Intro to MATLAB Fundamentals for Biomedical Scientists

Prerequisites: No prior programming experience is required.

Day 1 of 2. Learn MATLAB Fundamentals	
Using MATLAB as a Point and Click Desktop Environment	**Objective:** Use and gain familiarity with MATLAB's point and click interfaces to explore and understand the breadth of biomedical data types MATLAB can manage. • **Arrays and Matrices**: Load data from a multi-well plate assay, generate plots, compute statistics • **Tables**: Load and explore a 5000 row x 25 column table of numerical, logical, categorical, and string data, generate plots, compute statistics • **Biological Sequences**: Load multiple sequences directly from a web query to NCBI's database, visualize alignments, produce a phylogenetic tree • **Biological Signals**: Load EKG data, quantify peaks and generate a peak table, identify peaks with similar features to a reference (also works for chemical spectroscopy) • **Images**: Open a microscopy image, segment by color intensity, quantify region properties, generate statistics and plots
MATLAB as a Computational Language	**Objective:** Develop basic knowledge and skills to use the MATLAB language to build custom workflows you can apply to your own research. • Learn MATLAB language fundamentals: **Data Types**, **Functions**, **Scripts** • Understand how to find and apply **Functions for each Data Type** to expand your possibilities • Learn how to **create your own custom workflows and functions** for increased automation and reproducibility: MATLAB programming basics • Improve your workflows and performance: **intro to debugging**
Optional Take Home Exercise: Start to build your own custom workflow.	**Objective:** Maximize learning retention by immediately applying what you have learned to your own unique case. Experiment with building your own custom workflow for your data. Over the next day, you will continue to learn techniques, ideas, insights, and receive helper code and tips to apply to your own scientific research.

Day 2 of 2. Project Based Learning: Apply Fundamentals to Develop Several Custom Workflows	
Objectives: • Consolidate your understanding by extending the basic examples from day one to span complete scientific workflows of loading data, analyzing data, reporting, and automation for each major biomedical data type. • Develop familiarity using both the point and click and computational aspects of MATLAB together to solve problems. • Develop and obtain examples which you can take directly back to your own research and apply immediately to be more productive. While the examples are specific to various biomedical applications or fields, the workflows for each data type are extendable to seemingly unrelated applications. For example, microscopy, histology and medical imaging use 2D or 3D image processing; both neuroscience and cardiobiology use electrophysiology which shares signal processing similarities with chemistry or spectroscopy; most scientists work with tables of mixed data applying statistics, and many fields use sequence analysis.	
Exercise 1: Tables	Analyze a table of thousands of rows by dozens of columns, generate summary statistics, plots and an automatic PDF or HTML report. Understand options for processing tables too big to load into computer RAM.
Exercise 2: Automating the analysis of matrices	Automate the loading, curve fitting, quality control statistics, plotting, and reporting of thousands of dose response curves captured on hundreds of spreadsheet files. Identify most potent leads in a dose-response lead screen experiment. Example can be extended to any kind of array-based experiment.
Exercise 3: Working with Signals	Gain familiarity with the signal processing capabilities and apps in MATLAB. Load EKG data, apply signal processing functions to quantify beats per minute, find similar peaks to a reference peak. Apply statistics to heart rate variability. Generate a peak table and save to a spreadsheet. Understand strategies to flatten or detrend the baseline and remove noise including using wavelets, signal processing filters, or open source algorithms on the MATLAB file exchange.
Exercise 4: 2D Image Processing	Load images, understand the underlying data type, quantify regions of interest in a 2D image, generate and apply logical masks to quantify objects of interest within regions. Generate statistics from region properties. Generate histograms and summary statistics from statistics.
Exercise 5: 3D Image Processing	Analyze a 3D Image of a CT Scan of the torso. Explore apps for 3D visualization and image segmentation. Identify anatomical structures and quantify total lung volume. Generate a publication quality 3D image.
Exercise 6: Biological Sequence Analysis	Load sequence data from a web query to NCBI, analyze sequence similarities, build a phylogenetic tree. Understand other capabilities for microarray analysis, sequence comparisons, viewing NGS data, mass spectrometry.
Optional Exercise: Build your own custom workflow.	**Objective:** Maximize learning retention by immediately applying what you have learned to your own unique case. Share your custom workflow with the instructor for feedback or help, time permitting.