Institute for

Quantitative
THEORY AND METHODS

Darwin's theory of evolution

The industrial revolution

Social networking

JOIN THE DATA REVOLUTION

EMORY
COLLEGE
OF ARTS AND
SCIENCES

**Institute for Quantitative
Theory and Methods**

A Rising Program Begins with Leadership and Vision

We cultivate technically gifted, liberal arts–trained talent—and what does this yield for our data-driven world? The answer is individuals who can be the problem solvers, critical thinkers, data scientists, and communicators. These are the people who will lead the world with the data that drives it.

This Is What Makes Our Model Revolutionary

CLIFFORD J. CARRUBBA

Director, Institute for Quantitative Theory and Methods

Professor of Political Science and Law by courtesy

Carrubba earned his PhD from Stanford University in 1998 and previously served as an assistant professor at SUNY–Stony Brook. In addition to his role at Emory, he currently serves as the director of the Centre for the Study of Law, Politics and Economics. His specialization is in comparative legislative and judicial politics, comparative institutions, European politics, and game theory. Current research projects include studies of legislative behavior and roll-call vote analysis, the design and change of judicial institutions (with application to the European Court of Justice), and statistical tests of game theoretical models.

ADAM GLYNN

Associate Director, Institute for Quantitative Theory and Methods

Associate Professor of Political Science
Secondary appointment: Department of Biostatistics and Bioinformatics, Rollins School of Public Health

Glynn earned his PhD at the University of Washington in 2006 and previously served as an assistant and associate professor at Harvard University. His research focuses on causal inference and sampling/survey design for political science applications. His articles have been published in a number of leading journals, including the *American Journal of Political Science*, *Journal of the American Statistical Association*, *Journal of the Royal Statistical Society*, *Political Analysis*, and *Public Opinion Quarterly*.

Why Data Science at QTM?

The world's awash in data. The impact of it is felt in all fields and industries. An IBM report notes that "by 2020, the number of jobs for all US data professionals will increase by 364,000 openings to 2,720,000." —"The Quant Crunch: How the Demand for Data Science Skills Is Disrupting the Job Market"

Higher education has responded by investing in the field of data science, which consists of training in math, statistics, and computer science. Math skills are important for statistics; statistics skills are vital for drawing correct inferences from data; and computer science skills are critical for collecting, managing, and analyzing that data.

These skills are extremely useful but ultimately are just tools. Technical training alone is not enough. How do we identify the questions we want answered? How do we know if we are collecting, analyzing, and reporting the right data? Once we have results, how do we "sell" what we have learned?

At Emory, we believe the answer lies at the intersection of data science and the liberal arts. To be able to generate questions and demonstrate contextual

knowledge comes from exposure to fields such as the natural sciences, social sciences, humanities, business, health, and law. Using data intelligently requires theoretical and research design skills. Selling requires technical communication skills. Our Quantitative Sciences major programs provide future leaders with this complete skillset.

What does this education allow our students to do? They learn to identify the questions, collect the data, and answer those questions all in one—training that is normally reserved for PhD programs.

