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**Biomedical Informatics**

**Probability and Statistics for Biomedical Data Science (BMI 6106)**

**Spring 2022**

***Time and location***: Mondays 6:00 pm – 8:00 pm and Wednesday 5:10 pm – 6:10 pm BMI room 1016

***Instructors***: Edgar Javier Hernandez, Dept. Human Genetics, edgarh@genetics.utah.edu

***TA:*** TBA

**Class Modality:**

This course will be held **in person**. Except in cases of ADA accommodations or quarantining due to COVID-19 exposure or infection, you will be expected to attend class in person and complete assignments and exams in person. Changes to this policy are up to the discretion of the instructor.

Lecture content will be available online using mostly Jupyter notebooks and notifications will be posted on Canvas, the class will meet in person for hands-on activities twice a week for a total of three hours.

***Resources***: to access Canvas, the University’s online class resource, navigate to here: <https://utah.instructure.com/> Each student will need access to a laptop for in-class hands-on activities.

***Class numbers and Credit Hours***: Not-for-credit distance-education class: BMI 6106. For-credit class BMI 6106 (3 credit hours).

***Prerequisites***: Undergraduate level introduction to statistics course and BMI Introduction to Programming (Python) or permission of the instructors.

***Text Books:***

**An introduction to Statistical Learning**, Gareth James; Daniela Witten; Trevor Hastie and Robert Tibshirani. 2013. *New York :Springer, 2013.* Available free online (https://www.statlearning.com/)

Think Bayes (2012 - http://www.greenteapress.com/thinkbayes/thinkbayes.pdf), Downey, Allen.

Also a suggested text book is Think Stats: Exploratory Data Analysis in Python (2014 - <http://greenteapress.com/thinkstats2/thinkstats2.pdf> ) Downey, Allen.

# Description of the course:

This course offers an introduction to an extensive array of methods for mathematical biomedical data analysis with emphasis on three major topics (probability analysis, statistical inference, and the basic concepts of classificatory exploratory analysis through machine learning), with a clear emphasis on the biomedical field. We will cover basic probability concepts such as recognizing the importance of the analysis of random events in real life applications using probability axioms and rules. This course will present descriptive and inferential data methods for predictive analysis on samples and populations. This introductory course lays the foundation for more advance classes offered at the Biomedical Informatics Department. As an additional component of this class will be the extensive use of the statistical software R, which is one of the most used statistical packages in many disciplines.

# Learning Objectives:

1. By the end of this course, you will understand basic probability concepts, use probability rules, distinguish between discrete and continuous variables and the methods for their analysis, and solve problems related to random events.
2. By the end of the course, you will be able to describe the main methods for data exploration and analysis. You will use descriptive statistics to understand the nature of your data, and you will use hypothesis testing to predict the behavior of variables from samples and populations.
3. By the end of the course, you will understand the concepts of machine learning and pattern recognition, such as cluster recognition, data classification, dimensionality reduction, and temporal patterns.
4. By the end of the course, you will have experience with of the most widely use statistical software in the sciences, R. You will be able to use many of the statistical and graphical packages available for this software.

The skills we will be focusing on include:

* Identifying and explaining the characteristics of discrete and continuous variables.
* Distinguishing the various methods used to predict random events.
* Comparing inferential statistical methods, existing tools, and terminological resources.
* Proposing adequate statistical methods for specific clinical cases.
* Programming statistical analysis with R

# ADA Statement

The University of Utah seeks to provide equal access to its programs, services and activities for people with disabilities. If you will need accommodations in the class, reasonable prior notice needs to be given to the Center for Disability Services, 162 Olpin Union Building; phone: 581-5020 (V/TDD); email: [info@disability.utah.edu](mailto:info@disability.utah.edu); URL: <http://disability.utah.edu/>. CDA will work with you and the instructor to make arrangements for accommodations. All written information in this course can be made available in alternative format with prior notification to the Center for Disability Services.

