There are many good books that describe in-depth how various scientific instruments work. Understanding an experimental technique at the level presented in these texts is essential if you are a researcher relying on them to make claims about unknown materials. It is, however, overwhelming and unnecessary to read this much detail if you just want to be able to understand what one figure in a paper is telling you. What is generally missing from the literature are straight-to-the-point tutorials on how you analyze data generated by various instruments, yet this is a major stumbling block for new readers. Even Wikipedia can overwhelm the novice. In 2018, the Materials Chemistry students at Franklin & Marshall College began a text to develop the straight-to-the-point tutorials of characterization techniques we found necessary. In 2019, we revised these tutorials and prepared them for distribution via chem.libretext.org. In 2020, we continued to update and review the existing pages.

Each page addresses the following questions:

How does the technique work?

This should not be in great depth (do not discuss in detail the optics of an electron microscope, for example) but should be in enough depth that it is clear what is being measured and how.

How do you interpret the data it generates?

This should include a general guide to how to "read" data as it is commonly presented as well as important caveats or sources of error to be considered.

What are good literature examples?

Choose a paper or two that uses this technique, link to the figures presented (we can not show them unless they are licensed to allow this) and describe how they were interpreted. Provide appropriate citations.

What are useful resources for in-depth reading?

Prepare a list of resources for students who would like to gain more in-depth understanding of the technique.

If you find this text useful or have suggestions for improving it, please contact Prof. Kate Plass at kplass@fandm.edu.
• **Electron and Probe Microscopy**

  ◦ Atomic Force Microscopy (AFM)
  ◦ Basic TEM
  ◦ Scanning electron microscopy (SEM)
  ◦ TEM: Bright field versus dark field
  ◦ Transmission electron microscopy (TEM): TEM versus STEM and HAADF

• **Spectroscopy**

  ◦ Energy-Dispersive X-ray Spectroscopy (EDS)
  ◦ Light absorption and photoluminescence (PL) spectroscopy
  ◦ Raman spectroscopy
  ◦ Solid-state nuclear magnetic resonance spectroscopy (Solid-state NMR)
  ◦ X-ray Photoelectron Spectroscopy (XPS)

• **Electrochemistry**
- Cyclic Voltammetry (CV)
- Impedance Spectroscopy

**Diffraction Techniques**

- Crystal structure basics
- Electron Diffraction
- Other diffraction techniques
- WAXS and SAXS
- X-ray diffraction (XRD) basics and application

**Thermal Analysis**

- Differential scanning calorimetry (DSC) (empty)
- Thermogravimetric analysis (TGA)