DEFINING QUESTIONS

COLLECTING DATA

DATA

COMMUNICATING RESULTS

ANALYZING AND INTERPRETING DATA
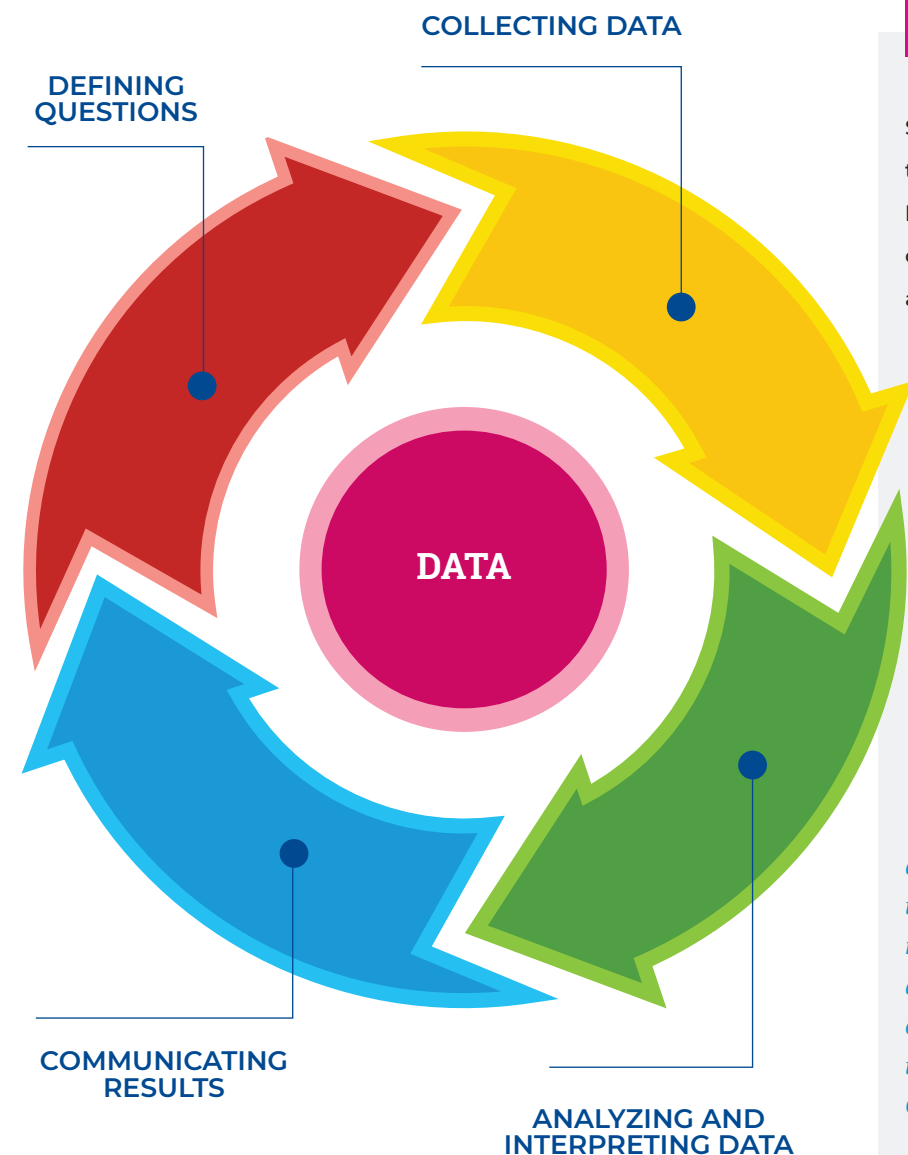
Predictive Modeling

Suppose you want to predict presidential election outcomes. The best predictive models are based on polls leading up to the election and, critically, those polls have to make assumptions about voter behaviors such as turnout. As long as voter behavior does not change, these models will perform quite well. However, if there is something that causes turnout patterns to change, then these models will perform poorly, as happened in the 2016 presidential election.

Our students' training in a substantive field (e.g., political science) and foundation in research design and theory position them to anticipate important changes before they occur. For instance, the presence of an atypical candidate such as Donald Trump in 2016 meant that turnout operated differently. In short, predictive models work great until they don't. If businesses are making decisions based on predictive models, or providing predictive models, they need someone trained to notice when that model is likely to break. **Our students are prepared to do just that.**

Causal Modeling

Suppose you hire a data scientist to examine whether higher teacher quality causes better educational outcomes with the goal of making a policy recommendation. The data scientist can demonstrate that teacher quality matters for long-term student success. She recommends holding teachers to a strict performance standard and that, if they do not meet it after two years, they should be fired.

The data scientist has excelled on the technical analysis but likely failed—badly—on the policy recommendation for not considering the bigger picture. Having high-quality teachers requires being able to recruit them.

Though a highly compensated football player may be willing to enter such a risky contract, a gifted individual who has ample professional opportunities is much less likely to take a teacher salary with such risk attached to it.

Our curriculum stresses research design and conceptual skills—the "how to" that undergirds examining any issue. The data scientist in this case would need not only such a foundation but also to learn more about the issue before making a policy recommendation. **Our students are prepared to do just that.**

Data Science with a Difference

"What matters now is not the skills you have but how you think. Can you ask the right questions? Do you know what problem you're trying to solve in the first place?"