Given the nature of this course, attendance is required, and adjustments cannot be granted to allow non-attendance, except in cases of quarantining due to COVID-19 exposure, or for those who have an ADA accommodation. If you need to seek an ADA accommodation to request an exception to this attendance policy due to a disability, please contact the Center for Disability and Access (CDA). CDA will work with us to determine what, if any, ADA accommodations are reasonable and appropriate

# Departmental Teaching Philosophy

*Biomedical Informatics* is defined as “…the interdisciplinary, scientific field that studies and pursues the effective uses of biomedical data, information, and knowledge for scientific inquiry, problem solving and decision making, motivated by efforts to improve human health” by the [American Medical Informatics Association](http://www.amia.org). We will work together with open communication in this course to help each other succeed, be collegial, and build skills and knowledge.

# Course Logistics

Jupyter Notebooks will be used for the didactic (lecturing) portion of this course. The advantage of using this platform is the practical convergence between lecture and programming practices within the software. Canvas, the University of Utah online teaching resource, will be used for tests and communication. Students will be given instructions about using Canvas and Jupyter after they enroll. ***Please*** limit all communication to the faculty to the Canvas email/conversations system (except emergencies). This greatly simplifies spreading the word when students spot an error or encounter a problem that affects the entire class. For technical assistance with Canvas, please contact the University’s Teaching and Learning Technologies (TLT) group: phone: 801-581-6112; email [classhelp@utah.edu](mailto:classhelp@utah.edu); or browse their URL at <http://tlt.utah.edu/>.

# Office Hours

In our experience students rarely avail themselves of online office hours, for this reason the instructor will be available after the in-class session to address any problems, concerns, or questions you might have during the course. To further increase the communication between the instructor and students on a personal basis, I will have a dedicated two hour window on Monday from 10-12 am, to schedule individual zoom meetings to address students’ questions, comments, problems and suggestions.

# Grading and course evaluation

Homeworks (50%): At the end of most practical modules (Mondays) there will be a set of exercises to reinforce each topic. This homework will be due at midnight of the following Monday.

Final project (25%): During the course we will work on developing a final project that will aim in addressing a question(s) or method(s) learned through the semester. For this exercise, the student will collect its own data, explore it, and analyze it using more than one method seen in class. There are no topic requirements, but an effective R script should be submitted with the analysis of the data. This will require R programming.

Exams (25%): We will have three exams presented during the semester. The grading criteria include conciseness, clarity, and proper use of statistical techniques.

***Participation:*** While there are no participation points awarded, weekly postings on the discussion board and contributing to the in-class sessions are strongly encouraged. Active participation can boost your final grade if your final total score is borderline between two grades. Discussion topics will be posted, but additional topics for discussion are welcome. When developing the system for the final project, students are encouraged to post questions and issues on the board for general discussion.

If for any circumstance deadline extensions or particular accommodations are needed for home works, tests or others, I am more than happy to work with each student individually and thoroughly to ensure academic success. Do not hesitate to request help or assistance.

# Course Topics

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| **Probability theory** |
| Introduction to R: installation, basic functions, reading data, data classes, installing packages |
| Probability Review: Notation, conditional, marginal and joint probabilities, Bayes’ rule, chain/product rule, Markov chains, Odds Ratios and Risk |
| Discrete and continuous distributions, Probability density functions, mass functions, kernel density estimation. |
| Introduction to Bayesian inference, naive bayes, Belief Networks, Resampling methods, Confidence intervals |
| **Estimation** |
| Histograms and other visualization tools for hypothesis testing (qq-plots plots, box plots, etc.) |
| Hypothesis testing: parametric and non-parametric methods, power analysis (t-test, ANOVA,Kruskal-Wallis), Post-Hoc Analysis |
| Linear regression and correlation, logistic regression. L1 and L2 Regularization Methods, introduction to cross-validation. |
| Discrete random variables estimation, contingency tables, chi square, Poisson distribution, exact test |
| **Advanced topics** |
| Clustering Analysis (k-means, hierarchical clustering, PCA), factor analysis, permutation and randomization: bootstrap |
| Survival Analysis, Time series, autocorrelation, ARIMA |
| Information Theory: Entropy, Information Gain, KL Diverge, and Mutual Information |
| Case studies |
| Case studies |

