

Research Vision

Computational modeling is transforming cardiovascular healthcare, yet current models fall short in predicting long-term, patient-specific outcomes. I will lead a research program to develop multiscale models that integrate mechanistic growth and remodeling into computational fluid dynamics simulations of complex cardiovascular lesions. This will create interconnected cell-tissue-organ frameworks that will identify biomechanical causes of disease, enable precision treatment planning, and leverage machine learning techniques to enable clinically actionable predictions.

Education

- 2019–2023 **Ph.D. in Bioengineering, Stanford University**, Advisor: Alison L. Marsden
Dissertation: Creating a novel finite element framework for simulating full, three-dimensional constrained mixture growth and remodeling of soft tissues.
- 2017–2019 **M.S. in Bioengineering, Stanford University**, Advisor: Alison L. Marsden
Focus: Quantifying the hemodynamic performance of tissue-engineered vascular grafts in congenital heart defect patients using multiscale computational fluid dynamics.
- 2013–2017 **B.S. in Biomedical Engineering and B.S. in Computer Science, Johns Hopkins University**, Advisor: Natalia A. Trayanova
Focus: Utilizing graph theory to identify ablation targets in patients with left atrial flutter.

Research Appointments

- Since 2023 **Postdoctoral Researcher, Yale University**, Advisor: Jay D. Humphrey
- Integrated gene expression data into models of postnatal pulmonary artery growth and remodeling.
 - Simulated aneurysm progression for machine learning-based outcome prediction.
- 2017–2023 **Graduate Researcher, Stanford University**, Advisor: Alison L. Marsden
- Developed a 3D fluid-solid-growth framework for patient-specific vascular modeling.
 - Simulated multiscale cardiac hemodynamics to assess the efficacy of surgical interventions.
- 2017 **Graduate Researcher, Stanford University**, Advisor: David B. Camarillo
- Applied neural networks to improve accuracy of pulmonary catheter systems for robotic surgery.
- 2016–2017 **Undergraduate Researcher, Applied Physics Laboratory**, Advisor: Philippe Burlina
- Designed a machine learning algorithm for ultrasound-based breast cancer detection.
- 2014–2017 **Undergraduate Researcher, Johns Hopkins University**, Advisor: Natalia A. Trayanova
- Modeled patient-specific atrial flutter and identified optimal ablation targets using graph theory.
- 2014 **Undergraduate Researcher, University of Arizona**, Advisor: Jonathan P. Vande Geest
- Evaluated coronary stent mechanics via finite element analysis.

Funding and Awards

- 2021–2023 **American Heart Association Predoctoral Fellowship**
- \$63,000 supporting doctoral cardiovascular research.
- 2017–2022 **National Science Foundation Graduate Research Fellowship**
- \$138,000 supporting graduate research in STEM.
- 2024 **North American Vascular Biology Organization Vasculata**
- Received the Novel Insights in Vascular Biology Poster Award.
- 2023 **Melosh Medal Finalist**
- Top national award in computational mechanics recognizing outstanding doctoral research.

- 2023 **Siebel Scholar Award**
- Recognized as a top graduate student for academic excellence and leadership at Stanford University.
- 2017 **1st Place, Tulane Business Model Competition**
- Awarded first place for developing an innovative biomedical startup and commercialization strategy to improve diagnosis of retinopathy of prematurity.
- 2015 **Generation Google Scholar Award**
- National award recognizing exceptional computer science students for academic excellence and leadership in promoting diversity in technology.
- 2015 **Vredenburg Scholar Award**
- International research fellowship in biomedical engineering completed at the National University of Singapore.
- 2014 **1st Place, NIH DEBUT Challenge**
- National first-place award from the NIH for developing a novel spinal probe that addressed an unmet clinical need in spinal fusion surgery.

