Ellen Roche Apr/6/2020

BIOGRAPHICAL SKETCH

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NAME: Ellen Tunney Roche, Ph.D

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POSITION TITLE: Assistant Professor, Massachusetts Institute of Technology, Mechanical Engineering Department and Institute for Medical Engineering and Science

EDUCATION/TRAINING

INSTITUTION AND LOCATION	DEGREE *(if applicable)*	Completion Date	FIELD OF STUDY
National University of Ireland, Galway (NUIGalway)	B.E	05/04	Biomedical Engineering
Trinity College, Dublin	M.Sc	10/11	Bioengineering
Harvard University, Cambridge, MA, USA	Ph.D.	05/15	Bioengineering

A. Personal Statement

My research focuses on applying new innovative technologies to the development of active or responsive implantable devices for improving patient outcomes. I direct the Therapeutic Technology Design and Development (TTDD) Lab at the Institute for Medical Engineering Science, Massachusetts Institute of Technology. My current research includes development of novel devices to repair or augment cardiac function using disruptive approaches such as soft robotics, the combination of mechanical actuation with delivery of cell therapy, and the use of photo-responsive biodegradable adhesives. Further, we develop enhanced testbeds for these therapeutic technologies including *in silico* computational modeling, *in vitro* and *ex vivo* models and *in vivo* models. I have been employed in industry for over five years as a research and development engineer, which has provided me with a deep understanding of the regulatory pathways to medical device commercialization and clinical implementation.

B. Positions and Honors

Positions and Employment

2004-2005	Graduate Research and Development Engineer, Mednova Ltd., Galway, Ireland and Abbott Vascular, Redwood City, CA, USA.
2005-2008	Research and Development Engineer, Abbott Vascular, Santa Clara, CA, USA
2008	Research and Development Engineer, Moximed, CA, USA
2009-2010	Senior Research and Development Engineer, Medtronic, Galway, Ireland
2015	Post-doctoral Fellow, Harvard John A Paulson School of Engineering and Applied Sciences, Harvard University, Cambridge, MA, USA
2015-2017	Postdoctoral Research Fellow, National University of Ireland, Galway, Ireland
2017-Present	Assistant Professor, Massachusetts Institute of Technology
2017-2019	Helmholtz Career Development Professor
2019-2022	W.M. Keck Foundation Career Development Professor

Honors

2004	Gold medal and 1st place in University class year 1,2 and 4
2004	Gold medal and 1st place in University entrance scholarship
2004	1st place in the Ryan Hanley Prize for best undergraduate final year project
2004	2nd place in the national final of the Siemens Young Engineer of the year award
2004	1st place in the Medtronic AVE award for best undergraduate final year project
2007	Awarded Technical Excellence Contribution Award Abbott Vascular, Santa Clara
2009	Overall winner of Speak Out for Engineers, Engineers Ireland
2010	First place in thesis in MSc in Bioengineering Trinity College, Dublin
2010	First place in examination in MSc in Bioengineering, Trinity College, Dublin
2012-2013	Recipient of open competitive fellowship supplement, Harvard University
2011-2014	Recipient of Harvard Pierce Fellowship for Outstanding Graduate students, Harvard University
2011-2014	Awarded Fulbright International Science and Technology Award
2013	First Place Award, Design of Medical Devices, Three in Five Competition
2013	First Place Award, Design of Medical Devices, International Student Design Showcase
2013	Overall Winner, Mimics Innovation Award- Engineering on Anatomy for Cardiovascular Applications
2014	PROMOS (RWTHAachen) study abroad scholarship was awarded to advisee for project work at Harvard Biodesign Lab.
2014	European Molecular Biology Organization (EMBO) travel scholarship awarded to mentee for project work at Harvard Biodesign Lab.
2014	Award for presentation, Judah Folkman research day, Boston Childrens Hospital
2014-2015	Wyss Institute for Biologically Inspired Engineering Director's Challenge
2014-2016	Awarded the American Heart Association Pre-doctoral fellowship
2016-2018	Awarded the Wellcome Trust Seed Award in Science
2016-2018	Awarded the Irish Research Council Government of Ireland Postdoctoral Award
2017-2020	Awarded the Helmholtz Career Development Professorship
2019-2024	Awarded the National Science Foundation CAREER Award
2018	Grand prize at the Design of Medical Device Conference for a pectin-patch delivery tool
2019-2021	Awarded the Charles H. Hood Award for Excellence in Child Health
2019-2022	Awarded the Helmholtz Career Development Professorship
2019	Named the W.M Keck Career Development Professor
2020	Appointed as Associate Scientific Advisor to Science Translational Medicine