# Course Policies

***Accommodation Policy:*** Some of the readings, lectures, films, or presentations in this course may include material that may conflict with the core beliefs of some students. Please review the syllabus carefully to see if the course is one that you are committed to taking. If you have a concern, please discuss it with the instructors at your earliest convenience. For more information, please consult the University of Utah’s Accommodations Policy, which appears at: [www.admin.utah.edu/facdev/accommodations-policy.pdf](http://www.admin.utah.edu/facdev/accommodations-policy.pdf)

***Attendance policy:*** The University expects regular attendance at all online meetings. Instructors must communicate any particular attendance requirements of the course to students in writing on or before the first class meeting. Students are responsible for acquainting themselves with and satisfying the entire range of academic objectives and requirements as defined by the instructor. (PPM, Policy 6-100III-O)

***Drop/Withdrawal Policies.*** Students may drop a course within the first two weeks of a given semester without any penalties. Students may officially withdraw (W) from a class or all classes after the drop deadline through the midpoint of a course. A “W” grade is recorded on the transcript and appropriate tuition/fees are assessed. The grade “W” is not used in calculating the student’s GPA. For deadlines to withdraw from full-term, first, and second session classes, see the U's Academic Calendar.

**COVID-19 Spring 2022 Statement**

*University leadership has urged all faculty, students, and staff to****model the vaccination, testing, and masking behaviors****we want to see in our campus community.*

These include:

Vaccination

Masking indoors

If unvaccinated, getting weekly asymptomatic coronavirus testing

**Vaccination**

* **Get a COVID-19 vaccination** if you have not already done so. Vaccination is proving highly effective in preventing severe COVID-19 symptoms, hospitalization and death from coronavirus. Vaccination is the single best way to stop this COVID resurgence in its tracks.
* Many in the campus community already have gotten vaccinated:
  + More than 80% of U. employees
  + Over 70% of U. students
* Visit [*http://mychart.med.utah.edu/*](http://mychart.med.utah.edu/), [*http://alert.utah.edu/covid/vaccine*](http://alert.utah.edu/covid/vaccine), or [*http://vaccines.gov/*](http://vaccines.gov/)to schedule your vaccination.

**Masking**

* While masks are no longer required outside of Health Sciences facilities, UTA buses and campus shuttles, **CDC guidelines now call for everyone to wear face masks indoors.**
  + Check the CDC website periodically for masking updates—[*https://www.cdc.gov/coronavirus/2019-ncov/vaccines/fully-vaccinated-guidance.html*](https://www.cdc.gov/coronavirus/2019-ncov/vaccines/fully-vaccinated-guidance.html)
  + Treat masks like seasonal clothing (i.e. during community surges in COVID transmission, masks are strongly encouraged indoors and in close groups outside).

**Testing**

* **If you are not yet vaccinated, get weekly asymptomatic coronavirus tests.** This is a helpful way to protect yourself and those around you because asymptomatic individuals can unknowingly spread the coronavirus to others.
* Asymptomatic testing centers are open and convenient:
  + Online scheduling
  + Saliva test (no nasal swabs)
  + Free to all students returning to campus (required for students in University housing)
  + Results often within 24 hours
  + Visit [*alert.utah.edu/covid/testing*](https://t.e2ma.net/click/1bwsez/txrh1ob/5mzpwso)
  + **Remember: Students must self-report if they test positive for COVID-19** via this website: [*https://coronavirus.utah.edu/*](https://coronavirus.utah.edu/).

***Faculty Responsibilities: (from the University of Utah Policies and Procedures Manual)***

1. Faculty members are expected to meet their regularly scheduled classes. Failure to meet scheduled classes without prior notice to students is excusable only for reasons beyond the control of faculty members. Alteration of schedules, cancellation or rescheduling of classes may be done only for valid reasons and after adequate notice to students.

2. Faculty members shall engage in reasonable and substantial preparation for the teaching of courses assigned to them, consistent with their scope and nature and appropriate to the educational objectives sought to be achieved.

