LEOPOLD N. GREEN

Mentor · Educator · Chemist · Bioengineer · Synthetic Biologist

(213)-999-4877 greenl@caltech.edu www.leopoldgreen.com

California Institute of Technology · Pasadena, CA 91125 USA · Office: 133 Keck Lab

Dear BTE Organizing and Steering Committee: January 15, 2021

I submit my application for the Black Trailblazers in Engineering hosted by Purdue University College of Engineering with great excitement. I am Leopold Green, a creative and passionate postdoc at Caltech. My research interests parlay off my mantra, "For the love of art, science, and humanity." For me, Synthetic Biology is an interdisciplinary tool that leverages chemistry, biology, engineering, and mathematics for diverse medical and environmental applications. I use computational models to experimentally design biological circuits and network architectures with predictable dynamics and tunable functionality *in vivo*. Most importantly, I am passionate about service and community; I focus on increasing accessibility to academic opportunities and scientific rigor while developing creative and solution-oriented ideas.

My purpose for applying to the Black Trailblazers in Engineering is two-fold, to network with fellow Black engineers as future colleagues and gain further insight into the tips of managing a successful research program. I believe that science's real power is in collaboration; mixing and matching tools from various disciplines to solve problems in other areas leads to innovation. Participating in the program will allow me to build relationships with peers from ranging perspectives with unique skillsets. I hope to learn how to effectively pair my research objectives to funding agencies and their research programs.

My previous research experiences have provided extensive training in engineering synthetic circuits with biological inputs *in vitro* and *in vivo*. In my doctoral work at UC Riverside, I coupled nucleic acid based circuits to the modulations of DNA-based nanostructures. As a postdoctoral fellow, I am implementing population controllers in bacterial communities. I developed a computation model to predict population dynamics within a synthetic microbial consortium.

As future faculty, I will continue to engineer regulatory systems (bacterial chassis or communities) for improved microbial diversity within the human microbiome as described in my research statement. In addition to developing an innovation-focused lab, I will contribute through mentorship and instructional excellence. My personal experiences and leadership roles have equipped me with the tools to make my goals for diversity, equity, and inclusion achievable. As a graduate student, I served as President of the Bioengineering Graduate Student Association and the graduate advisor for the National Society of Black Engineers, each cohort elevating my awareness and appreciation of pluralism. As I prepare to transition into a tenure-track faculty appointment, I will continue stimulating personal passions leading to career development in the lives of those around me.

Thank you for your time and consideration. I have enclosed my research and teaching plan and curriculum vitae for your review. I look forward to the possibility of being recognized as a Black Trailblazer in Engineering.

Sincerely,

Leopold N. Green, Ph.D.
Postdoctoral Fellow

LEOPOLD N. GREEN

MENTOR · EDUCATOR · SYNTHETIC BIOLOGIST

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EDUCATION & TRAINING

California Institute of Technology — April 2017 - Current
Post-Doctoral Researcher in Biology and Biological Engineering — *Pasadena, CA*

University of California, Riverside — December 2016
Ph.D. in Bioengineering — *Riverside, CA*

Hampton University — May 2011
B.S. in Chemistry — *Hampton, VA*

RESEARCH INTERESTS

Keywords: Synthetic biology, Control theory, Inter-kingdom signaling, Chemistry, Biosensors, Microbiome, Personalized medicine, Microscopy,and image processing, Data Analysis (Python, MATLAB)

Detailed Projects:

1. Identify interkingdom signals produced by bio-films of either environmentally relevant or medically relevant signals and chemical toxins for real-time contamination/pathogen detection.
2. Expound on current synthetic biology toolkit by designing, integrating, and characterizing functional circuits in environmentally and medically relevant pathogenic or commensal microbial strains (e.g., *Pseudomonas aeruginosa*; *Staphylococcus aureus*).
3. Design, model, and implement bacterial controllers that sense and respond to pathogen-induced interkingdom signals, improving the conditions of concern (e.g., biofilm production; healing dynamics of chronic conditions).

