

Pharmacogenomics

These resources may be helpful to utilize as reading material for learners and in developing didactic or experiential curricular. Each cited article provides background information on pharmacogenomics and its integration in pharmacy education.

E1. Pharmacists should advance the use of pharmacogenomic information for personalized medication treatment.

Learner Resources

[ASHP Pharmacogenomics Resource Center](#)

- This ASHP Resource Center is an area for pharmacists to obtain additional information and resources about pharmacogenomics and related topics. This resource center is managed by the Section of Clinical Specialists and Scientists Advisory Group on Emerging Sciences.

Haidar CE, Petry N, Oxencis C, Douglas JS, Hoffman JM. ASHP Statement on the Pharmacist's Role in Clinical Pharmacogenomics. *Am J Health Syst Pharm.* 2022; 79(8): 704-707. doi: 10.1093/ajhp/zxab339.

[Clinical Pharmacogenetics Implementation Consortium \(CPIC\) Guidelines](#)

- Detailed gene-drug pharmacogenetic clinical practice guidelines designed to help clinicians understand how available genetic test results should be interpreted and utilized to guide drug therapy

[CDC Public Health Genomics and Precision Health Knowledge Base \(PHGKB\)](#)

- Online, continuously updated, searchable database of published scientific literature, CDC resources, and other materials that address the translation of genomics and precision health discoveries into improved health care and disease prevention.

[FDA Pharmacogenomic Biomarkers in Drug Labeling Table](#)

- The website lists therapeutic products from Drugs at FDA with pharmacogenomic information found in the drug labeling.

Inclusion in Pharmacy Didactic Curriculum

Chang A, Nelson R, Brixner D. Advancing pharmacy practice by reducing gaps in pharmacogenetic education. *Am J Health-Syst Pharm.* 2019; 76:320-6. DOI: 10.1093/ajhp/zxy066

- Commentary on best practices in advancing pharmacogenomics in pharmacy education

Krynetskiy E, Calligaro IL. Introducing Pharmacy Students to Pharmacogenomic Analysis. *American Journal of Pharmaceutical Education.* 2009; 73(4): DOI: [10.5688/aj730471](#)

- Introduction of modern, fast-throughput genotyping technologies in the academic process facilitated comprehension of the potential that pharmacogenomics holds for pharmacy practice

Ga'ivez-Peralta, Szklarz GD, Geldenhuys WJ, Lockman PR. An Effective Approach to Teaching Pharmacogenomics in the First Year of Pharmacy Curriculum. *American Journal of Pharmaceutical Education*. 2018; 82 (8): 954-962. DOI: [10.5688/ajpe6345](https://doi.org/10.5688/ajpe6345)

- Impact of a curricular revision, with implementation of a new pharmacogenomics course with a series of active learning activities in the P1 year, rather than later in the curriculum.

Powers KE, Buffington TM, Contaifer D, Wijesinghe DS, Donohoe KL. Implementation of an Active-Learning Laboratory on Pharmacogenetics. *American Journal of Pharmaceutical Education*. 2019; 83(3): 422-429. DOI: [10.5688/ajpe6605](https://doi.org/10.5688/ajpe6605)

- An active-learning laboratory session to teach pharmacy students about clinical pharmacogenetics improved students' knowledge, confidence, and skills.

Adams SM, Anderson KB, Coons JC, Smith RB, Meyer SM, Parker LS, Empey PE. Advancing Pharmacogenomics Education in the Core PharmD Curriculum through Student Personal Genomic Testing. *American Journal of Pharmaceutical Education*. 2016; 80(1): DOI: [10.5688/ajpe8013](https://doi.org/10.5688/ajpe8013)

- Implementation of personal genomic testing in the second year of the core pharmacy curriculum was feasible, well-received, and enhanced student learning of pharmacogenomics.

Assem M, Broeckel U, Mackinnon GE. Personal DNA Testing Increases Pharmacy Students' Confidence and Competence in Pharmacogenomics. *American Journal of Pharmaceutical Education*. 2021; 85 (4): 281-287. DOI: [10.5688/ajpe8249](https://doi.org/10.5688/ajpe8249)

- Novel pedagogy that involved voluntarily individual pharmacogenomics testing was beneficial to student pharmacists by improving knowledge, interest, and confidence in pharmacogenomics and its incorporation into their future pharmacy practice.

Remsberg CM, Bray BS, Wright SK, Ashmore J, Kabasenche W, Wang S, Lazarus P, Dadoud SS. Design, Implementation, and Assessment Approaches Within a Pharmacogenomics Course. *American Journal of Pharmaceutical Education*. 2017; 81 (1): DOI: [10.5688/ajpe81111](https://doi.org/10.5688/ajpe81111)

- Pharmacogenomic course design that included genetic-based didactic sessions, genomic techniques and self-genotype/phenotype laboratory exercise, and clinical-based case studies. Student learning assessment included knowledge and application based tests and performance on a group project.