Teaching

- 2025 **Cardiac Mechanics, Fairfield University, Guest Lecturer**
- Delivered a guest lecture introducing fundamental principles of fluid dynamics, including the Navier–Stokes equations and Poiseuille flow.
- 2025 **Biomedical Engineering Senior Seminar, Yale University, Guest Lecturer**
- Presented a seminar and moderated a panel offering perspectives on academic career development and interdisciplinary research trajectories.
- 2024 **Mathematical Methods I, Yale University, Guest Lecturer**
- Delivered a two-part series introducing vector calculus and led application-based examples.
- 2024 **Cardiovascular Fluid Mechanics, University of California, San Diego, Guest Lecturer**
- Taught a module on soft-tissue growth and remodeling, emphasizing constitutive modeling and mechanobiological principles.
- 2023–2024 **Discover and Design in Biomedical Research, Yale University, Guest Lecturer**
- Presented on research study design and execution, with a focus on congenital heart defects as a case study.
- 2021 **Computational Modeling in the Cardiovascular System, Stanford University, Teaching Assistant**
- Led discussions on computational fluid dynamics and structural mechanics, supporting student implementation of cardiovascular models.
- 2018–2019 **Bioengineering Senior Capstone Design, Stanford University, Teaching Assistant**
- Mentored student teams through project development, prototyping, and competition preparation; several teams earned national recognition.

Research Supervision

- Since 2025 **Colin W. Means, Yale University, Graduate Researcher**
- Simulated vascular injury and aneurysm progression using a finite element solver and high-performance computing clusters.^{A21}
- 2025 **Alexandria Regan, Yale University, High School Researcher**
- Performed quantitative histological analysis of proximal pulmonary arteries.^{A18}
- 2024 **Murat Khidoyatov, Yale University, Undergraduate Researcher**
- Implemented novel constitutive material models within the FEBio biomechanics platform.
- 2023–2024 **Cole Anderson, The Ohio State University, Graduate Researcher**
- Modeled the constitutive equations governing tissue-engineered vascular graft material behavior.
- 2021–2023 **Zinan Hu, Stanford University, Graduate Researcher**
- Developed a multiphysics finite element framework to evaluate design parameters of a bioprinted pulsatile conduit.^{A6, A17}

- 2021–2022 **Chris Chankyo Kim**, *Stanford University*, Undergraduate Researcher
- Created interactive virtual reality models of congenital heart defects for education and surgical visualization.
- 2020–2023 **Aaron Panduro**, *California State University, Fresno*, Undergraduate Researcher
- Co-investigated (with Allyson Weiss) hemodynamic characteristics of cerebral aneurysms to identify hemodynamic differences between growing and stable lesions.^{A11}
- 2020–2023 **Allyson Weiss**, *Stanford University*, Undergraduate Researcher
- Co-investigated (with Aaron Panduro) hemodynamic characteristics of cerebral aneurysms to identify hemodynamic differences between growing and stable lesions.^{A11}
- 2020–2022 **Kyle Feliciano**, *Stanford University*, Undergraduate Researcher
- Simulated aortic flow following endovascular aneurysm repair (EVAR) to study post-surgical hemodynamic changes.^{A8}

Service and Outreach

- 2024–2025 **Yale Postdoctoral Association**, *Yale University*, Committee Member
- Organized monthly networking and community events promoting inclusion, diversity, and interdisciplinary engagement among postdoctoral scholars.
- 2023–2024 **Women and Gender Minorities in Science at Yale**, *Yale University*, Mentor
- Mentored graduate students on research development, academic career pathways, and navigating gender equity challenges in STEM.
- 2020 **SimVascular Tutorial Series**, *Online / Stanford University*, Presenter
- Created and presented video tutorials on cardiovascular simulation workflows, accumulating over 15,000 views on YouTube. [Available online.](#)
- 2018–2019 **Biomedical Association for the Interest of Minority Students**, *Stanford University*, Advocacy Chair
- Led initiatives to support underrepresented students through social issue roundtables, gender-inclusion programming, and campus advocacy.
- 2017–2018 **Redwood Peninsula Elementary**, *Redwood City, CA*, Tutor
- Led weekly hands-on STEM engagement activities to foster early scientific curiosity in elementary school students.
- 2017, 2019 **National Youth Science Camp**, *Monongahela National Forest*, Counselor and Presenter
- Led interactive workshops on cardiovascular simulation and computational modeling for high-achieving high school students.
- 2014 **Girls Who Code**, *Baltimore, MD*, Instructor
- Taught introductory coding and algorithmic thinking to elementary school students, promoting gender diversity in computer science.