RESEARCH EXPERIENCE

Caltech — May 2017 - Current
Post-doctoral Research Fellow — *Pasadena, CA*
Advisor: *Richard Murray*, Collaborator: *Sarkis Mazmanian*

I am project lead for multiple, concurrent projects where I am responsible for both coordinating high-level strategic visions and implementing ideas experimentally. Scientifically I engineer the regulation of multi-cellular systems that enable the expansion of synthetic biology tools and systems. By integrating concepts of control theory and inter-kingdom biomedical signaling processes (host to microbes), I am engineering multi-cellular population circuits in both synthetic and *in vivo* microbial communities for potential health applications; promoting chronic to acute conditions using microbial interactions. (Projects are funded by DAPRA Biological Control; NSF AGEP; Caltech Rosen Grant).

University of California Riverside — August 2011 - December 2016
Dept. of Bioengineering and Mechanical Engineering — *Pasadena, CA*
Advisor: *Elisa Franco (now at UCLA)*

I engineered nucleic-acid based biosensors as self-assembling tile motifs (DNA nanotubes) whose dynamic assembly were modulated via environmental biosignals; nucleic-acid inputs regulated by synthetic transcriptional oscillator or environmental pH. (Projects are funded by NSF GRFP).

Hampton University September 2009 - May 2011
Dept. of Chemistry and Physics *Hampton, VA*
Advisor: *Kesete Ghebreyessus, Uwe Hommerich*

I synthesized lanthanide luminescence Yb^{3+}/Er^{3+} co-doped LaF^{3+} nano-crystals for 2-photon up-conversion fluorescence. Using laser spectroscopy, I quantified luminescent properties of the nano-particles.

University of Rochester Medical Center Summer 2009
Dept. of Dermatology - McNair Scholar *Rochester, NY*
Advisor: *Lisa DeLouise*

I chemically modified the surface of toxic, heavy metal core quantum dots and analyzed absorption and penetration of quantum dots on ex-vivo skin samples using flow cytometry.

INDUSTRY EXPERIENCE

Holoclara 2019
Technical Consultant *Pasadena, CA*

Thermo Fisher Scientific, One Lambda June 2016 - December 2016
R&D Project Manager *Canoga Park, CA*

UNCF - Merck & Co. Summer 2010
R&D Process Chemistry Intern *Rahway, NJ*

HONORS & AWARDS

California AGEP Postdoctoral Fellowship	Caltech	2019
Rosen Center Pilot Grant Awards	Caltech	2018
National Science Foundation GRFP	UC Riverside	2013
Ford Fellowship Foundation Honorable Mention	UC Riverside	2012, 2013
U.S. Department of Education GAANN	UC Riverside	2012
Future Nobel Laureate	Hampton University	2011
United Negro College Fund MERCK	Undergraduate Fellow	2010
Ronald E. McNair Fellowship Program	Undergraduate Fellow	2009

SELECTED PUBLICATIONS

8. "Engineering Logical Inflammation Sensing Circuit for Gut Modulation.". Liana N. Merk, Andrey S. Shur, Ayush Pandey, Richard M. Murray, and Leopold N. BioRXiv. 2020.
7. "Bacterial controller aided wound healing: A Case study in dynamical population controller design". Leopold N. Green, Chelsea Y. Hu, Xinying Y. Ren, and Richard M. Murray. BioRXiv. 2019.
6. "Autonomous dynamic control of DNA nanostructure self-assembly". Leopold N. Green, Hari K. K. Subramanian, Vahid Mardanlou, Jongmin Kim, Rizal F. Hariadi, and Elisa Franco. Nature Chemistry. 2019.
5. "T7 RNA polymerase can transcribe and induce disassembly of DNA nanostructures". Samuel Schaffter, Leopold N. Green, Joanna Schneider , Hari K. K. Subramanian, Rebecca Schulman, and Elisa Franco. Nucleic Acids Research. 2018.
4. "Control of bacterial population density with population feedback and molecular sequestration". Reed D. McCardell, Shan Huang, Leopold N. Green, and Richard M. Murray. BioRXiv. 2017.
3. "pH-driven reversible self-assembly of micron-scale DNA scaffolds". Leopold N. Green, Alessia Amodio, Hari K. K. Subramanian, Francesco Ricci, and Elisa Franco. Nano Letters. 2017.

2. "A coarse-grained model captures the temporal evolution of DNA nanotube length distributions".Vahid Mardanlou, Kimia C. Yaghoubi, Leopold N. Green, Hari K. K. Subramanian, Rizal F. Hariadi, Jongmin Kim, and Elisa Franco. Natural Computing. 2017.