Munson A, Pierce R. Flipping Content to Improve Student Examination Performance in a Pharmacogenomics Course. *American Journal of Pharmaceutical Education* 2015; 79 (7): 103. DOI: [10.5688/ajpe797103](https://doi.org/10.5688/ajpe797103)

- The flipped class instructional model in this project included active-learning activities and formative assessments that provided students spaced and repetitive curricular engagement

Bailey SL, Kleina ER, Capasso S, Kinney SRM. Development of a laboratory-based pharmacogenomics independent study and advanced pharmacy practice experience: Connecting basic science to clinical application. *Currents in Pharmacy Teaching and Learning* 13 (2021) 1236–1243. DOI: [10.1016/j.cptl.2021.06.043](https://doi.org/10.1016/j.cptl.2021.06.043)

- Exploration of the benefits of a six-week APPE course that involved laboratory-based genomic testing, use of personal commercial genomic testing, and incorporated interactions with practicing pharmacists and a genetic counselor. Builds upon a required first-year didactic course entitled "Principles of Genetics and Genomics."

Lee KC, Ma JD, Suchanek Hudmon K, Kuo GM. A Train-the-Trainer Approach to a Shared Pharmacogenomics Curriculum for US Colleges and Schools of Pharmacy. *American Journal of Pharmaceutical Education* 2012; 76 (10): 193. DOI: [10.5688/ajpe7610193](https://doi.org/10.5688/ajpe7610193)

- Use of a web-based, train-the-trainer program in pharmacogenomics resulted in faculty participants with more confidence in teaching pharmacogenomics to their students.

Kisor D, Calinskz DM, Farrell CL. Beyond the didactic lecture: pharmacogenomics in pharmacy education. *Per Med.* 2018; 15(1): 9-12. doi: 10.2217/pme-2017-0056.

- Review of laboratory-based genotyping exercises and interprofessional pharmacogenomics activities that could be utilized within pharmacy curriculum.

Grace C, Larriva MM, Steiner HE, Marupuru S, Campbell PJ, Patterson H, Cropp C, Quinn D, Klimecki W, Nix DE, Warholak T, Karnes JH. Efficacy of personal pharmacogenomic testing as an educational tool in the pharmacy curriculum: A nonblinded, randomized controlled trial. *Clin Transl Sci.* 2021; 14(6): 2532-2543. doi: 10.1111/cts.13121.

- First randomized study aimed at assessing the efficacy of personal genomic educational testing in the PharmD classroom

O'Brien TJ, Goodsaid F, Plack M, Harralson A, Harrouk W, Hales TG. Development of an undergraduate pharmacogenomics. *Pharmacogenomics.* 2009; 10(12): 1979-1986. DOI: [10.2217/pgs.09.145](https://doi.org/10.2217/pgs.09.145)

- Incorporation of pharmacogenomic content in undergraduate pre-requisite coursework

Lee KC, Suchanek Hudmon K, Ma JD, Kuo GM. Evaluation of a shared pharmacogenomics curriculum for pharmacy students. *Pharmacogenomics.* 2015; 16(4): 315-322. DOI: [10.2217/pgs.14.181](https://doi.org/10.2217/pgs.14.181)

- This study demonstrated that a shared curriculum is an effective approach for broadscale curricular dissemination of complex, rapidly evolving content.

Nutter SC, Alvez-Peralta MG. Pharmacogenomics: From classroom to practice. *Mol Genet Genomic Med.* 2018; 6(3) :307-313. doi: 10.1002/mgg3.417.

- Commentary regarding the challenges connecting pharmacogenomics taught in classrooms and translating it to advance pharmacy practice rotations and healthcare settings and potential areas of development.

Thomas D, Soldner JA, Cropp CD, Beall J. Pharmacy Student Perceptions of a Virtual Pharmacogenomics Activity. *Healthcare.* 2022; 10(2): 286. doi: 10.3390/healthcare10020286.

Nickola TJ, Munson AM. Pharmacogenomics primer course for first professional year pharmacy students. *Pharmacogenomics.* 2014; 5(1):39-48. doi: 10.2217/pgs.13.197.

- This article describes the development and evaluation of a PGx primer course designed for first professional year pharmacy students.

Rao US, Mayhew SL, Rao PS. Strategies for implementation of an effective pharmacogenomics program in pharmacy education. *Pharmacogenomics.* 2015; 16(8): 905-11. doi: 10.2217/pgs.15.50.

- Commentary on the importance of genetics in prerequisite courses, integration into PharmD curriculum, PharmD school dedication to pharmacogenomic research, and recruitment of faculty with pharmacogenomic training.

Inclusion in Pharmacy Experiential Curriculum

Gammal RS, Nguyen J, Audi E, Ming Lee Y, Petry N, Empey PE. Advanced Pharmacy Practice Experiences in Pharmacogenomics Offered by US Pharmacy Programs. *American Journal of Pharmaceutical Education*. 2020; 84(12): 1584-1588. DOI: [10.5688/ajpe8031](https://doi.org/10.5688/ajpe8031)

- Survey highlights that only a small number of US pharmacy schools (40% in 2020) offer an APPE with a primary focus in pharmacogenomics.

Drozda K, Labinov Y, Jiang Ruixuan, Thomas MR, Wong SS, Patel S, Nutescu EA, Cavallari LH. A Pharmacogenetics Service Experience for Pharmacy Students, Residents, and Fellows. *American Journal of Pharmaceutical Education*. 2013; 77 (8): 175. DOI: [10.5688/ajpe778175](https://doi.org/10.5688/ajpe778175)

- Newly implemented warfarin pharmacogenetics service in a hospital setting, staffed by P1-P3 students on elective independent studies, P4 students on APPE rotations, pharmacy residents, and pharmacy fellows.