Selected Publications

† and ‡ denote equal contribution

- A22. Han J, Kong D, **Schwarz EL**, Takaesu F, Lee S, Kim C, Yang E, Park M, Kim E, Kim W, Ramachandra AB, Manning EP, Humphrey JD, Park H, Davis M. A cross-scale causal mapping framework pinpoints macrophage orchestrators of balanced arterial development, *bioRxiv* (Under Review at *Circulation Research*), 2025. [DOI](#)
- A21. **Schwarz EL**, Li DS, Means CW, Assi R, Humphrey JD. Mechanisms driving thoracic aortic aneurysm stability, *bioRxiv* (Under Review at *Biomechanics and Modeling in Mechanobiology*), 2025. [DOI](#)
- A20. **Schwarz EL**, Ramachandra AB, Yeung N, Manning EP, Weiss D, Humphrey JD. Postnatal pulmonary artery development from transcript to tissue, *bioRxiv* (Under Review at *Journal of the Royal Society Interface*), 2025. [DOI](#)
- A19. Cao Q[†], **Schwarz EL**[†], Li DS, Goswami S, Means CW, Assi R, Humphrey JD, Karniadakis GT. Neural operators for forecasting thoracic aortic aneurysm growth and rupture, In preparation, 2025.
- A18. De Man R[†], Cai Z[†], Doddaballapur P, Guerrera N, Regan A, Lin L, **Schwarz EL**, Justet A, Abu Hussein NS, DiPalo J, Cavinato C, Raredon MSB, Heerdt PM, Singh I, Yan X, Kang MJ, Bruns DR, Lee PJ, Tellides G, Humphrey