1. "Screening Chelating Agents and Carbon or Silica Gel-Based Binary Systems for a Cost-Effective Method to Remove Palladium from Pharmaceutical Intermediates and APIs". Lijun Wang, Leopold N. Green, et. al. Organic Process Research & Development ACS. 2011.

SCHOLARLY ACTIVITIES

Teaching

- Adjunct Professor: Elementary Chemistry at Long Beach City College (2018 - 2020)
- Guest Lecturer: Synthetic Biology - Bi1x Introductory to Biology Lab at Caltech (2018, 2019)
- Science Lecturer: TRiO and Upward Bound at UC Riverside (2014, 2015)

Leadership

- Recruitment Liaison: Center for Diversity at Caltech (2018 - Current)
- Member: Caltech Postdoc Association; Career development committee (Summer 2019)
- Member: Black Scientists and Engineers at Caltech (BSEC) (2017 - Current)
- Graduate Advisor: National Society of Black Engineers (NSBE) (2012 - 2018)
- Mentor: Graduate Student Mentorship Program (2013 - 2016)
- President: Bioengineering Graduate Student Association (GSA) (2012 - 2013)

Community

- Speaker: Hackaday Los Angeles Meetup (2019)
- Speaker: Dropping Knowledge ODDBalls Summit (2019)
- Speaker: European Congress on Cell-Free Synthetic Biology (2016)

REFERENCES

Richard Murray, Ph.D
Postdoctoral Research Advisor
Professor, Control & Dynamical Systems, Biology and Biological Engineering
Caltech
Email: murray@cds.caltech.edu

Elisa Franco, Ph.D
Graduate Studies Research Advisor
Assistant Professor, Department of Mechanical Engineering
University of California, Los Angeles
Email: efranco@seas.ucla.edu

Teaching, Diversity, and Inclusion

As a proud graduate of two Minority Serving Institutions—Hampton University and the University of California Riverside, **my goal is to develop scientific researchers and innovators by fostering new outlooks and identify creative solutions to medical and ecological concerns**. I will build on students' diverse perspectives, focusing mainly on supporting students from underrepresented communities. Being of Black-American heritage, I am familiar with the benefits and adversity minorities face, from environmental factors, such as exposure and representation, to psychological factors, including mindset and perspective[1].

My plan for contributing to inclusion and diversity comprises the following three aims:

1. Increasing the accessibility and application of knowledge gathered from peer-reviewed resources.
2. Improving equity to rigorous research and the sequential stages beyond.
3. Implementing synthetic biology tools to design living therapies for health conditions predominant in ethnic minority communities.

Traditional classroom learning environments are shifting to include virtual lectures, affecting students globally, but vastly those who cannot afford the technology[2]. I aim to establish a peri- and post-pandemic learning community where each student will develop the tools, confidence, and self-awareness for successful self-directed learning. As an adjunct faculty, I re-designed the learning curriculum to incorporate journal club-like discussions on topics relevant to the course subject matter and current events. The learning objectives include locating, accessing, and analyzing journal articles pertinent to the issue of interest. I walk students through reviewing the literature, critically examining the research methodology, and summarizing the ecologic and economic outlook from personal and global perspectives. As in classroom settings, student engagement in virtual learning environments is critical to their success.

Research Statement—Synthetic biology approaches to engineering microbial-based therapeutics for auto-immune and chronic conditions.

My overall research goal is to uncover the biological control principles in bacterial chassis for regulating microbial populations and host immune response by integrating synthetic biology tools as new immunotherapies strategies.

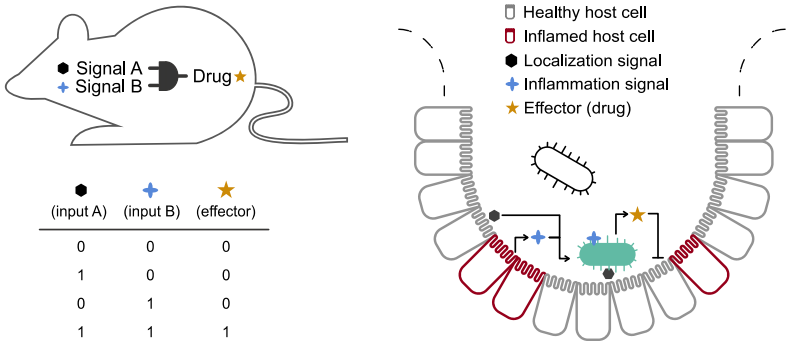

Figure 1. Proposal Overview. (left) Schematic of the smart therapeutic logic circuit. Truth table; the drug effector is produced only when inputs A and B are present. (right) Illustration of the inactive circuit (white bacteria) receiving both localization and inflammation signal producing drug and improving inflammation in the host cells.

