BIOMEDICAL DATA SCIENCE CERTIFICATE

The goal of this program is to provide graduate students, postdoctoral fellows, faculty, and other health care professionals with formal education in the essential components of biomedical data science. This training program will prepare professionals to integrate within interdisciplinary investigative teams and implement data science driven solutions in diverse biomedical settings.

The specific aims of the Biomedical Data Science Certificate Program are to:

- Support the intellectual environment at the UT Health Science Center at San Antonio for biomedical data centric and informatics research.
- Provide fundamental curricular activities in the biomedical data science to UT Health Science Center at San Antonio students, postdoctoral trainees, clinical residents and fellows, and faculty from the Schools of Medicine, Nursing, Dentistry, Health Professions, and Graduate School of Biomedical Sciences (GSBS) as well as from local organizations that are partnered with UT Health Science Center at San Antonio.

The aims of the CBDS program will be achieved via participation and successful completion of required didactic coursework.

Student Pathways

- Regular Students: After acceptance as a candidate working towards the certificate, students may undertake course requirements for graduation while enrolled as either a full-time or part-time student.
- Full-Time students: Full-time students are enrolled in at least eight (8) semester credit hours (SCH) per semester during the Fall and Spring semesters.
- Part-time Students: Part-time students are enrolled for a minimum of four (4) credit hours per semester during the Fall and Spring semesters.
- UT Health San Antonio Faculty and Staff as Students in the Graduate Certificate in Translational Science Program: UT Health San Antonio faculty and staff may apply for admission in the Graduate Certificate in Translational Science Program. The amount of course work that can be taken by faculty or staff in a given semester is subject to the 'quantity of work' rules outlined in the current UT Health San Antonio Catalog and Handbook of Operating Procedures.
- Non-Degree Seeking Students in the GSBS: Non-degree seeking students may enroll in courses and receive GSBS course credit without matriculation (admission) into a graduate program. For those not already matriculated into other GSBS graduate programs, an online application must be submitted to the GSBS for approval by the Dean [this would also include UT Health San Antonio faculty, staff, or others]. The appropriate Course Director must approve the enrollment of any non-degree seeking student in their course and sign course cards (provided by the GSBS Dean's office). Additional details about non-degree seeking students are available online (https://www.uthscsa.edu/academics/biomedical-sciences/non-degree-student-status/).

Certificate Program Governance

Oversight for the routine operations and implementation of the Biomedical Data Science Certificate Program will be provided by the Master of Science in Clinical Investigation and Translational Science (MSCI-TS) Program and the corresponding MSCI-TS Committee on Graduate Studies (COGS).

All students should have a sufficient educational background in the quantitative computational or biomedical sciences prior to admission to the program. It is expected that most students will have a health professional degree (*e.g.*, MD, DDS/DMD, DVM, or BS in nursing and/or allied health) or a BS/BA, MS, or PhD degree with emphasis in statistics, data science or a health-related discipline. The following general requirements will be applied:

1. A medical, dental, Ph.D., masters and/or baccalaureate degree from an accredited institution in the United States or an U.S. equivalent degree and training at a foreign institution as determined by an evaluation from the Educational Credential Evaluators, Inc. (ECE) or the World Education Services, Inc. (WES) of the foreign transcripts.

2. A Grade Point Average (GPA) no lower than a B (3.00 in a 4.00 system) in the last 60 hours of coursework for a BS/BA degree or a GPA of at least 3.0 for applicants with a MS degree

3. A minimum score of 84 on the internet version of the Test of English as a Foreign Language (TOEFL) or 7.0 on the academic version of the International English Language Testing System (IELTS) for applicants from countries where English is not the native language. Scores on the TOEFL and IELTS (academic version) tests taken more than two years prior to the date of enrollment will not be accepted.

4. Three (3) Letters of Recommendation attesting to the applicant's readiness for graduate level studies in Biomedical Data Science. These letters of recommendation should be uploaded by the individual recommenders who will receive an e-mail from the EMBARK online application system with a link to the Recommendation Form.

A. Residents or fellows in an approved UT Health San Antonio residency or fellowship program are required to submit one (1) of the three (3) letters from their departmental chair or program director with a statement indicating the availability and approval of release of time for the completion of the CBDS educational activities.