3. Faculty members must maintain regular office hours during which they are available for consultation with students or otherwise assure their accessibility to students.

4. Faculty members must, at the beginning of a course, give reasonable notice to students of the general content of the course, what will be required of the students, and the criteria upon which their performance will be evaluated. Evaluations must be performed promptly, conscientiously, without prejudice or favoritism, and consistently with the criteria stated at the beginning of the course. The criteria for evaluating student performance must relate to the legitimate academic purposes of the course. Grade appeals submitted by students are not considered charges of misconduct under this code. [For the appeals procedure, see the student code, PPM 8-10.2, Article III, section 3.04.]

5. Faculty members must not misuse the classroom by preempting substantial portions of class time for the presentation of their own views on topics unrelated to the subject matter of the course. Where faculty members find it pedagogically useful to advocate a position on controversial matters, they must exercise care to assure that opportunities exist for students to consider other views. Faculty members must not reward agreement or penalize disagreement with their views on controversial topics.

6. Faculty members must not use their position, authority, or relationship with students to obtain uncompensated labor for their own personal or pecuniary gain. They may not ask students to perform services unrelated to legitimate academic requirements of a course unless the student is adequately compensated for such services. Faculty members must not solicit gifts or favors from students. They must not accept gifts or favors where they have reason to believe that such gift or favor is motivated by a desire to secure some academic advantage.

7. Faculty members must not plagiarize the work of a student. Where a faculty member and a student work together, appropriate credit must be given to the student. Faculty members may not limit or curtail the right of a student to publish or otherwise communicate the result of the student's own scholarly activities.

8. Faculty members must not reveal matters related in explicit confidence by a student, except as required by law or university policy. Personal matters relating to a student must not be revealed by faculty members except to persons entitled to such information by law or university policies. Faculty members may, however, report their assessment of a student's academic performance and ability to persons making legitimate inquiry provided such disclosure is in accordance with the Family Educational Rights and Privacy Act ("FERPA").

***Student Responsibilities (From University of Utah student handbook)***

Students are expected to follow the Code of Student Rights and Responsibilities (“Student Code”) as delineated in the University of Utah Policies and Procedures Manual (http://www.admin.utah.edu/ppmanual/8/8-10.html).

1. Students are responsible for satisfying the entire range of academic objectives, requirements and prerequisites as defined by the instructor.

2. The University expects regular attendance at all class meetings. If you are absent from class to participate in officially sanctioned University activities, religious obligations, or with instructor's approval, you will be permitted to make up assignments and examinations.

3. In order to ensure that the highest standards of academic conduct are promoted and supported at the University, students must adhere to generally accepted standards of academic honesty, including but not limited to refraining from cheating, plagiarizing, research misconduct, misrepresenting one's work, and/or inappropriate conduct.

***University Safety Statement.*** The University of Utah values the safety of all campus community members. To report suspicious activity or to request a courtesy escort, call campus police at 801-585-COPS (801-585-2677). You will receive important emergency alerts and safety messages regarding campus safety via text message. For more information regarding safety and to view available training resources, including helpful videos, visit safeu.utah.edu.

***Addressing Sexual Misconduct***. Title IX makes it clear that violence and harassment based on sex and gender (which Includes sexual orientation and gender identity/expression) is a civil rights offense subject to the same kinds of accountability and the same kinds of support applied to offenses against other protected categories such as race, national origin, color, religion, age, status as a person with a disability, veteran’s status or genetic information.  If you or someone you know has been harassed or assaulted, you are encouraged to report it to the Title IX Coordinator in the Office of Equal Opportunity and Affirmative Action, 135 Park Building, 801-581-8365, or the Office of the Dean of Students, 270 Union Building, 801-581-7066.  For support and confidential consultation, contact the Center for Student Wellness, 426 SSB, 801-581-7776.  To report to the police, contact the Department of Public Safety, 801-585-2677(COPS).