Overview

Microbiome-targeted therapeutics for inflammatory bowel diseases (IBD) relies on a strict dosage schedule of antimicrobial drugs for improved microbial diversity. However, an estimated one-half of patients suffering from IBD struggle to adhere to their prescribed regimens, leading to disease relapse and preventable deaths[3]. Technological progress in synthetic biology offers exciting opportunities to engineer 'smart' microbial-based therapeutics compared to traditional prebiotics and probiotics. Microbial systems can be designed to sense inflammation and respond by producing an anti-inflammatory compound. The proposed research's expected outcome is to develop living therapeutics capable of multiplexing and to respond to medically relevant and host environmental signals (**Figure 1**).

Past and Current Research

My DNA nanotechnology and microbial synthetic biology experience have prepared me to lead an exciting research program implementing synthetic circuits in biological systems to uncover new therapeutics designed in microbial systems. I will combine the engineering techniques I gained through my graduate and postdoc studies for circuit design and optimization for complex, in-vivo environments.

During my graduate studies, I coupled a synthetic transcriptional oscillator to drive the mechanical dynamics of DNA-based nanostructures, driven by specified nucleic acid inputs and changes in the environmental pH conditions[4]. The engineered DNA nanotubes' structural and self-assembling dynamics resemble microtubules and have promising implications of synthetic cell division and motility, a primary research goal of synthetic biology.

As a postdoctoral fellow, I led a team of undergraduate and graduate researchers, who together coupled a two-component tetrathionate system to a Split Activator AND Gate (SAAG) detector as a logical inflammation sensor. The SAAG logic detector comprises two co-activating genes, hrpR and hrpS, controlled by two orthogonal environmental inputs, tetrathionate and isopropyl β-D-1-thiogalactopyranoside (IPTG). As illustrated in **Figure 2**, I demonstrated the successful integration of inflammation paired to the AND Boolean input sensor from two distinct bacteria in an EcN chassis. As designed, the logic inflammation sensor requires both tetrathionate and IPTG to be present in the system at appropriate concentrations for the induced expression of super-folding Green Fluorescent Protein in the engineered circuit[5]. I am currently working to extend the circuit's capabilities to sense a disease-relevant secondary input and secrete an anti-inflammatory agent in response to AND-gate activation in DSS-induced IBD mouse models.

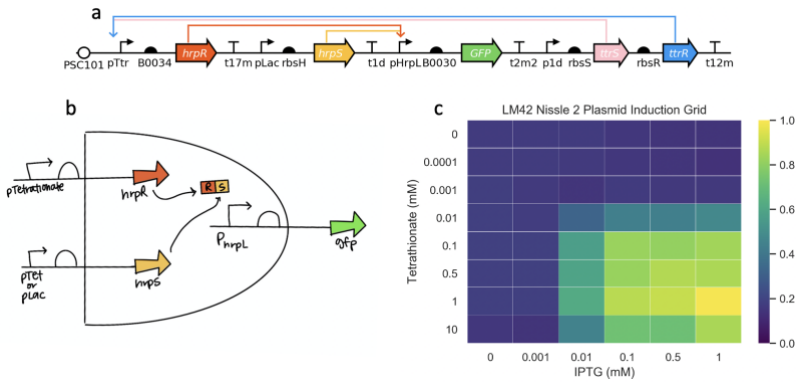

Figure 2. Coupled inflammation-logic gate sensor. **(a)** Plasmid diagram of Boolean AND gate system induced by tetrathionate and isopropyl β-D-1-thiogalactopyranoside (IPTG) **(b)** Circuit overview of AND gate with inputs tetrathionate and IPTG expressing GFP. **(c)** Plate reader data showing optical density-normalized GFP expression, signifying AND-gate activation at high IPTG and tetrathionate concentration.