- JD, Kaminski N, Ramachandra AB[‡], Manning EP[‡]. Proximal pulmonary artery stiffening as a biomarker of cardiopulmonary aging, *bioRxiv* (In Revision at *Aging Cell*), 2025. [DOI](#)
- A17. Hu Z, Herrmann JE, **Schwarz EL**, Gerosa FM, Emuna N, Humphrey JD, Feinberg AW, Hsia T, Skylar-Scott MA, Marsden AL. Multiphysics simulations of a bioprinted pulsatile Fontan conduit, *Journal of Biomechanical Engineering*, 2025. [DOI](#)
- A16. Blum KM, Turner ME, **Schwarz EL**, Best CA, Kelly JM, Yates AR, Hor KN, Matsuzaki Y, Drews JD, Zakko J, Shah K, Shinoka T, Humphrey JD, Marsden AL, Breuer CK. Oversized conduits predict stenosis in tissue engineered vascular grafts, *JACC: Basic to Translational Science*, 2025. [DOI](#)
- A15. Turner ME, Blum KM, Watanabe T, **Schwarz EL**, Nabavinia M, Leland JT, Villarreal DJ, Schwartzman WE, Chou T, Baker PB, Matsumura G, Krishnamurthy R, Yates AR, Hor KN, Humphrey JD, Marsden AL, Stacy MR, Shinoka T, Breuer CK. Tissue engineered vascular grafts are resistant to the formation of dystrophic calcification, *Nature Communications*, 2024. [DOI](#)
- A14. Pfaller MR, Latorre M, **Schwarz EL**, Gerosa FM, Szafron JM, Humphrey JD, Marsden AL. FSGe: A fast and strongly - coupled 3D fluid–solid–growth interaction method, *Computer Methods in Applied Mechanics and Engineering*, 2024. [DOI](#)
- A13. **Schwarz EL**, Pegolotti L, Pfaller MR, Marsden AL. Beyond CFD: Emerging methodologies for predictive simulation in cardiovascular health and disease, *Biophysics Reviews*, 2023. [DOI](#)
- A12. **Schwarz EL**, Pfaller MR, Szafron JM, Latorre M, Lindsey SE, Breuer CK, Humphrey JD, Marsden AL. A fluid–solid–growth solver for cardiovascular modeling, *Computer Methods in Applied Mechanics and Engineering*, 2023. [DOI](#)
- A11. Weiss AJ, Panduro AO, **Schwarz EL**, Sexton ZA, Lan IS, Geisbush TR, Marsden AL, Telischak NA. A matched - pair case control study identifying hemodynamic predictors of cerebral aneurysm growth using computational fluid dynamics, *Frontiers in Physiology*, 2023. [DOI](#)
- A10. **Schwarz EL**. Computational modeling of tissue - engineered vascular grafts, *Ph.D. Thesis, Stanford University*, 2023. [DOI](#)
- A9. Blum KM, Zbinden JC, Ramachandra AB, Lindsey SE, Szafron JM, Reinhardt JW, Heitkemper M, Best CA, Mirhaidari GJ, Chang Y, Ulziiibayar A, Kelly J, Shah KV, Drews JD, Zakko J, Miyamoto S, Matsuzaki Y, Iwaki R, Ahmad H, Daulton R, Musgrave D, Wiet MG, Heuer E, Lawson E, **Schwarz EL**, McDermott MR, Krishnamurthy R, Hor K, Armstrong AK, Boe BA, Berman DP, Trask AJ, Humphrey JD, Marsden AL, Shinoka T, Breuer CK. Tissue engineered vascular grafts transform into autologous neovessels capable of native function and growth, *Communications Medicine*, 2022. [DOI](#)
- A8. Tran K, Feliciano KB, Yang W, **Schwarz EL**, Marsden AL, Dalman RL, Lee JT. Patient - specific changes in aortic hemodynamics are associated with thrombotic risk after fenestrated endovascular aneurysm repair with large diameter endografts, *JVS–Vascular Science*, 2022. [DOI](#)
- A7. Ramachandra AB, Wang H, Wnorowski A, **Schwarz EL**, Pickering J, Heiler JC, Lucian HJ, Hironaka CE, Tran NA, Liu Y, Khan MO, Obafemi O, Tada Y, Kahn AM, Sayed N, Wu JC, Humphrey JD, Boyd JH, Marsden AL. Biodegradable external wrapping promotes favorable adaptation in an ovine vein graft model, *Acta Biomaterialia*, 2022. [DOI](#)
- A6. Hu Z, **Schwarz EL**, Herrmann J, Skylar - Scott M, Marsden A. Simulated performance of a bioprinted pulsatile Fontan conduit, *Bulletin of the American Physical Society*, 2022. [DOI](#)
- A5. **Schwarz EL**[†], Kelly JM[†], Blum KM, Hor KN, Yates AR, Zbinden JC, Verma A, Lindsey SE, Ramachandra AB, Szafron JM, Humphrey JD, Shinoka T, Marsden AL, Breuer CK. Hemodynamic performance of tissue - engineered vascular grafts in Fontan patients, *NPJ Regenerative Medicine*, 2021. [DOI](#)
- A4. Annadanam A, Allen R, Bettgowda C, Gaddipati R, Herrera L, Isaacs B, Lo S, Xie E, Andrews C, Malla A, **Schwarz EL**. A spinal probe incorporating an electromechanical system for detection and prevention of breaches during surgery, *U.S. Patent US20170056075A1*, 2017. [DOI](#)
- A3. Zahid S, Cochet H, Boyle PM, **Schwarz EL**, Whyte KN, Vigmond EJ, Dubois R, Hocini M, Haïssaguerre M, Jaïs P, Trayanova NA. Patient - derived models link re - entrant driver localization in atrial fibrillation to fibrosis spatial pattern, *Cardiovascular Research*, 2016. [DOI](#)
- A2. Zahid S, Whyte KN, **Schwarz EL**, Boyle PM, Chrispin J, Prakosa A, Ipek EG, Pashakhanloo F, Halperin HR,