C. Contribution to Science

1. One of my key contributions to science is the use of soft robotic technologies to augment cardiac function. I lead a multi-disciplinary team on the development of an extra-cardiac compression device that augments cardiac function without contacting blood. The device is fabricated using fluidic powered actuators and assists the heart ejecting and filling in a bioinspired fashion by using artificial muscles oriented in a manner similar to those of the natural cardiac fibers. Pertinent to the current proposal, I have recently shown that intermittent actuation of an implantable device can modulate the host foreign body response, and reduce the thickness of the fibrous capsule surrounding the implant. I have also begun to explore the role of mechanical actuation on regeneration in skeletal muscle, and the concept of taking advantage of the host response to couple these robotic assist devices to disease organs. Work on extended applications (both cardiac and non-cardiac) for soft robotic assist devices is ongoing in my group.

a) Dolan EB, Varela CE, Mendez K, Whyte W, Levey RE, Robinson ST, Maye E, O'Dwyer J, Beatty A, Rothman A, Fan Y, Hochstein J, Rothenbucher S, Wylie R, Starr JR, Monaghan M, Dockery P, Duffy GP, **Roche ET**. An actuatable soft reservoir modulates host foreign body response. *Science Robotics* 4;33;eaax7043
b) **Roche ET**, Horvath MA, Wamala I, Alazmani A, Song SE, Whyte W, Machaidze Z, Vasilyev NV, Mooney DJ, Pigula FA, and Walsh CJ. Soft Robotic Sleeve Restores Heart Function. *Science Translational Medicine 9;*373;eeaf3925, 2017. (Impact factor 16.796, *cover article*).
c) **Roche ET**, Wohlfarth R, Overvelde JTB, Vasilyev NV, Pigula FA, Mooney DJ, Bertoldi K, Walsh CJ. A Bioinspired Soft Actuated Material. *Advanced Materials* 2014 26,1200-1206. (impact factor 15.78, *cover article*).
d) Horvath MA, Varela CE, Dolan, EB, Whyte W, Monahan DS, Payne CJ, Wamala I, Vasilyev NV, Pigula FA, Mooney DJ, Walsh CJ Duffy GP, **Roche ET**, Towards Alternative Approaches for Coupling of a Soft Robotic Sleeve to the Heart *Ann Biomed Eng*, Available online ahead of print. https://doi.org/10.1007/s10439-018-2046-2, 2018 (Impact factor 3.221).

2. I have designed multiple catheter-based technologies, many while working in industry. In my academic research I developed a novel device for enabling light-activated atraumatic closure of intracardiac defects. I led the engineering team in a highly collaborative project involving the design of this device to deliver, deploy, activate and pressurize a biodegradable patch/adhesive system for closing tissue defects. We showed that the device works in multiple anatomies, particularly for closing intracardiac defects in a beating porcine heart. This technology has been licensed to a start-up company who are commercializing the catheter. Recently I have worked on a mechanical thrombectomy catheter for the treatment of acute ischemic stroke and a double-sided tape that can improve adhesion to the beating heart for minimally invasive applications.

a) Weafer FM, Duffy S, Machado IP, **Roche ET**, McHugh PE, Gilvarry M. Characterization of Strut Indentation during Mechanical Thrombectomy in Acute Ischemic Stroke Clot Analogues. *Journal of NeuroInterventional Surgery*. Published Online First: 19 January 2019. doi: 10.1136/neurintsurg-2018-014601 (Impact factor 3.925)
b) **Roche ET**, Fabozzo A, Lee Y, Polygerinos P, Friehs I, Schuster L, Casar Berazaluce AM, Bueno A, Lang N, Pereira MJN, Feins E, Wassermann S, O'Cearbhaill ED, Vasilyev NV, Mooney DJ, Karp JM, del Nido, PJ, Walsh CJ A light reflecting balloon for atraumatic tissue defect closure, *Science Translational Medicine* 306:306ra149, 2015 (Impact factor 16.796, *Front cover article).*
c) Fabozzo A***, Roche ET***, Lee Y, Polygerinos P, Friehs I, Schuster L, Casar Berazaluce AM, Bueno A, Lang N, Pereira M, Feins E, Wassermann S, O'Cearbhaill ED, Vasilyev NV, Mooney DJ, Karp JM, del Nido, PJ, Walsh CJ Enabling minimally invasive atraumatic repair of intracardiac septal defects with light. *American Association for Thoracic Surgery (AATS) Annual Meeting,* July 2015 (*co-first author).

3. Another research strand that I have contributed to is the development of methods to improve stem cell delivery and retention in the infarcted heart, and computational methods to model these systems. We assessed the ability of a panel of biomaterials to improve cell retention in the infarcted heart. Recently, we developed an implantable epicardially placed cell reservoir device that allows replenishment of therapy to the heart, enabling multiple, localized administrations of therapy, and developed a computational model to predict drug penetration through this reservoir into the heart. We also describe a dynamic diffusion-tensor imaging-based computational model for intramyocardial injection.

