to steer the changing landscape of medicine and healthcare and provide academic, executive, administrative, and scientific leadership in the areas of genomic and precision medicine. Translational research in his laboratory focuses on repetitive genetic elements, while his clinical investigations focus on the development and characterization of diagnostic and prognostic biomarkers of cancer and pulmonary disease and pharmacogenomics.

Dr. Ramos served as the Chief Academic Officer and Interim Dean of the University of Arizona College of Medicine – Phoenix and as Associate Vice President for Precision Medicine during the early phases of curriculum development and implementation in the College.



Steven Curry, MD

Steven Curry, MD is a professor of Medicine at the University of Arizona College of Medicine – Phoenix. He directs the Department of Medical Toxicology at Banner – University Medical Center Phoenix and co-directs the

Center for Toxicology and Pharmacology Education and Research at UA College of Medicine – Phoenix.

Dr. Curry graduated from Southern Illinois University School of Medicine. After a residency in Emergency Medicine in Indianapolis, Dr. Curry completed a fellowship in Medical Toxicology in Phoenix, holding board-certification in both specialties. Dr. Curry has received awards for excellence in medical toxicology, outstanding teaching and research from University of Arizona College of Medicine – Phoenix, the American College of Medical Toxicology and other organizations. He has consulted for the Agency for Toxic Substances and Diseases Registry and has been recognized for service provided to the US Food and Drug Administration.

Dr. Curry has published more than 150 peer-reviewed articles, monographs, textbook chapters and letters in the medical literature concerning pharmacology and toxicology. Research interests include critical care pharmacology, hematologic toxins, hepatic failure, mitochondrial actions of drugs and neurotoxicology, as well as health outcomes research.



Paul R Standley, PhD

I earned my doctoral degree in medical physiology at Wayne State University School of Medicine in Detroit, Michigan then completed a post-doctoral fellowship in the Division of Endocrinology and Hypertension

at the same institution. I moved to Arizona to become a founding faculty member at Midwestern University's Arizona College of Osteopathic Medicine where I directed the physiology division, co-developed the school's new curriculum, and continued NIH- and AHA -funded research on biomechanical modeling of arterial pressure waveforms and developing in vitro models of myofascial release and other manual therapies.

In 2006 I became a founding member of The University of Arizona College of Medicine – Phoenix. I have served as an NIH-funded investigator, block director, director of faculty development, Assistant Dean of preclerkship block curricula, and now Associate Dean of Curricular Affairs and Program Evaluation. In 2013 I championed a compressed preclerkship curriculum to allow students early entry into clerkships and in 2016 I began to lead a 5-year curriculum renewal plan to move to a flipped classroom / active learning approach to teaching organ systems-based blocks in years 1 and 2. My joys include outdoor recreation of all sorts, bringing educators and researchers together to solve large issues, and teaching / mentoring medical students to be their very best.



Will Heise, MD

Will Heise, MD, is a medical toxicologist and family physician who joined the faculty of the University of Arizona in 2015 and became a member of the Scientific Review Board for CredibleMeds in 2016. He earned

his MD from the University of Iowa. He completed a residency and fellowship at Banner – University Medical Center Phoenix and is board certified in medical toxicology and family medicine. He has appointments at the University of Arizona College of Medicine – Phoenix in Family, Community & Preventative Medicine, Biomedical Informatics and Medicine. He directs the Precision Medicine Theme at the College of Medicine – Phoenix.



Kurt E Gustin, PhD

Dr. Gustin received his BA in Computer Science Applications in Chemistry from the University of Colorado, Boulder. His graduate work in the Department of Microbiology and Immunology at the University

of Michigan focused on identifying the role of adenovirus proteins in virus assembly. He did his postdoctoral training at Stanford University, where he characterized the impact of picornavirus infection on nucleo-cytoplasmic trafficking. His lab continues to examine the interactions of RNA viruses with host cells in an effort to better understand the mechanisms governing pathogenesis and identify potential therapeutic targets.



Raymond L. Woosley, MD, PhD

Raymond L. Woosley, M.D., Ph.D. is Professor of Medicine and Biomedical Informatics in the University of Arizona (UA) College of Medicine in Phoenix (COM-P), Arizona. He is also the founding

President of the Arizona Center for Education and Research on Therapeutics (AZCERT), a Tucson-based non-profit organization initially funded by the U.S. Food and Drug Administration (FDA) to work with the UA COM-P and Banner Health to improve the safe use of medications through application of clinical decision support systems.

Dr. Woosley received his medical degree from the University of Miami, FL, his doctorate in pharmacology from the University of Louisville, KY, and his bachelor's degree from Western Kentucky University. After an internship and residency in internal medicine, he completed a fellowship in clinical pharmacology at Vanderbilt University before joining the faculty.

In 2001, Dr. Woosley joined the faculty at The University of Arizona as Vice President of the Arizona Health Sciences Center and the Dean of the College of Medicine-Tucson. In 2005, he founded Critical Path Institute (C-Path), an independent, non-profit organization created jointly by the FDA and the University of Arizona. C-Path implements the FDA's Critical Path Initiative by creating consortia of scientists from FDA, industry and academia that improve the testing and accelerate the development of new drugs and diagnostics. In 2012, he left C-Path to launch the non-profit AZCERT and serve as Co-director of the Division of Data Analytics and Decision Support in the UA COM-P. Dr. Woosley's research has been reported in more than 300 peer-reviewed publications and serves as the basis for eleven patents. For his contributions to medicine, Dr. Woosley has received numerous awards and honors from academic institutions, the FDA and professional societies.

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