I propose to engineer genetic circuits that will sense the environmental signals that occur around IBD lesions and respond by releasing therapeutic molecules at the epithelial surface using the probiotic strain *E. coli* Nissle 1917 (EcN). The proposal's overall objective is to use a Split Activator AND Gate (SAAG) detector[6] to sense tetrathionate, a host-produced marker of inflammation[7], and interaction with the gut epithelial surface. The rationale is that the proposed work will improve dosage-based medication regimens for those with IBD by substituting modular circuit components with functionally characterized inflammatory sensors and anti-inflammatory actuators.

To address the needs for medical integration of synthetic circuits, I propose four specific aims:

Aim 1: Create a pro-inflammatory sensor with an AND logic gate. This aim will combine knowledge from the characterized tetrathionate inflammation systems with the SAAG detector to allow the engineered EcN to sense local tetrathionate concentrations as one of two medically relevant inputs. I will investigate and tune the sensitivity of detecting inflammation in bulk culture and a mouse colitis model.

Aim 2: Develop an anti-inflammatory effector. The small metabolite itaconate has demonstrated anti-inflammatory responses in macrophages[8] and in DSS induced colitis mouse models, while short-chain fatty acids and mammalian cytokines interleukin-10 and interleukin-22 have improved inflammatory response in intestinal epithelial cells. I will determine if an IBD mouse model can be protected from inflammation-induced intestinal injury by colonizing the mice with EcN expressing these anti-inflammatory molecules.

Aim 3: Create proximity sensors for localized epithelial detection in vivo. I will repurpose mechano-induced promoters derived from EcN-epithelial cell interactions[9] and EcN-mucosal interactions[10] to add a level of control to the circuit by including a "mechanosensor" that activates when EcN is bound to host mucosal epithelium. I will optimize the mechanosensor, which will serve as the secondary input into the SAAG detector, for near-epithelial sensing in vivo using healthy mice.

Aim 4: Implement microbial-based therapeutics in vivo. By combining the elements described above, I will build a 'smart' bio-therapeutic with the optimized pro-inflammatory sensor and anti-inflammatory effector. To demonstrate improved inflammation in IBD impaired systems, I will compare this new bio-therapeutic against the clinical standard of fixed dosage regimen for IBD treatments in an IBD-induced mouse model. To improve the resolution of chronic conditions using microbial therapeutics, I will build upon previous computational models of characterized regulator circuit designs.

My independent research will explore the design principles for engineering synthetic controllers capable of regulating the onset of various diseases and conditions. The proposed project will encourage future collaborations with the long-term goal of advancing novel therapeutics for human IBD and other medical disorders with shared dynamic complexity. Diseases of interest include intersecting the gut microbiome-host interactions, multicellular coordination involved in healing, and viral sensing and eradication.

References

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[4] **Green, L.N.**, Subramanian, H.K.K., Mardanlou, V. *et al.* Autonomous dynamic control of DNA nanostructure self-assembly. *Nature Chemistry*, (2019). https://doi.org/10.1038/s41557-019-0251-8

[5] Merk, L., Shur A.S., Pandey, A., Murray, R.M., **Green, L.N**. Engineering Logical Inflammation Sensing Circuit for Gut Modulation. *BioRxiv*, (2020). https://doi.org/10.1101/2020.11.10.377085

[6] Wang, B., Kitney, R., Joly, N. et al. Engineering modular and orthogonal genetic logic gates for robust digital-like synthetic biology. *Nature Communication*, (2011). https://doi.org/10.1038/ncomms1516

[7] Winter, S., Thiennimitr, P., Winter, M. et al. Gut inflammation provides a respiratory electron acceptor for Salmonella. *Nature,* (2010). https://doi.org/10.1038/nature09415

[8] Mills, E., Ryan, D., Prag, H. et al. Itaconate is an anti-inflammatory metabolite that activates Nrf2 via alkylation of KEAP1. *Nature*, (2018). https://doi.org/10.1038/nature25986

[9] Schwan WR, Beck MT, Hung CS, Hultgren SJ. Differential Regulation of *Escherichia coli fim* Genes following Binding to Mannose Receptors. *J Pathog*. (2018). doi:10.1155/2018/2897581

[10] Valeri M, Rossi Paccani S, Kasendra M, Nesta B, Serino L, et al. Pathogenic *E. coli* Exploits SslE Mucinase Activity to Translocate through the Mucosal Barrier and Get Access to Host Cells. *PLOS ONE*, (2015). https://doi.org/10.1371/journal.pone.0117486

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January 18, 2021

To Whom It May Concern:

This is a letter of support for Leopold Green, who is applying for the Black Trailblazers in Engineering program. I am Leo's postdoctoral advisor at Caltech and I have worked with him for the past four years.