B. Staff employed at UT Health San Antonio are required to submit one (1) of the three (3) letters from their authorized supervisor with a statement indicating the availability and approval of release time for the completion of the CBDS educational activities.

C. Faculty (*non-tenured only*) at UT Health San Antonio are required to submit one (1) of the three (3) letters from the Chair of their department. In addition, the Chair's letter must have the approval of both the Dean of the school that houses the department and the President (or his designee) of UT Health San Antonio. (See the Handbook of Operating Procedures (HOP), Policy 3.2.5)

5. A Personal Statement (1-2 pages) that includes a brief description of the applicant's background, long term research and/or career goals, and an indication of the basis for application into the CBDS Program including how this program fits into the applicant's career objectives. The Personal Statement should be submitted with the on-line application to the GSBS.

6. Current curriculum vitae. This should be submitted with the on-line application to the GSBS.

The proposed certificate program will target professionals already working in the health care field who are positioned to implement the acquired skills and knowledge. The certificate curriculum will be

composed of 13 SCH of required coursework and 3 SCH of electives (non-prescribed). We have created 5 unique courses that students will be able to absorb and apply to real world health care issues, applications and clinical/educational programs. It is estimated that a student would be able to complete this certificate program within one year.

Plan of Study

First Year Fall		Credit Hours
TSCI 5070	Responsible Conduct of Research	2
CSAT 6005	Rigor & Reproducibility	1
TSCI 5201	Statistical Principles of Machine Learning for Biomedical Data	3
TSCI 5230	Analytical Programming for Biomedical Data Science	3
	Total Credit Hours:	**9.0**

First Year Spring		Credit Hours
TSCI 6201	Data Science Leadership in Healthcare	1
TSCI 6202	Data Visualization and Building Applications	2
TSCI 6203	Practicum in Biomedical Data Science	1
Elective courses		3
	Total Credit Hours:	**7.0**

Elective courses:

TSCI 5073	Integrated Molecular Biology With Patient-Oriented Clinical Research	1
TSCI 5074	Data Management, Quality Control And Regulatory Issues	2
TSCI 5075	Scientific Communication	2
TSCI 5076	Applied Healthcare Informatics and Analytics	2
TSCI 6060	Patient-Oriented Clinical Research Methods-2	2
TSCI 6061	Patient-Oriented Clinical Research Biostatistics-2	2
TSCI 6067	Genomic Healthcare	1
TSCI 6100	Practicum In IACUC Procedures	1
TSCI 6102	Practicum In IRB Procedures	1
CSAT 6095	Analysis and Visualization of Genomic Data	2
CSAT 5024	RNA Biology and Genomics	1
INTD 6062	Next-Generation Sequencing Data Analysis	2

The Program Objectives for the Certificate in Biomedical Data Science program consist of the following:

- Lead, manage and collaborate Data Science teams with data driven approaches to healthcare organizations.
- Recognize the social and ethical responsibilities of data scientists.
- Utilize programming languages and software to implement Data Science capabilities such as machine learning, data visualization, statistical and causal inference.
- Assess and optimize artificial intelligence solutions for real-world performance.
- Three (3) program Student Learning Outcomes (SLOs) (see below) have been established by the program leadership to identify and develop direct measures of student assessment and to ensure student success.

Students will be able to:

- **Use statistical methods, programming languages, and analytic software with biomedical data to develop data science applications.** *Assessment: Use of rubric to assess final project with data visualizations and building data science applications*
- **Apply techniques for machine learning to healthcare data.** *Assessment: Use of rubric to assess final project and building models that predict healthcare outcomes using machine learning.*
- **Measure, assess, and analyze health outcomes within healthcare organizations**. *Assessment: Use of rubric to assess final project with data visualizations and data science applications*

Attendance Policy

The UT Health Science Center at San Antonio MSCI-TS faculty believe that attendance at scheduled classes and examinations is crucial to meeting course and program objectives. Therefore, regular attendance in class is expected of each student. Attendance is defined as being present within 15 minutes after the scheduled beginning of the class and until 15 minutes before the scheduled ending of the class.

Excused absences may be granted by the Course Director in cases such as formal presentations at scientific meetings, illness, or personal emergency. Excused absences are considered on an individual basis and require electronic communication with the Course Director to request an excused absence. The e-mail request to the Course Director for consideration of an excused absence must provide details regarding the circumstances and specific dates. It is expected that students will provide advanced notice of absence for scheduled events.