— *J. M. Olejarz*
"Liberal Arts in the Data Age," Harvard Business Review
July–August 2017

No matter what pathway our students choose, they begin with the same foundational course of study. This core coursework provides them with the necessary statistical, computational, and scientific background to succeed.

QTM students learn multivariable calculus, matrix algebra, probability theory, statistics, and programming in R. They also take electives in a wide variety of topics and techniques including casual inference, machine learning, experimental design, Python, text as data, data visualization, generalized linear model, and more.

The core of our curricula consists of hard data science skills. We then ask our students to go further: in three of our four majors (under the umbrella of quantitative sciences), students must take classes in a substantive focus, ranging from biology and neuroscience and behavioral biology to any of the social sciences, and from history and English to more preprofessional foci like public policy and business. We offer electives that develop theory building (e.g., game theory and computational modeling) and technical communication skills.

Quantitative Sciences at Emory University

TECHNICAL COMMUNICATION

PROGRAMMING | **SUBSTANTIVE EXPERTISE** | **MATHEMATICS & STATISTICS**

RESEARCH DESIGN & THEORY

ALLISON ROSE
[BS, Quantitative Sciences with a Political Science track; second major, Music Performance]

By pursuing quantitative sciences, Allison is expressing the family DNA. After all, her mother does data testing for NAPA Auto Parts and her father started a computer company.

She first heard about QTM in her second semester and, upon learning that she could concentrate in public policy analysis, was sold. Very tuned into the 2016 election—the first in which she voted—Allison often found herself on FiveThirtyEight.com, with its opinion poll analysis and elegant data visualizations. She won Best Data Visualization at last year's DataFest™ for an ingenious map showing where Expedia customers traveled, thereby helping the company understand its base better.

Data is the gift that keeps on giving, with Allison sometimes helping others online when their code isn't working. Most of all, she covets her role as translator—being able to narrow data and solve questions that others need answered.

Talk about practice making perfect: Allison uses her skills working for Emory's housing program and also is an "expert graider" for the Graide Network, norming and scoring critical-thinking questions for the Chicago Public School System's computer science program.

This summer, she'll work as a forensic technology solutions intern at PwC. "It's a mouthful," she admits, "but what it means is that firms will be sending PwC data; I will analyze it and work with their lawyers regarding any fraudulent activity."

The president of the Data Science Club is busy, but she is well-rounded—loving art, time with friends, and deepening her skill as a bassoon player.

Says Allison, "There are still so many fields that haven't caught up to what data science can provide. It excites me to think of all I can do."

Our Curriculum

The curriculum also includes an intensive research design class and a technical communication class, which teaches students how to talk clearly and succinctly about their results and research to any type of audience.

Students select from four types of electives, all of which allow them to enhance their skill set, with advanced classes in the many statistical, theoretical, computational, and communication tools currently in demand.

A student's major pathway provides in-depth knowledge of a particular field within the humanities, social sciences, or natural sciences. This focus gives students the opportunity to develop the research skills necessary to answer questions expertly in their field of study.

In a world crawling with data and in need of solutions to pressing issues, our students graduate knowing how to apply cutting-edge data science methods to ask the right questions and arrive at the right answers.

KONYA BADSA

[BS, Quantitative Sciences with a Biological Anthropology track; minor, Women's, Gender, and Sexuality Studies]

What kinds of stories can we tell from people's environments, behaviors, and choices? That's something that has long fascinated Konya Badsa. It's what drew someone interested in public health and population health management to the QSS major.

"While qualitative data allows me to understand these stories," she explains, "I realized that in order to actually implement any initiative, shape policies, or make grounded decisions or conclusions about any population, I needed to have a good understanding of numbers and skills to manipulate and present data in order to tell powerful stories that lead to change."

