Max Kearns   Columbia University PhD Application

To the Graduate Program Admissions Committee,

I graduated in the Spring of 2020 from the University of Rochester with my undergraduate degree in Chemical Engineering, when Covid-19 had just begun and no one knew how long the pandemic era of learning would last. I decided to postpone my goal of earning a graduate degree and gain professional experience working in industry. In the two years I worked as a process engineer, I gained a deep appreciation for the role of chemical engineering in improving food quality and reducing the environmental impact of large manufacturing plants. During this time, I also witnessed many incredible innovations in the biotechnology industry – multiple vaccines, antibody therapies, and antiviral treatments emerged over a short time span of two years. It was a miraculous feat and inspired me to return to an innovative academic environment for my master's degree in chemical engineering with a focus in biotechnology. Through technical coursework in tissue engineering, biological machine learning, and core chemical engineering subjects, I was able to develop new skills to implement in my research. I began working in the lab of Dr. Allie Obermeyer, where I had the opportunity to apply machine learning algorithms to synthetic biology problems. Working at this exciting intersection of fields expanded my research interests in synthetic biology, cellular engineering, and applied machine learning and motivated me to apply into the PhD program at Columbia University.

My motivation to earn a doctorate degree is driven by both short-term and long-term goals – as a graduate student, I want to continue learning, be intellectually challenged, and contribute original work in the field of chemical engineering. My research experience in the lab of Dr. Allie Obermeyer solidified these goals. To enhance the quantitative analysis of *E. coli* cell

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morphology using microscopy images, I developed a support vector machine (SVM) to classify whether individual cells were correctly segmented from their background. During this process, I experienced numerous programming challenges, struggled to take high quality images of fixed bacteria cells, and spent a large portion of the project figuring out how to manage the large data sets I was constructing. Ultimately, I wrote a MATLAB script to extract image data from more than 10,000 individual *E. coli* cells expressing green fluorescent protein (GFP) with various charged peptide tags. To incorporate this training data into the SVM, I needed to produce high quality labels for my data. To accomplish this, I spent several weeks using my "human eye" combined with open-source software to manually label all 10,000 cells. Using this high-quality curated data set, I trained, validated, and tested the SVM. The overall classification accuracy was 85%, with a low false positive rate of 7%, which significantly improved the quantitative image analysis of bacteria cell morphology. It was immensely gratifying to achieve improved results after encountering numerous project obstacles. This experience has been a driving force for me to pursue challenging research as a doctoral student. In addition to gaining skills in molecular cloning, cell culture techniques, plasmid design, and microscopy, this project also introduced me to the exciting intersection of synthetic biology and machine learning.

As a PhD student at Columbia University, I want to continue working on complex chemical and biological engineering problems. I believe my research interests in synthetic biology, cellular engineering, and applied machine learning would make me a strong candidate to do research in the labs of Professor Allie Obermeyer, Professor Scott Banta, and Professor Mijo Simunovic.

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Earning a doctorate degree will fulfill a long-term goal of becoming a credible scientist with the ability to engage with other technical leaders. My goal is to use the skills from my PhD degree and consulting experience to start a business venture in the biotechnology industry. My previous industry experience exposed me to the high-intensity atmosphere of engineering proposals, client relationships, and technical presentations. Our clients, including several multibillion-dollar food and beverage companies in the U.S, tasked us with designing new manufacturing facilities and process lines. It was incredibly satisfying designing technical solutions for major clients, but I desired to work on problems of greater complexity and open-endedness. A doctoral degree will allow me to develop an expertise in a niche area of chemical engineering and approach emerging challenges in a methodical and technically rigorous way. These are the skills I want to develop to be a scientific leader in my future career. Furthermore, Columbia University has one of the strongest entrepreneurship environments in the world – the Columbia Startup Lab in Morningside offers resources to enhance my entrepreneurship skills while pursuing fulltime research. Other opportunities, such as the technology track Venture Competition, would be perfect for gaining startup capital with a more mature innovation. I believe Columbia University will provide me with unparalleled support and opportunities to engage in intense research while simultaneously progressing towards my long-term entrepreneurial goals.

Alongside academics, I hope to enrich the engineering community at Columbia University. As an undergraduate, I was deeply involved in student government and the American Institute of Chemical Engineers (AIChE). I spent 3 years as a student accountant where I collaborated weekly with a committee to review the budgets of 200+ student organizations. This

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culminated in being selected as Deputy Treasurer, where I helped steer student account meetings and met weekly with the Associate Dean of students to allocate over $1 million to 200+ diverse student organizations. As a member of AIChE, I was elected to Business Manager my junior year, and then President my senior year. In these roles, I led our team to create professional development opportunities for underclassman and collaborated with other engineering organizations to increase underclassman involvement. As a result of our successful student engagement, the career center presented us with the annual "Gwennie" award for exemplifying the values of professional development and career education. These roles allowed me to support my fellow classmates, grow as a student leader, and contribute to a vibrant engineering community. I am excited about the opportunity to become just as involved with organizations like ChEGO or the Engineering Graduate Student Council (EGSC).

I have had an exceptional research and academic experience while earning my MS degree at Columbia University. My research in the lab of Dr. Allie Obermeyer inspired me to continue studying in the field of chemical and biological engineering, and I hope to have the opportunity to join this world-class department for my doctorate degree. Columbia University has supportive faculty, cutting-edge research projects, and an entrepreneurial culture that would enable me to achieve my long-term professional goals. I sincerely hope to contribute as a full-time PhD student in the Chemical Engineering department, and I thank you for reviewing my application.