Repeated unexcused absences make it impossible to achieve course objectives. Thus, if a student has excessive unexcused absences in a given course, they will automatically receive a grade of unsatisfactory unless makeup has been approved by the Course Director (see below). Allowable unexcused absences will be determined by the credit hours of the course as follows:

> ***Absence Makeup.*** Makeup of absences (both excused and unexcused) is allowed at the discretion of the Course Director.

Courses

TSCI 5050. Introduction to Data Science. 1 Credit Hour.
This elective course is designed to train participants to use programming languages such as R and SQL to extract, prepare, and analyze data. This course is designed to be self-contained: statistical methods and theory relevant to analyzing large datasets will be covered with the computer-related course content providing tangible applications and motivating examples. In addition, the course will include organizational skill training and best practices needed to run a successful collaboration between researchers conducting patient oriented clinical research and the researchers in the computational fields.

TSCI 5070. Responsible Conduct of Research. 2 Credit Hours.
This foundational course introduces students to core ethical content necessary for responsible research conduct. Through interactive seminars, students will learn about (1) scientists as responsible members of society (contemporary ethical issues in biomedical research and environmental/social impacts of research), (2) policies for research with human subjects and vertebrate animals, (3) collaborative research, (4) conflicts of interest (personal, professional, financial), (5) data acquisition and laboratory tools (management, sharing, ownership), (6) responsible authorship and publication, (7) mentor/trainee responsibilities and relationships, (8) peer review (9) research misconduct (forms of misconduct and management policies) (10) informed consent, privacy regulations, good clinical practice, and special populations in clinical investigations.

TSCI 5071. Patient-Oriented Clinical Research Methods-1. 2 Credit Hours.
This interdisciplinary course is the first in a two-semester sequence designed to train participants in the conduct of patient-oriented clinical research. Students will have the opportunity to learn to and, by the end of the course, be required to: (1) define a research question; (2) effectively conduct a systematic review of the scientific literature; (3) design strategies for recruitment into a study; (4) delineate strategies for minimizing bias in cross-sectional and retrospective studies; and (5) read and interpret research reports of cross-sectional and case-control investigations.

TSCI 5072. Patient-Oriented Clinical Research Biostatistics-1. 2 Credit Hours.
This interdisciplinary course is the first in a two-semester sequence designed to train participants in the analysis and biostatistics of patient-oriented clinical research. Students will have the opportunity to learn to and, by the end of the course, be required to: (1) identify and summarize different categories of data; (2) set up and perform tests of hypotheses; (3) estimate sample sizes for survey and case-control studies; and (4) use statistical software packages to enter, summarize, graph, visualize, and analyze data.

TSCI 5073. Integrated Molecular Biology With Patient-Oriented Clinical Research. 1 Credit Hour.
This interdisciplinary course is designed to train participants on integrating molecular biology methods into patient-oriented clinical research. Students will have the opportunity to learn to: (1) appropriately use molecular terms in clinical investigation; (2) describe the events involved in protein synthesis; (3) describe the principles involved in molecular techniques (e.g., polymerase chain reactions, southern blots); (4) identify the appropriate specimens, collection, and handling requirements for each molecular technique; (5) identify and correct common sources of error in performing molecular techniques; (6) cite examples of clinical applications of molecular techniques in clinical medicine; and (7) apply molecular techniques in the laboratory to specific clinical problems.

TSCI 5074. Data Management, Quality Control And Regulatory Issues. 2 Credit Hours.
This interdisciplinary course is designed to train participants in the necessary data management and quality control procedures required for the conduct of patient-oriented clinical research. It consists of three segments: (1.) introduction to data management principles and standard practices; (2) development of the student's own mentored research; and (3) introduction to bioinformatics.

TSCI 5075. Scientific Communication. 2 Credit Hours.
This interdisciplinary course is designed to train participants to write effectively in all aspects of conducting patient-oriented clinical research. Students will have the opportunity to learn to and, by the end of the course, be required to: (1) recognize and avoid errors in grammar, punctuation, and usage that are common in scientific writing; (2) construct units of writing whose structure, style, and logical continuity allows instant and clear comprehension; (3) construct concise, informative titles; (4) develop clear, comprehensive, abstracts for papers and grant proposals; (5) construct complete, well-rationalized sets of specific aims for grant proposals; and (6) effectively apply the 4-Point Rule (What is the question? How did we approach it? What happened? What does it mean?) to all forms of scientific writing.

