

Figure of the Week: Skills for interpreting comparative genomics figures

Course: Comparative Genomics CURE

Course format: Online labs

Module: Figure of the Day, adapted by Robert Furrow

Student learning and affective objectives:

- Be able to interpret scatterplots, heatmaps, and dendrograms.
- Develop confidence to analyze a novel data figure and comfortably share ideas with peers.

Classroom climate objective: Create a welcoming and respectful space in the Q&A forum for students to share random observations about these figures, and respond to each other's ideas.

Dates of implementation: Spring quarter 2020

Overview

This resource is an adaptation of the QUBES [Figure of the Day module by Flemming-Davis and Wodjak](#) (2018). The goal of this module is to provide a repeated student activity that helps students learn to interpret scientific figures in a low-stakes environment. By offering “incomplete” figures that don’t include full axes, captions, and legends, students are free to propose a creative diversity of potential interpretations of the figure. With no single correct answer, students can focus without anxiety on the process of how you use the structure and information types within a figure to put together a potential interpretation.

This module was implemented during Spring 2020, in a class that was fully online due to shelter-in-place restrictions to reduce COVID-19 transmission. The course was a CURE (course-based research experience) focused on comparative genomic analyses of novel genomes generated from student-cultured salt-living microbes. Because we wanted to build classroom cohesion, we adapted this module to be a fun, low-stakes weekly online forum post. We specifically developed this adaptation using the [Universal Design for Learning guidelines from CAST](#), aiming to optimize this module for this online learning environment and for the diversity of students in the class.

Addressing UDL Checkpoints

The Universal Design for Learning framework provides a diversity of specific suggestions for classroom and assessment practices. There are [many potential checkpoints to consider](#); we focused on making only a few small “plus-ones” -- small adaptations of Figure of the Day to

align with specific UDL checkpoints. Below we outline four examples of the alignment between this Figure of the Week module and the UDL guidelines.

Checkpoint 7.3 - Minimize threats and distractions

The discussion is designed to be low stakes and fun, creating a safe space for people to share ideas that might feel silly or unpolished. The discussion is also a structured routine; the prompt and task are the same each week to make the assignment a predictable part of each week's coursework. To emphasize the low stakes, the discussion prompt explicitly states "*This is not a test. It's a chance to get comfortable reading figures and making weird predictions about what you think the data are. In real life, quantitative thinking is creative and flexible, and skills such as quickly interpreting figures take a lot of practice to master.*"

Checkpoint 8.3 - Foster collaboration and community

Because the online forum-based implementation is based on collective knowledge generation, it can help foster collaboration and discussion among students. The prompt clearly defines the rules for how a student can engage, and it leads to students collectively building incrementally greater understanding with each new student comment.

Checkpoint 3.2 - Highlight patterns, critical features, big ideas, and relationships

By tying the figure types directly to the data we will be looking at in the following week, this provides an opportunity for students to slowly and systematically dissect the figure, understanding the key elements. When students later visualize their own data in the course, instructions explicitly prompt students to draw upon their understanding of the Figure of the Week to help them interpret these new data.

Checkpoint 3.3 - Guide information processing and visualization

The addressing of this UDL checkpoint is not unique to this Figure of the Week adaptation, but is fundamental to all Figure of the Day/Week modules. The interpretation of a figure is a very high-dimensional task -- there are axes, legends, colors, data types, and a wide diversity of potential patterns to process, even before a student can attempt to connect the figure to a potential biological insight. The initial figure each week is displayed without full legends and axes, and is potentially zoomed in only on a small part of the full, original figure. This scaffolds the process of figure interpretation, allowing students to engage first with fundamental features of the axes, colors, and data types being displayed before trying to interpret the meaning of labels and their units.

Module structure

Each week, a figure is presented as a post on a discussion forum (the initial implementation was using the Q&A forum website [Piazza](#), with each post as an *instructor note*). The figures are designed to align with data and figure types that the students will analyze and generate in the

upcoming week of class. These figure types include scatterplots, heatmaps, and dendrograms. Students are given the following prompt in the text of the forum post:

Here's our new Figure of the Week. Your responses should either be a follow-up discussion or a reply to another student's follow-up discussion. Your task for this discussion is to read over all the other student responses, then give one of two possible responses:

- *either make one new observation about this plot (e.g. what do you think it represents? what's one pattern you notice? are the data numerical or categorical? if there are colors, what might they represent? etc.),*
- *or reply to another students' comment with one question or one related idea.*

This is not a test. It's a chance to get comfortable reading figures and making weird predictions about what you think the data are. In real life, quantitative thinking is creative and flexible, and skills such as quickly interpreting figures take a lot of practice to master.

During the next week's lab session, instructors summarized student posts, shared the figure with more complete axes/legends, and typically had students generate similar figures related to the course data (see the [partial course website](#) for examples of data and analyses performed during lab).

Modifying the figures

Please feel free to modify (and share-alike) the figures in this module. Figure 1 (the scatterplot) and the additional Figures 5 and 6 were created by Robert Furrow. The R code used to generate these figures is included in this QUBES resource as `plots_code.R`, and the three datasets are available as csv files in the resource. Figure 2, the measles heatmap, has complete data and code available at [this R programming site](#). Figure 3, the dendrogram, is from the interactive tree of life [website Evogeneao](#). Figure 4, the Manhattan plot, does not have publicly available data; it is from a genome-wide association study on gout, with a manuscript [available here](#).