

A Data Science Course

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2021-03-04

Contents

1 About this course	5
1.1 Course Delivery	5
1.2 Online materials	6
1.3 Course Topics	6
1.4 Course Assessments	6
2 Why study data science?	7
2.1 All experimental science is data science sooner or later	7
2.2 Biology is getting bigger	9
2.3 Data science methods are 21st Century realisations of the scientific method	9
3 Introduction to Genomics	11
3.1 The materials	11
3.2 For you to do	11
4 Data Exploration and Visualisation	13
4.1 The materials	13
4.2 For you to do	13
5 Understanding Statistics With Linear Models	15
6 Introduction to Non-Frequentist Statistics	17
7 Introduction to Machine Learning	19
8 Beginning Programming	21
9 Literate Computation	23
10 Projects	25

Chapter 1

About this course

Welcome to the handbook for the data science component of the TSL M.Sc in Global Plant Health.



Figure 1.1: Artwork by AllisonHorst

In here you will find links to the written content for each of the separate topics covered as well as the descriptions of the course assessments and projects.

1.1 Course Delivery

Data Science is a set of practical research skills grounded in statistics and computer science. Learning a practical skill requires practice! So this course is not a lecture course, it is a ‘flipped’ classroom course with a very strong practical component. In a flipped classroom the onus is on the student to lead their

work and practice with the provided materials prior to contact and discussion time with the wider learning group and group mentors. To get the most out of this course you must read the relevant online material before you come to the contact sessions. Contact time will then be an opportunity to discuss the materials and any problems arising with the group and the teacher and to practice and problem solve with others. The aim is that by the end of the course you will have a strong practical grounding in applying data science approaches to research problems that will enhance the biology that you are doing.

1.2 Online materials

The rest of this handbook outlines the online materials provided to you for this course, broken down by the separate topics we will cover. The materials are a mixture of self-led tutorials and interactive challenges or problems to solve.

1.3 Course Topics

We will cover the following topics in data science

1. Introduction to Genomics
2. Data Exploration and Visualisation
3. Understanding Statistics With Linear Models
4. Introduction to Non-Frequentist Statistics
5. Introduction to Machine Learning
6. Beginning Programming
7. Literate Computation

1.4 Course Assessments

The culmination of all this learning and practice will be a written essay and a large group project on which you will be assessed and receive a grade. These will be set at the end of the course and deadlines will be given to you explicitly for each. You will not be formally assessed on other projects, quizzes and challenges occurring through the course.

Chapter 2

Why study data science?

At first thought, you may imagine that data science is not going to be of much interest to you, your desire and interest is in biology, not computers and mathematics. That may be true but data science is actually going to be one of the main technical themes throughout your entire scientific career and it will help you truly master your science and to become an informed and healthily sceptical interpreter of scientific results. Adding data science as your super power will be of benefit in lots of ways. Learning data science now isn't a tax on your time so that you can get through this M.Sc, it's a valuable investment in your skill set that will help to give you an advantage that will pay definite dividends later. Getting on with data science is like getting on with Jedi training for biologists

2.1 All experimental science is data science sooner or later

“Data Science” is a new-ish term that describes an interdisciplinary approach to the practical application of statistics and computer science concepts and tools. The term data scientist is most often applied to people who analyse large amounts of high throughput data full time and have a research or industrial interest in that but the techniques of data science are useful to all researchers, data science is useful to biologists. There is no such thing as a purely lab- or field-based biologist, once our data are collected we must use it in a computer to perform analyses, draw conclusions and draw figures. All modern scientists are at some point a data scientist, irrespective of field and training. Knowledge of data science techniques will therefore underpin everything you do as a scientist at the most fundamental level, from experimental design, data collection, analysis and interpretation of results. A scientist that lacks data science skills will find it very difficult to progress beyond the most basic levels of expertise in experimental analysis.



Figure 2.1: Artwork by AllisonHorst

2.2 Biology is getting bigger

All biological disciplines including genomics and genetics, microscopy, biochemistry and proteomics generate volumes of data that are too great to handle by a scientist armed only with a clipboard and spreadsheet, no matter how hard working they are. At the heart of data science are the techniques for dealing with the biggest data sets yet generated and learning just a little about them will stand you in good stead across your entire career.

2.3 Data science methods are 21st Century realisations of the scientific method

Reproducibility and clear description of process is the keystone of the scientific method, using point and click tools to carry out analyses often do nothing to help you reach this goal but many data science techniques are built with these qualities as a primary design principle and can help to reduce your workload by helping you to do things reproducibly over and again with ease. They can help you share and report on your research and data in a way that is transparent and clear to the reader. They can also help you make the data and analysis you have generated shareable and findable by others.

Chapter 3

Introduction to Genomics

Genomics is a big field with wide use within biology. On the Plant Health M.Sc you are going to learn about a lot of applications of genomics technologies and data science skills underpin *all* of those applications and analysis. So in this first, foundational topic we will look at how to run a basic genomics SNP calling pipeline on the Linux command line. This will include developing the basic skills to use the computer from the command line.

3.1 The materials

As a source for this we will follow the excellent Data Carpentry Genomics Curriculum <https://datacarpentry.org/lessons/#genomics-workshop>. We will do the following two lessons

1. Shell Genomics
2. Data Wrangling and Processing for Genomics

3.2 For you to do

TODO: Check with SB: about logistics, place and machines and timetables etc
TODO: Schedule this one with contact time first

Chapter 4

Data Exploration and Visualisation

Data exploration and visualisation is the first step in most analyses and the R statistical computing environment is a great tool to work with.

In this topic we will explore techniques in R that allow us answer research questions of our data in a way that follows consistent and straightforward principles. We will learn a data format for keeping our research data organised so that we can readily apply all sorts of useful tools to it. We will also learn a grammar of plots that will allow us to make informative and clear figures. By the end of this you will be comfortable with using R to summarise and work with data frames and create a wide range of plots.

4.1 The materials

For this topic we will use these courses

1. dplyr
2. ggplot2

4.2 For you to do

TODO: Check with SB: about logistics, place and machines and timetables etc.
TODO: Add in AHorst figures and rewrite challenges, tidy tuesdays?



Figure 4.1: Artwork by AllisonHorst

Chapter 5

Understanding Statistics With Linear Models

Chapter 6

Introduction to Non-Frequentist Statistics

Chapter 7

Introduction to Machine Learning

Chapter 8

Beginning Programming

Chapter 9

Literate Computation

Chapter 10

Projects