TSCI 5076. Applied Healthcare Informatics and Analytics. 2 Credit Hours.
This elective course is designed for students interested in applied healthcare informatics and analytics. This course will focus primarily on practical skills and knowledge for hands-on analytics applied to healthcare settings. Discussions of theory will be more limited and directed to a greater understanding required for practical application of the knowledge. The course will include traditional lectures as well as in-class and assigned database work using Microsoft Access, Excel, and Power BI. The course will include periodic short quizzes as well as a mid-term and final exam. Course participants will plan and evaluate a small healthcare analytics project for use in a healthcare system.

TSCI 5077. Translational Science Training (TST) Practicum. 1-3 Credit Hours.
This elective course provides an opportunity for participation in unique clinical and translational research activities that are highly individualized for each student on the basis of prior experience and research interests.

TSCI 5078. Introduction to Intellectual Property, Technology Transfer and Commercialization. 1 Credit Hour.
This elective course provides an in-depth overview of the essential components encompassed in the protection of intellectual property, patents, licensing, technology transfer, and product commercialization. Content is provided through a series of lectures, assigned readings, literature reviews, class presentations, and discussions with faculty.

TSCI 5079. Practicum in Intellectual Property, Technology Transfer and Commercialization. 0.5-1 Credit Hours.
This elective course provides an opportunity for participation in unique and translational research activities that focus on the processes involved in the protection of intellectual property and the transfer and commercialization of technology. Activities are highly individualized for each student on the basis of prior experience and research interests.

TSCI 5080. Integrating Molecular Biology with Patient-Oriented Clinical Research Practicum. 1 Credit Hour.
This is the required practicum to TSCI 5073. This practicum is designed to provide the opportunity for highly individualized research activities for integrating molecular biology methods into patient-oriented clinical research.

TSCI 5201. Statistical Principles of Machine Learning for Biomedical Data. 3 Credit Hours.
This class offers a hands-on approach to machine learning and data science. The class discusses the application of supervised and unsupervised techniques for machine learning including random forests, support vector machines, boosting, deep learning, K-means clustering and mixture models. The course focuses on real data application with open source implementations in Python and R. Prerequisites: Introductory-level course in probability and statistics; comfort with a programming language (R and/or Python) will be essential for completing the homework assignments; basic linear algebra and calculus are plus.

TSCI 5230. Analytical Programming for Biomedical Data Science. 3 Credit Hours.
This class offers a hands-on approach to data science programming for biomedical research. We will introduce R, Python, SQL, and the software tools that interoperate with them. We will also cover cross-cutting best practices for organizing one's work to facilitate collaboration, reproducibility, and portability. Students who already have data they want to analyze are encouraged to use it in their assignments.

TSCI 6001. Introduction To Translational Science. 1 Credit Hour.
This elective course provides an in-depth overview of the essential components encompassed by translational science. Content is provided through a series of lectures, assigned readings, literature reviews, class presentations, and discussions with faculty.

TSCI 6060. Patient-Oriented Clinical Research Methods-2. 2 Credit Hours.
This interdisciplinary course is the second in a two-semester sequence designed to train participants in the conduct of patient-oriented clinical research. Students will have the opportunity to learn to and, by the end of the course be required to: (1) define criteria for inferring causation from observational studies; (2) design strategies for subject retention in a prospective study; (3) design strategies for monitoring progress in a randomized control trial; (4) delineate strategies for minimizing bias in cohort studies and randomized control trials; (5) compare and contrast the uses, strengths, and weaknesses of different clinical trial designs; (6) read and interpret research reports of cohort studies and randomized control trials; and (7) describe the steps in conducting a meta-analysis. Prerequisites: TSCI 5071.