Konya likes the small and collaborative nature of the QSS major. "I have made some really close friends working through some difficult projects, and I love that my professors know me by name and want to get to know me inside and outside the classroom," she says.
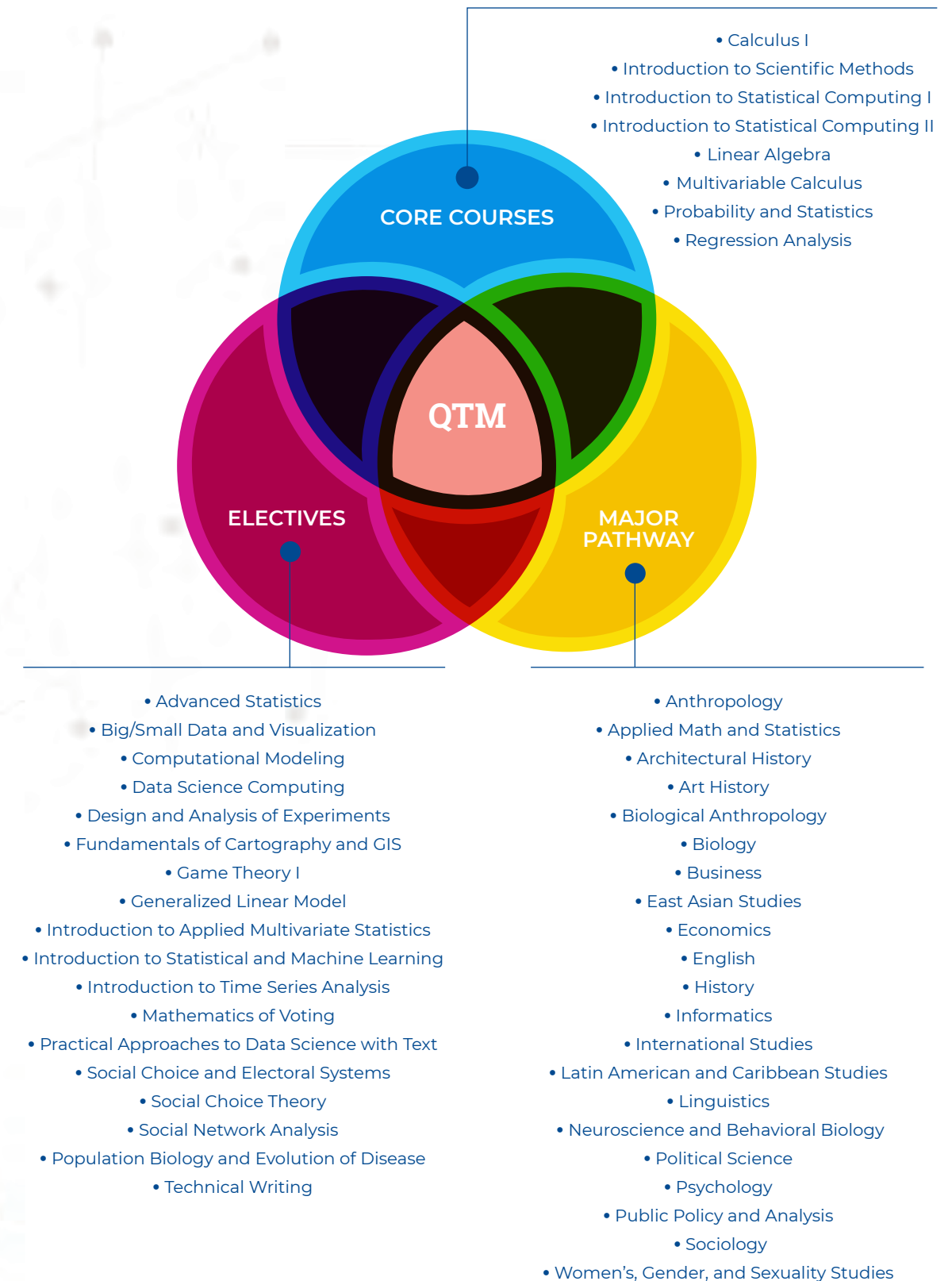
Some of her favorite classes have been electives such as the one on cartography, where she learned to create maps and data visualizations with a special software. Another class looked at Haiti's cholera outbreak after 2016's Hurricane Matthew.

Konya was able to talk about this project in an internship interview with Aetna. She got the position and, while there, used geographic and spatial data to analyze patient decisions regarding emergency rooms and urgent care centers.