a) Fan Y, Ronan W, Teh I, Schneider J, Varela CE, Whyte W, McHugh PE, Leen S, **Roche ET**. A comparison of two quasi-static computational models for assessment of intra-myocardial injection as a therapeutic strategy for heart failure, *International Journal of Numerical Methods in Biomedical Engineering*, https://doi.org/10.1002/cnm.3213, 2019
b) Shirazi RN, Islam S, Weafer FM, Villanyi A, Ronan W, McHugh PE, **Roche ET**. Multi-scale experimental and computational modeling approaches to characterize therapy delivery to the heart from an implantable epicardial biomaterial reservoir. *Advanced Healthcare Materials,* https://doi.org/10.1002/adhm.201900228, 2019 (cover article, impact factor 6.27)
c) Whyte W*, **Roche ET***, Mendez K, Islam S, Shirazi RS, Weafer F, O'Neill HS, Vasilyev NV, Murphy B, McHugh PM, Duffy GP, Walsh CJ, and Mooney DJ, "A method for sustained release of targeted cardiac therapy with a replenishable, implantable reservoir.," *Nature Biomedical Engineering* 2018. *http://dx.doi.org/*10.1038/s41551-018-0247-5. *co-first authors. (impact factor 17.14)
d) **Roche ET***, Hastings CL*, Lewin SA, Shvartsman DE, Brudno Y, Vasilyev NV, O'Brien FJ, Walsh CJ, Duffy GP, Mooney DJ. Comparison of biomaterial delivery vehicles for improving acute retention of stem cells in the infarcted heart. *Biomaterials*. 35(25):6850-8, 2014 (impact factor 8.402)

D. Research Support

Ongoing Research Support

Muscular Dystrophy Association of America 10//01/18 – 09/30/21
Title: Development of a soft robotic implantable ventilator
The primary objective of this award is to develop a robotic diaphragm mimic that can recapitulate diaphragmatic motion and thoracic and abdominal pressures. The robot will serve as a benchtop simulator, and eventually as an implantable device to help muscular dystrophy patients to breathe.
Role: PI

National Science Foundation 06/01/19 – 05/31/24
Title: CAREER: Hybrid Biorobotic Matrices to Simulate Diaphragmatic and Myocardial Biomechanics
The primary objective of this proposal is to develop an organosynthetic thoracic simulator that replicates the biomechanics of the diaphragm and the heart with biohybrid robotic tissue mimics for the purpose of device testing, surgical training and pedagogy.
Role: PI

Juvenile Diabetes Research Foundation 06/01/19 – 05/31/2020
Title: RoboTherIP: A soft robotics actuatable cell-loaded reservoir system to reduce fibrosis and improve efficacy of beta-cell replacement therapies for the treatment of Type 1 Diabetes.
The primary objective of this proposal is to investigate the feasibility of using an actuatable cell reservoir to enhance the survival and delivery of stem-cell derived beta cells in the peritoneal space to reverse Type 1 Diabetes.
Role: PI

Charles H. Hood Foundation 07/01/19 – 06/30/21
Title: A Circulatory Support Device for Univentricular Hearts with Fontan Physiology.

The primary objective of this proposal is to develop an active cavopulmonary shunt to assist venous return in patients that have undergone the Fontan surgical procedures for congenital heart defects.
Role: PI

National Science Foundation EFRI Award 9/01/19 – 8/31/2023
Title: EFRI C3 SoRo: Functional-Domain Soft Robots (FunDo SoRo) Precisely Controlled by Quantitative Dynamic Models and Data"
The primary objective of this proposal is to develop soft robotic magnetically-steerable catheters that are controlled with dynamic models to perform intravascular tasks such as aneurysm closure and thermal bronchoplasty.
Role: PI

Completed Research Support
Muscular Dystrophy Canada 11/01/17 – 02/28/19
Title: Development of a Soft Diaphragmatic Assist Device for Diaphragm Dysfunction in Muscular Dystrophy
The primary objective of this proposal is to design and develop an implantable soft robotic actuator that will apply the appropriate forces to augment a pathological diaphragm to achieve normal ventilatory motion.
Role: PI

Irish Research Council Postdoctoral Award 10/1/16 – 9/31/18
Title: Development of a computational model of a localized, replenishable therapy delivery device for the heart
The major goal of this project was to develop a finite element computer simulation of the kinetics of drug delivery into the heart from an implanted reservoir in order to optimize device design and reveal fundamental insights about localized, replenishable delivery of therapy to tissue.
Role: PI

Science Foundation Ireland/Health Research Board/Wellcome Trust Seed Award in Science 6/20/16 – 9/20/17
Title: 'Modelling of pharmacokinetics into ischemic heart tissue from an implantable, replenishable therapy reservoir.' 202073/Z/16/Z
The major goal of this project was to develop a finite element computer simulation of the kinetics of drug delivery into the heart from an implanted reservoir in order to optimize device design and reveal fundamental insights about localized, replenishable delivery of therapy to tissue.
Role: PI

American Heart Association 7/1/14-6/30/16
Title: Mechanical and Biological Combination Therapy for Failing Hearts 14PRE20380899
The major goal of this project was to develop a soft robotic bioinspired sleeve to assist with mechanical function of the heart and to combine this mechanical assistance with localized, refillable therapy that could be delivered to the epicardium of the heart.
Role: PI