TSCI 6061. Patient-Oriented Clinical Research Biostatistics-2. 2 Credit Hours.
This interdisciplinary course is the second in a two-semester sequence designed to train participants in the biostatistical analysis and patient-oriented clinical research. Students will have the opportunity to learn to and, by the end of the course, be required to: (1) perform a two-way analysis of variance and explain the results; (2) perform survival analysis; (3) compare and contrast the purpose and characteristics of different forms of interventional trials; and (4) plan the sample size, analysis, and stopping rules of a randomized clinical trial. Prerequisites: TSCI 5072.

TSCI 6064. Grantsmanship and Peer Review. 1 Credit Hour.
The purpose of this elective course is to provide an overview of the peer review process for research proposals as well as the essential components of grant management. Lecture and assignment topics will include: (1) funding agencies, missions, deadlines, and instruction; (2) Institutional Grantsmanship Issues; (3) National Institutes of Health (NIH) Organization (Institutes, Councils, Centers, and Budgets); (4) NIH Awards and Study Sections; (5) process and communications with the NIH; (6) interpreting and responding to written critiques; (7) mock study section meeting; and (8) grantsmanship after funding.

TSCI 6065. Health Services Research. 2 Credit Hours.
This course focuses on concepts and methods used in research focusing on health care quality, utilization, access, and safety. The seminar will utilize skills-based learning, small group activities, and outside assignments. By the end of the course, candidates will be required to: (1) Articulate underlying core concepts; (2) Describe basic methods used in health services research; (3) Identify relevant databases and data sources for health services research; (4) Critically appraise and interpret published reports of health services research; (5) Discuss current issues in HSR; (6) Understand how to incorporate health services concepts, methods, or tools into current research. Prerequisites: TSCI 5071 and TSCI 6060.

TSCI 6066. Instrument Development And Validation. 1 Credit Hour.
This elective course introduces methods to develop and evaluate self-report measures. The seminar is built on classical test theory with a focus on the practice of creative surveys. Participants should be able to (1) estimate various forms of reliability; (2) demonstrate various forms of validity evidence; and (3) explain how statistical analyses may be used to inform the validation process.

TSCI 6067. Genomic Healthcare. 1 Credit Hour.
This course prepares students to integrate genomic and other omics technology into patient care and clinical research. It begins with an introduction to genomics and overview of omics technologies. Students will explore the different resources of genomic information and have opportunities to apply these resources to keep abreast of current knowledge in their health topic of interest including the ethical individual and societal challenges ahead. Genomics in cancers is an active area in personalized medicine, and this topic will be discussed by a local cancer genomics expert. The course will also provide an introduction and overview of current applications of gene therapeutics to a variety of disorders. By the end of the course, students will have a working knowledge of the human genome and the tools for integrating this information into clinical research as well as conveying it to patients.

TSCI 6068. Cross-Cultural Adaptation Of Research Instruments. 1 Credit Hour.
This elective course introduces students to the concept of cross-cultural equivalence of research instruments - a prerequisite for making valid comparisons across two or more ethnic groups - and the process of cross-cultural adaptation used to achieve this equivalence. Students will have the opportunity to learn the multiple steps necessary to successfully cross-culturally adapt research instruments and how to assure content, semantic, technical, conceptual, and criterion equivalence of individual items and scales. A number of instruments used in cross-cultural research will be reviewed and critiqued with regard to their cross-cultural equivalence.

TSCI 6069. Statistical Issues, Planning, And Analysis Of Contemporary Clinical Trials. 2 Credit Hours.
This elective course will serve as an in-depth survey of the various clinical trial designs, analysis, and regulatory issues. Students will learn to apply statistical principles in designing clinical trials to minimize risk to patients while maximizing generalizable discovery. Specific topics include Phase I-V studies, adaptive designs, longitudinal and survival studies. Students will learn to specify the primary outcome and to estimate the required sample size for common trial designs. Clinical trial design and analysis is often complicated by idiosyncrasies such as missing data, and the methodology for handling these will be covered. Prerequisites: TSCI 5072 and TSCI 6061.

TSCI 6070. Biostatistics Methods For Longitudinal Studies. 2.5 Credit Hours.
This elective course will discuss a broad range of statistical techniques for deriving statistical inference from longitudinal studies. Main topics include design of longitudinal studies (power analyses and sample size estimation), analyses of repeated measured outcomes (continuous and discrete), analyses of time to event outcomes, techniques to address challenges associated with missing data and confounding, and rigorous casual modeling approaches. Students will learn to identify feasible and efficient statistical design of longitudinal; studies and to conduct rigorous and robust statistical methods to analyze data arising from longitudinal studies. The goal is to develop students' biostatistical competencies in conducting high-quality longitudinal studies in medical research. Prerequisites: TSCI 5072 and TSCI 6061.