She plans to work after graduating and eventually find her way back to graduate school, where she will explore her interests in predictive and spatial analytics.

The Data Science Difference

CORE COURSES
- Calculus I
- Introduction to Scientific Methods
- Introduction to Statistical Computing I
- Introduction to Statistical Computing II
- Linear Algebra
- Multivariable Calculus
- Probability and Statistics
- Regression Analysis

QTM

ELECTIVES
- Advanced Statistics
- Big/Small Data and Visualization
- Computational Modeling
- Data Science Computing
- Design and Analysis of Experiments
- Fundamentals of Cartography and GIS
- Game Theory I
- Generalized Linear Model
- Introduction to Applied Multivariate Statistics
- Introduction to Statistical and Machine Learning
- Introduction to Time Series Analysis
- Mathematics of Voting
- Practical Approaches to Data Science with Text
- Social Choice and Electoral Systems
- Social Choice Theory
- Social Network Analysis
- Population Biology and Evolution of Disease
- Technical Writing

MAJOR PATHWAY
- Anthropology
- Applied Math and Statistics
- Architectural History
- Art History
- Biological Anthropology
- Biology
- Business
- East Asian Studies
- Economics
- English
- History
- Informatics
- International Studies
- Latin American and Caribbean Studies
- Linguistics
- Neuroscience and Behavioral Biology
- Political Science
- Psychology
- Public Policy and Analysis
- Sociology
- Women's, Gender, and Sexuality Studies

Rigorous but Accessible

Though QTM courses are rigorous, the major is accessible to students of all academic interests and mathematical backgrounds. You are not expected to have a grounding in math beyond algebra and calculus when you enroll in the introductory courses.

SANYA JAFFAR

[BS, Quantitative Sciences with a Political Science track]

There have been Disney princesses almost since the advent of movie sound. Sanya wanted to know how these animated royals have changed throughout the decades. In a semester-long project for her Big/Small Data Visualization class, Sanya analyzed Walt Disney Company movies from 1929 to 2013.

"I focused on Disney princesses and how rhetoric, sentiment, and language have changed over time with the changing of social norms," she says. Sanya used a program to analyze the scripts of *Snow White*, *Aladdin*, *Frozen*, and 15 other Disney movies. It's what she loves about quantitative sciences. "I love the analytical nature of this major and how it truly teaches you to think outside the box," she says.