Leo's did his PhD work with my former student, Elisa Franco, at UC Riverside, focused on an experimental system for implementing a method to assemble and disassemble DNA nanostructures (double cross-over tile based tubes) with dynamic DNA inputs and circuits. These related to some work that Elisa had done during her PhD on the use of "genelet" circuits (short pieces of DNA and RNA that interact with RNA polymerase to create biomolecular processing systems). Leo came to Caltech with excellent experimental skills and an interest in learning more about synthetic biology.

Since joining Caltech as a postdoc, Leo has been instrumental in his role as a task lead for a collaborative project engineering multicellular control system that mimics the population dynamics of wound healing. In this project, Leo has design and implemented genetic circuits that are capable of modulating the growth of engineered bacteria and using cell-cell signaling to generate a sequential growth pattern. This work requires careful attention to detail and Leo's strong experimental background has been extremely useful. In addition to working with a couple of different liquid handling robots and associated plate readers, stereoscopes, and other equipment, Leo has also learned the basics of synthetic biology, including design, implementation (cloning), and measurement of genetic circuits in engineered micro-organisms.

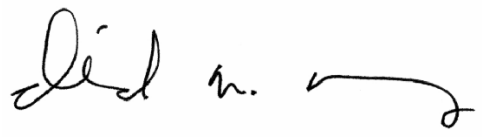
Leo is passionate about engineering systems using synthetic biology tools for future therapeutic applications. His creativity has established a new collaboration with Professor Sarkis Mazmanian, co-mentor of Leo's proposal, including receiving seed funding and postdoctoral fellowships through the Rosen Center of Bioengineering, NSF-sponsored California Alliance for Graduate Education and the Professoriate (AGEP), and most recently, Caltech's Center for Environmental Microbial Interactions (CEMI). Leo has also taken on the mentor role for Caltech undergraduate student Liana Merk, now a senior who is applying to graduate schools (and one of the strongest students working in my group for the last decade).

Leo is also active in the Caltech and local communities as a member of Black Scientist and Engineers at Caltech (BSEC), volunteering as a guest lecture in a hands-on freshman biology course (Bi 1x) taught with Professor Justin Bois, and teaching at local community colleges and virtually at minority-serving institutions. Minority representation in science and engineering is important to Leo, and we have had discussions in both individual and group settings about how to improve diversity and inclusion at Caltech and in science and engineering more generally.

Leo's long-term goal is to engineer microbes capable of modulating inflammatory markers that promote beneficial interactions between the host and its microbiome. His future work aims to integrate adaptive sense and response circuits in *E. coli* by adopting medically significant circuit components and elucidating circuit design principles required for efficient and durable functionality against human disease. Toward this goal, Leo has led the optimization of an inflammatory tetrathionate sensor, designed regulatory circuit architectures, and characterized the circuit's dynamics in the well-characterized *E. coli* chassis. This application's rationale is that this is the next step toward a new generation of treatments that can systematically improve chronic conditions via microbial-based therapeutics.

Overall, I have been very impressed with Leo in the time that he has been in my group. He is smart, dedicated, and curious. He works well independently but also has a great interaction with others in the group, and is involved in several joint projects. He has a passion to be a researcher and to both uncover new knowledge and spread knowledge to others. He is going to be an outstanding researcher, teacher, and scholar, and I am happy to recommend him as a participant in the Black Trailblazers in Engineering program.

Sincerely,



Richard M. Murray (Mentor)
Thomas E. and Doris Everhart Professor of Control & Dynamical Systems and Bioengineering
California Institute of Technology

Elisa Franco
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Department of Mechanical and Aerospace Engineering
University of California, Los Angeles
420 Westwood Plaza, 48-121 Engineering IV
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efranco@seas.ucla.edu

January 19th, 2021

To whom it may concern,

It is my pleasure to write this letter to support Dr. Leopold (Leo) N. Green's application for the Purdue Engineering program "Black Trailblazers in Engineering". I was Leo's PhD research advisor between 2012-2016.