TSCI 6097. Research. 1-12 Credit Hours.
The Research Course is set up for the student to conduct their Mentored Research Project with their supervising professor. This time is to be spent directly working on the project and includes, but is not limited to, writing consent forms, collecting data, analyzing data, and preparing a manuscript. After MSCI-TS COGS approval of the research project, students take three semester credit hours of research during each semester of the Master of Science in Clinical Investigation and Translational Science Degree Program.

TSCI 6098. Thesis. 1-12 Credit Hours.
An MSCI-TS Program Program student is required to enroll in Thesis the semester they submit their manuscript for approval by the MSCI-TS COGS. The 1.0 semester credit hour is required to graduate from the MSCI-TS Program.

TSCI 6100. Practicum In IACUC Procedures. 1 Credit Hour.
This elective course presents an in-depth introduction to the institutional program that provides oversight and regular review of projects that involve the care and use of animals. This includes consideration of the operational procedures of the Institutional Animal Care and Use Committee (IACUC) of the UT Health Science Center at San Antonio. Course objectives are achieved through a combination of readings, monthly attendance at selected IACUC meetings, and discussions with faculty.

TSCI 6101. Topics In Translational Science. 1 Credit Hour.
This research seminar course is designed to introduce graduate students to the field of Translational Science and to members of academic, business, health, and scientific communities who are actively engaged in Translational Science. This course will also provide a forum for students to discuss their own Translational Science research.

TSCI 6102. Practicum In IRB Procedures. 1 Credit Hour.
This elective course presents an in-depth introduction to the institutional program that provides oversight and regular review of research projects that involve human subjects. This includes consideration of the operational procedures of the multiple Institution Review Boards (IRB) of the UT Health Science Center at San Antonio. Course objectives are achieved through a combination of readings, monthly attendance at selected IRB meetings, and discussions with faculty.

TSCI 6103. Selected Topics In Advanced Research Ethics. 1-3 Credit Hours.
This elective course provides an in-depth understanding of a selected topic in research ethics. Students work independently to develop a detailed literature review specific to an area of research and are required to prepare a manuscript describing the results. Regular meetings with the Course Director will review progress towards course goals.

TSCI 6105. Topics in Cancer Prevention. 1 Credit Hour.
This course address current topics in cancer prevention science through a series of didactic lectures and discussions with cancer prevention faculty. Topics span the continuum of cancer prevention from basic cancer epidemiology and carcinogenesis, to cancers of special relevance in South Texas and interventions. An exposure to prevention clinical trials and disparity research will also be presented. Consent of instructor is required for registration.

TSCI 6106. Practicum in Cancer Prevention Science. 0.5-1 Credit Hours.
This elective course provides an opportunity for participation in unique clinical and laboratory cancer prevention research activities that are highly individualized for each student on the basis of prior experience and research interests. Consent of the instructor is needed for registration.

TSCI 6201. Data Science Leadership in Healthcare. 1 Credit Hour.
This class offers a hands-on approach to data science operations in biomedical science. The class discusses the management of data science teams, collaboration within healthcare organizations, and the social and ethical responsibility of data scientists. The course focuses on real world applications.

TSCI 6202. Data Visualization and Building Applications. 2 Credit Hours.
This class offers a hands-on approach to data visualization for biomedical data science. The class uses R, Python and Javascript and the software tools that interoperate with them. Some cross-cutting best practices. The course focuses on real world applications. Prerequisites: Introductory-level courses in probability and statistics; comfort with a programming language will be helpful to completing the homework assignments.

TSCI 6203. Practicum in Biomedical Data Science. 1 Credit Hour.
This elective course provides an opportunity for participation in unique biomedical data science and translational research activities that are highly individualized for each student on the basis of prior experience and research interests.

TSCI 7099. Dissertation. 1-12 Credit Hours.
Preparation and writing of the Doctoral dissertation. Registration for at least two terms is required of Ph.D. candidates.