Originally a political science major, Sanya wanted to add something more to her major but not completely change it. She's on QSS's political science track with a concentration in national politics. "I take core classes in political science alongside my core classes and electives in QSS," she explains.
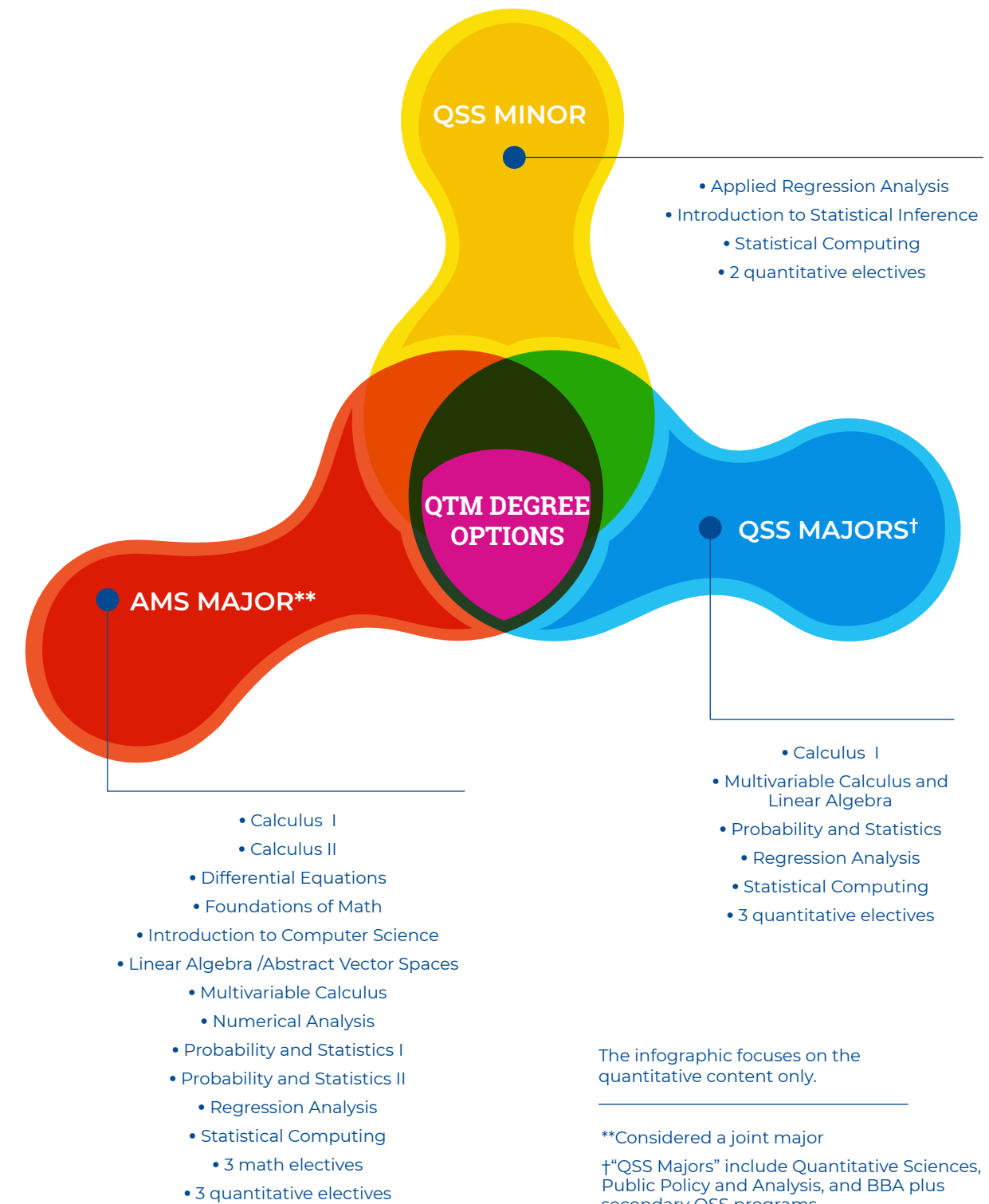
She found not just a major in QSS but a family, she says, a close-knit group of students and professors. "We are all there to struggle through the harder times and support one another," she says.

For this reason and many others, Sanya believes becoming a QSS major was the best decision she could have made. "Data is at the cutting edge of so many different industries. I find it to be so interesting because there isn't a field that doesn't have a need for data science. Data science can be used for anything."

There's no doubt the Disney princesses would have to agree.

How Much Math?

QSS MINOR
- Applied Regression Analysis
- Introduction to Statistical Inference
- Statistical Computing
- 2 quantitative electives

QTM DEGREE OPTIONS

AMS MAJOR**
- Calculus I
- Calculus II
- Differential Equations
- Foundations of Math
- Introduction to Computer Science
- Linear Algebra /Abstract Vector Spaces
- Multivariable Calculus
- Numerical Analysis
- Probability and Statistics I
- Probability and Statistics II
- Regression Analysis
- Statistical Computing
- 3 math electives
- 3 quantitative electives

QSS MAJORS†
- Calculus I
- Multivariable Calculus and Linear Algebra
- Probability and Statistics
- Regression Analysis
- Statistical Computing
- 3 quantitative electives

The infographic focuses on the quantitative content only.

**Considered a joint major

†"QSS Majors" include Quantitative Sciences, Public Policy and Analysis, and BBA plus secondary QSS programs

From College . . .

At the heart of our program is a commitment to day-one readiness for our graduates.
That means equipping them to ask the right questions, think critically, and communicate their insights with clarity. In unlocking data's true potential through the QTM curriculum, experiential learning, and professional development, our students become revered researchers and problem solvers; valued employees who successfully bridge the space between technical and nontechnical audiences; and adroit managers who can maximize the potential of any business's data science investment.