I received my Ph.D. from the California Institute of Technology (Caltech) in 2012. I was an Assistant Professor in Mechanical Engineering at the University of California – Riverside (2011-2018); I am now an Associate Professor in Mechanical and Aerospace Engineering at UCLA. All research projects in my group are interdisciplinary and span across DNA nanotechnology, synthetic biology, and control and dynamical systems theory.

First, I will summarize Leo's doctoral research, which focused on designing and building responsive biomolecular materials using nucleic acids. A material is responsive when it can change its properties (shape, elasticity, granularity etc.) depending on environmental stimuli. Responsive biomolecular materials such as membranes and cytoskeletal scaffolds make it possible for biological cells to respond to environmental stimuli, and grow, move, self-repair, and self-replicate, all extremely complex tasks hardly achievable by man-made materials. The goal of Leo's dissertation was to achieve adaptive responses in a simplified molecular analogue of cytoskeletal scaffolds, made with programmable molecular elements. Leo was able to achieve his goal by using DNA self-assembling components, that can yield filamentous scaffolds (DNA nanotubes) when sequences are properly designed. Leo engineered a well-known type of DNA nanotubes so that they could assemble and disassemble from small monomers, depending on the presence of other DNA strands in solution as well as on the solution pH levels. He showed that the mean nanotube length can be reversibly increased or decreased, demonstrating the ability to actively modify the macroscopic properties of the material by influencing the properties of nanoscale components.

The mechanical and physical properties of cytoskeletal scaffolds in cells depend on the outputs of gene networks, for instance circadian clocks determine microtubule reorganization to carry out cell division. Leopold tried to mimic this architecture, and he showed that DNA nanotube length distribution can be modulated using biological reactions such as transcription and enzymatic degradation. Further, he successfully tuned a synthetic *in vitro* biomolecular oscillator to direct nanotube assembly: the oscillator is comprised of two artificial templates that mutually regulate their activity with their RNA transcripts, and all components of the circuits oscillate over time. Leo carefully programmed one of the RNA outputs of the oscillator to direct nanotube assembly. This multi-year project was summarized in several publications; the

most important report was published in *Nature Chemistry*. Two additional manuscripts on smaller projects that originated from Leo's thesis were published in *Nano Letters* and *Nucleic Acids Research*. Some of his work was done in collaboration with the Schulman lab at Johns Hopkins (Chemical and Biomolecular Engineering). Leo is also coauthor of a journal paper published in *Natural Computing*, that describes computational modeling of the evolution over time of DNA nanotube length distributions.

The success of Leo's projects largely depended on his ability to learn techniques and approaches from different fields, including biochemistry, synthetic biology, and control theory. He led the majority of experimental efforts, which presented a variety of challenges. For example, he had to develop new protocols for collecting and quantifying nanotube length distributions (using microscopy, image processing, and gel electrophoresis), and he developed assays to quantify nanotube stability in the presence of enzymes and diverse pH conditions. He interacted very productively with other members of the laboratory to complete all necessary control experiments, and to develop a computational model to describe his results.

In summary, during his Ph.D. studies Leo developed a conceptual and experimental framework to study complex biochemical systems in which sensing and feedback are embedded in the molecular machinery. His work is of fundamental relevance to materials science, chemical engineering, and biology, as it provides us with new tools to think about how to build advanced living materials.

In addition to his technical and academic skills, Leo proved to be an excellent mentor who trained other graduate and undergraduate students in my group. Leo is extremely patient, kind, and dependable; not once I have seen him become frustrated or demoralized due to the length (and tediousness) of many of his experiments. His oral and written communication skills are very good. Although I have not worked with him on course instruction, I know he has gained teaching experience as a postdoctoral scholar at Caltech.

Leo is a first generation college student, and one of his career goals is to promote diversity in STEM fields by working as a teacher and researcher. Based on what I observed, I am certain that Leo will become a successful academic and will have a very positive impact on his coworkers and mentees, thus I believe he is an outstanding candidate for the Purdue Trailblazer program.

If you have additional questions about Leo, please do not hesitate to contact me at efranco@seas.ucla.edu.

Sincerely,

Elisa Franco