**Student Mental Health Resources**

* Rates of burnout, anxiety, depression, isolation, and loneliness have noticeably increased during the pandemic. If you need help, reach out for [campus mental health resources](https://studentaffairs.utah.edu/mental-health-resources/index.php), including counseling, trainings and other support.
* Consider participating in a [Mental Health First Aid](https://studentaffairs.utah.edu/mental-health-first-aid.php) or other [wellness-themed](https://wellness.utah.edu/workshops-training/)training provided by our Center for Student Wellness and sharing these opportunities with your peers, teaching assistants and department colleagues

***Diverse Student Support.*** Your success at the University of Utah is important to all of us here! If you feel like you need extra support in academics, overcoming personal difficulties, or finding community, the U is here for you.

**Student Support Services (TRIO)**

TRIO federal programs are targeted to serve and assist low-income individuals, first-generation college students, and individuals with disabilities. Student Support Services (SSS) is a TRIO program for current or incoming undergraduate university students who are seeking their first bachelor's degree and need academic assistance and other services to be successful at the University of Utah. For more information about what support they provide, a list of ongoing events, and links to other resources, view their website or contact:

**Student Support Services (TRIO)**  
801-581-7188  
[trio.utah.edu](https://trio.utah.edu/)  
 Room 2075   
     1901 E. S. Campus Dr.  
     Salt Lake City, UT 84112

**American Indian Students**

The AIRC works to increase American Indian student visibility and success on campus by advocating for and providing student centered programs and tools to enhance academic success, cultural events to promote personal well-being, and a supportive “home-away-from-home” space for students to grow and develop leadership skills. For more information about what support they provide, a list of ongoing events, and links to other resources, view their website or contact:

**American Indian Resource Center**  
 801-581-7019  
[diversity.utah.edu/centers/airc](https://diversity.utah.edu/centers/airc/)  
Fort Douglas Building 622  
     1925 De Trobriand St.  
     Salt Lake City, UT 84113

**Black Students**

Using a pan-African lens, the Black Cultural Center seeks to counteract persistent campus-wide and global anti-blackness. The Black Cultural Center works to holistically enrich, educate, and advocate for students, faculty, and staff through Black centered programming, culturally affirming educational initiatives, and retention strategies.

For more information about what support they provide, a list of ongoing events, and links to other resources, view their website or contact:

**Black Cultural Center**  
801-213-1441  
[diversity.utah.edu/centers/bcc](https://diversity.utah.edu/centers/bcc/)  
Fort Douglas Building 603  
     95 Fort Douglas Blvd.  
     Salt Lake City, UT 84113

**Students with Children**

Our mission is to support and coordinate information, program development and services that enhance family resources as well as the availability, affordability and quality of child care for University students, faculty and staff.For more information about what support they provide, a list of ongoing events, and links to other resources, view their website or contact:

**Center for Childcare & Family Resources**  
801-585-5897  
[childcare.utah.edu](https://childcare.utah.edu/)  
408 Union Building  
    200 S. Central Campus Dr.  
     Salt Lake City, UT 84112

**Students with Disabilities**

The Center for Disability Services is dedicated to serving students with disabilities by providing the opportunity for success and equal access at the University of Utah. They also strive to create an inclusive, safe, and respectful environment.For more information about what support they provide and links to other resources, view their website or contact:

**Center for Disability Services**  
801-581-5020  
[disability.utah.edu](https://disability.utah.edu/)  
162 Union Building  
    200 S. Central Campus Dr.  
     Salt Lake City, UT 84112

**Students of Ethnic Descent**

The Center for Ethnic Student Affairs offers several programs dedicated to the success of students with varied cultural and ethnic backgrounds. Their mission is to create an inclusive, safe campus community that values the experiences of all students.For more information about what support they provide, a list of ongoing events, and links to other resources, view their website or contact:

**Center for Ethnic Student Affairs**  
801-581-8151  
[diversity.utah.edu/centers/cesa/](https://diversity.utah.edu/centers/cesa/)  
 235 Union Building  
    200 S. Central Campus Dr.  
     Salt Lake City, UT 84112

**English as a Second/Additional Language (ESL) Students**

If you are an English language learner, there are several resources on campus available to help you develop your English writing and language skills. Feel free to contact:

**Writing Center**801-587-9122  
[writingcenter.utah.edu](http://writingcenter.utah.edu/)  
2701 Marriott Library  
     295 S 1500 E  
     Salt Lake City, UT 84112

**English Language Institute**801-581-4600  
[continue.utah.edu/eli](http://continue.utah.edu/eli)  
540 Arapeen Dr.  
     Salt Lake City, UT 84108

**Undocumented Students**

Immigration is a complex phenomenon with broad impact—those who are directly affected by it, as well as those who are indirectly affected by their relationships with family members, friends, and loved ones. If your immigration status presents obstacles that prevent you from engaging in specific activities or fulfilling specific course criteria, confidential arrangements may be requested from the Dream Center.

**Arrangements with the Dream Center will not jeopardize your student status, your financial aid, or any other part of your residence.** The Dream Center offers a wide range of resources to support undocumented students (with and without DACA) as well as students from mixed-status families.

For more information about what support they provide and links to other resources, view their website or contact:

**Dream Center**801-213-3697   
[dream.utah.edu](http://dream.utah.edu/)  
 1120 Annex (Wing B)  
     1901 E. S. Campus Dr.  
     Salt Lake City, UT 84112

**LGBTQ+ Students**

The LGBTQ+ Resource Center acts in accountability with the campus community by identifying the needs of people with a queer range of [a]gender and [a]sexual experiences and responding with university-wide services.

For more information about what support they provide, a list of ongoing events, and links to other resources, view their website or contact:

**LGBTQ+ Resource Center**  
801-587-7973  
[lgbt.utah.edu (Links to an external site.)](http://lgbt.utah.edu/)  
409 Union Building  
    200 S. Central Campus Dr.  
     Salt Lake City, UT 84112

**Veterans & Military Students**

The mission of the Veterans Support Center is to improve and enhance the individual and academic success of veterans, service members, and their family members who attend the university; to help them receive the benefits they earned; and to serve as a liaison between the student veteran community and the university.

For more information about what support they provide, a list of ongoing events, and links to other resources, view their website or contact:

**Veterans Support Center**  
801-587-7722  
[veteranscenter.utah.edu](http://veteranscenter.utah.edu/) (Links to an external site.)  
418 Union Building  
    200 S. Central Campus Dr.  
     Salt Lake City, UT 84112

**Women**

The Women’s Resource Center (WRC) at the University of Utah serves as the central resource for educational and support services for women. Honoring the complexities of women’s identities, the WRC facilitates choices and changes through programs, counseling, and training grounded in a commitment to advance social justice and equality.For more information about what support they provide, a list of ongoing events, and links to other resources, view their website or contact:

**Women's Resource Center**  
801-581-8030  
[womenscenter.utah.edu](https://womenscenter.utah.edu/)  
411 Union Building  
     200 S. Central Campus Dr.  
     Salt Lake City, UT 84112

**Inclusivity at the U**

The Office for Inclusive Excellence is here to engage, support, and advance an environment fostering the values of respect, diversity, equity, inclusivity, and academic excellence for students in our increasingly global campus community. They also handle reports of bias in the classroom as outlined below:

Bias or hate incidents consist of speech, conduct, or some other form of expression or action that is motivated wholly or in part by prejudice or bias whose impact discriminates, demeans, embarrasses, assigns stereotypes, harasses, or excludes individuals because of their race, color, ethnicity, national origin, language, sex, size, gender identity or expression, sexual orientation, disability, age, or religion.

For more information about what support they provide and links to other resources, or to report a bias incident, view their website or contact:

**Office for Inclusive Excellence**801-581-4600  
[inclusive-excellence.utah.edu](https://inclusive-excellence.utah.edu/)[(Links to an external site.)](http://continue.utah.edu/eli)  
170 Annex (Wing D)  
     1901 E. S. Campus Dr.  
     Salt Lake City, UT 84112

**Other Student Groups at the U**

To learn more about some of the other resource groups available at the U, check out:

[getinvolved.utah.edu/](https://getinvolved.utah.edu/)

[studentsuccess.utah.edu/resources/student-support](https://studentsuccess.utah.edu/resources/student-support/)