Experiential learning is part one of this equation. Our partnerships with industry, alumni, and programs at Emory facilitate invaluable hands-on experiences for students. Collaborative technical workshops equip them with leading-edge analytical tools. Initiatives such as DataFest™, Capstone, and the research fellowship enable students to apply these tools to real-world problems, all while strengthening their leadership and communications skills under faculty mentorship. Internships allow students to apply their cumulative skills in a professional setting. In its simplest form, experiential learning is *Challenge and Experience*, followed by *Reflection*, leading to *Learning and Growth*.

Professional development is part two. To prepare our students for successful entry into the workforce, QTM actively partners with industry and career development professionals, along with the Career Center, to offer a variety of events, workshops, and resources that help students understand how to navigate the transition into a professional environment. QTM creates and delivers skills training and programming that covers job search basics, branding, career management, and other essential topics. We also host networking opportunities throughout the year, support a student-run organization—the Data Science Club—as well as maintain the Career Navigator, an online resource library.

Career Readiness
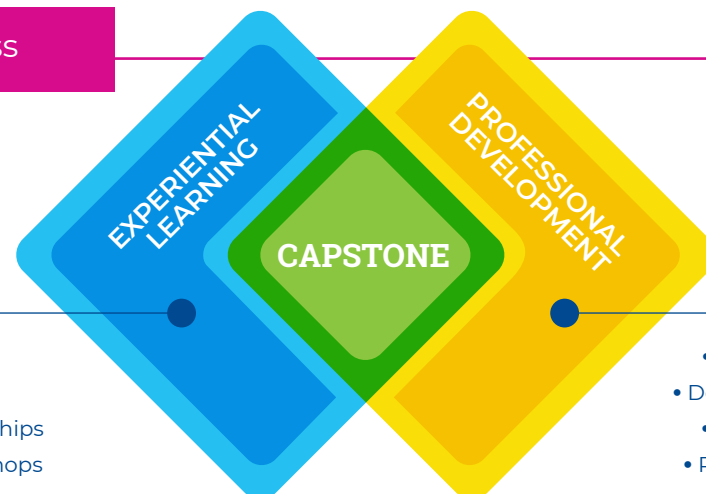
- DataFest™
- Internships
- Research Fellowships
- Technical Workshops

EXPERIENTIAL LEARNING

CAPSTONE

PROFESSIONAL DEVELOPMENT

- Career Exploration
- Dedicated Career Portal
- Personal Branding
- Post-college Planning

to Career

Where it all adds up.
According to the National Academies of Sciences, Engineering, and Medicine, "The continued transformation of work requires . . . a cadre of talented graduates with highly developed data science skills and knowledge, acquired through substantial coursework and practice." Upon graduation, Emory's QTM students are prepared to enter the workforce immediately or continue on to pursue graduate studies.

Business and consulting. Data impacts all aspects of business and commerce—from operations optimization and business analysis to risk management and fraud investigations.

Government. Agencies in the federal, state, and local government need quantitatively skilled individuals to help prevent waste, fraud, and abuse; combat cyberattacks and safeguard sensitive information; use business intelligence to make better financial decisions; and improve defense systems and protect soldiers.

Health/medicine. Data permeates the health care ecosystem, including research—where open data sets are fueling drug discovery—and the patient experience—where machine learning is providing effective diagnosis.

Nonprofit. There is a need to collect, process, and analyze data from a variety of sources. With limited resources, nonprofits must maximize efforts that are likely to succeed. Data science can also be leveraged to improve the quality of services nonprofits provide.

Graduate studies. Many advanced degrees—master's/ PhD, MD, JD—require quantitative dexterity; having quantitative skills sets QTM students apart from other applicants.