Calkins H, Berger RD, Nazarian S, Trayanova NA. Feasibility of using patient-specific models and the “minimum cut” algorithm to predict optimal ablation targets for left atrial flutter, *Heart Rhythm*, 2016. [DOI](#)

- A1. Boyle PM, Murphy M, Karathanos TV, Wang D, Zahid S, Whyte KN, **Schwarz EL**, Entcheva E, Trayanova NA. Pulse duration determines efficacy of arrhythmia termination via targeted optogenetic stimulation, *Biophysical Journal*, 2016. [DOI](#)

Invited Talks

- I1. **Schwarz EL**. A Fluid–Solid–Growth Solver for Cardiovascular Modeling, *Melosh Medal Seminar at Duke University*, Durham, NC, 2023.

Selected Conference Presentations

- P12. **Schwarz EL**, Ramachandra AB, Yeung N, Manning EP, Weiss D, Humphrey JD. A computational model of neonatal pulmonary artery development, *Summer Biomechanics, Bioengineering, and Biotransport Conference*, 2025.
- P11. **Schwarz EL**, Ramachandra AB, Yeung N, Manning EP, Weiss D, Humphrey JD. Postnatal pulmonary artery development from transcript to mechanics, *Single Ventricle Investigator Meeting*, 2024.
- P10. **Schwarz EL**, Ramachandra AB, Yeung N, Manning EP, Weiss D, Humphrey JD. A data-informed model of murine pulmonary artery development and disease, *Vasculata*, 2024.
- P9. **Schwarz EL**, Ramachandra AB, Cavinato C, Rego BV, Murtada SI, Weiss D, Yeung N, Humphrey JD. Developmental characterization of the aorta and pulmonary arteries, *Additional Ventures Cures Collaborative*, 2024.
- P8. **Schwarz EL**, Pfaller MR, Szafron JM, Lindsey SE, Latorre M, Humphrey JD, Marsden AL. A computational framework for simulating the growth and remodeling of patient-specific vessels, *World Congress of Biomechanics*, 2022.
- P7. **Schwarz EL**, Pfaller MR, Hu Z, Sexton ZA, Herrmann JE, Skylar-Scott MA, Marsden AL. Simulated performance of a pulsatile Fontan conduit, *Single Ventricle Investigators Meeting*, 2021.
- P6. **Schwarz EL**, Lindsey SE, Verma A, Kelly JM, Hor KN, Szafron JM, Ramachandra AB, Kunh E, Humphrey JD, Breuer CK, Marsden AL. How stenosis in tissue-engineered vascular grafts affects performance in Fontan patients, *BioFluids*, 2020.
- P5. **Schwarz EL**, Lindsey SE, Verma A, Kelly JM, Humphrey JD, Breuer CK, Marsden AL. The effect of tissue-engineered vascular graft material properties on hemodynamics in Fontan patients during exercise, *North American Vascular Biology Organization*, 2019.
- P4. **Schwarz EL**, Lindsey SE, Verma A, Kelly JM, Humphrey JD, Breuer CK, Marsden AL. Patient-specific performance of tissue-engineered vascular grafts under simulated exercise conditions, *Biomedical Engineering Society Annual Meeting*, 2019.
- P3. **Schwarz EL**, Verma A, Kelly JM, Humphrey JD, Breuer CK, Marsden AL. Quantifying energy loss, growth, and remodeling in Fontan patients with tissue-engineered vascular grafts, *6th International Conference on Clinical and Engineering Frontiers in Pediatric and Congenital Heart Disease*, 2019.
- P2. **Schwarz EL**, Billings S, Harvey S, Burlina P. Preliminary study of optimal ultrasound parameter selection and automated breast cancer detection by lesser-trained operators, *IEEE Biomedical and Health Informatics*, 2017.
- P1. **Schwarz EL**, Zahid S, Whyte K, Boyle P, Chrispin J, Blake R, Prakosa A, Ipek E, Halperin H, Calkins H, Berger R, Nazarian S, Trayanova NA. Using graph theory to predict ablation targets in patient-specific models of left atrial flutter, *Biomedical Engineering Society Annual Meeting*, 2016.