GRADUATE SCHOOL

BUSINESS/ CONSULTING

QTM CAREER PATHWAYS

NONPROFIT

GOVERNMENT

HEALTH/ MEDICINE
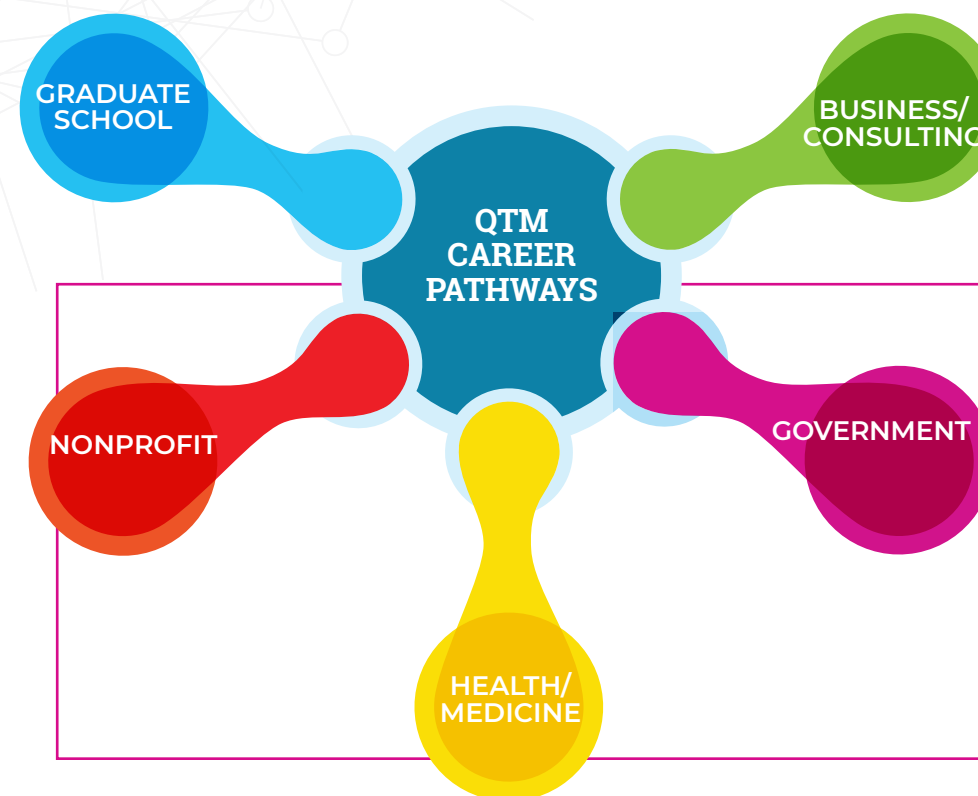
Workforce and Advanced Studies

Data is revolutionizing almost every sector of the economy, demanding specialized and applied quantitative skills that our graduates have.

ALEKSANDER HUBERT

[BS, Quantitative Sciences with a Linguistics track]

While looking through Emory's course atlas for a freshman seminar, Aleksander came upon Map, Charts, and Graphs. Finding visualizations interesting, he signed on. The first day, his instructor challenged the class to find the worst graph they could and then explain why it was so. The faculty member confessed, "I hope I can make you all QSS majors after this class."

As Aleksander delved deeper, each class had a clever hook. In QTM 110, the first question the teacher wrote on the board was, "Does using antibacterial soap make you have peanut allergies?" "None of us knew what to think," Aleksander recalls, but students were intrigued to discover the correlation: parents who use antibacterial soap are less likely to give their kids peanuts. To Aleksander's delight, the course continued generating its lessons from *Huffington Post* headlines.

One professor asked him to be a TA in her class about R, and it has been transformative. When he started, he feared being asked something he couldn't answer, and he has had some "Um, we need to Google this" moments. However, he describes the experience of helping students in class and then running office hours as "incredibly rewarding," to the point that he wants a career in which sharing knowledge with others will be a big part.

Aleksander, in his words, "grew up all over the place" but did spend his formative years in Norway. As he contemplates his next move, he is considering a master's in computational sciences from the University of Oslo. And a PhD looms as a twinkle in his eye.

Meanwhile, the young scholar who "finds so many things interesting" is taking a class in game theory, the better to talk to a brother with a PhD in same, and helping make maps at Emory's Center for Digital Scholarship. And those times that he needs a break from numbers? He plays the theremin that his parents playfully presented him with for his birthday—an instrument that Aleksander describes as "sounding like a ghost."

Still have questions about Quantitative Theory and Methods? Call or go to our website.

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