BM327 microbiology S1 lab manual

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# Preface

This is a Quarto book, generated using the sipbs-compbiol-book-template GitHub template.

The index.qmd file provides this Preface page, which is intended as a frontispiece with brief introductory information about the book and its contents and scope and, maybe, its authors. To change the main text and content you see here (the content in the middle section of the page), you need to edit the index.qmd file.

* To learn more about writing Quarto books, visit <https://quarto.org/docs/books>.

|  |
| --- |
| Tip |
| To put links into Quarto pages, use the structure:  [Text to be displayed](URL of the link)  For example, [this link](https://www.youtube.com/watch?v=dQw4w9WgXcQ) is written as  [this link](https://www.youtube.com/watch?v=dQw4w9WgXcQ) |

## How this page is structured

### Section headers

Section headers are written in [Markdown](#markdown) using hash/pound signs:

## This is a (level two) section header.  
### This is a (level three) section header

* To learn more about sections and headers, see this [quick guide to Markdown basics](https://quarto.org/docs/authoring/markdown-basics.html).

|  |
| --- |
| Changing title and author information, or the cover image (click to expand) |
| The book title, author, date, and cover image are specified in the \_quarto.yml. To change this information, edit that file, and re-render the page.  book:  title: "THE TITLE OF THE BOOK"  author: "AUTHOR NAME"  date: "DD/MM/YY"  cover-image: sipbs\_compbio\_800.png |

### Callout blocks

Callout blocks, like the ones above, are highlighted regions of the document which carry a title, icon and colour, which may indicate the kind of information the callout contains. For example:

|  |
| --- |
| Warning |
| This is a warning block. To insert a block like this, use:  ::: { .callout-warning } The text of the callout goes here ::: |

|  |
| --- |
| Caution (click to expand) |
| This is a caution block, which is collapsible when rendered as HTML/webpage but appears in full in the Word document. To make a callout collapsible, use collapse="true" as in the example below. This places a dropdown icon to the right of the title bar, which controls expansion.  ::: { .callout-caution collapse="true" title="Caution (click to expand)"} This is a collapsible caution block. The callout content goes here. :::  Notice also that the title of the callout is specified between the curly braces as title="Caution (click to expand)". |

You can learn more about callout blocks in the [Quarto documentation](https://quarto.org/docs/authoring/callouts.html).

# 1. Introduction

The Introduction page is intended as a short introduction to the book.

Like most Quarto books, this is a book created from markdown and executable code.

This kind of book is an example of literate programming - the intertwining of nicely-formatted text and images, and executable code. For example, the R code cell below executes and produces output when the book is compiled:

1 + 1

[1] 2

But the R code cell below does not:

summary(cars)

See Knuth ([1984](#ref-knuth84)) for additional discussion of literate programming.

# 2. Early Section Topic

This .qmd file represents some topic-related text. We use the {#sec-REFERENCE} option to make it cross-referenceable elsewhere in the text.

# 3. Interactive Multiple Choice Questions

This page demonstrates the setup of an [naquiz multiple-choice quiz](https://nareal.github.io/naquiz/example.html). The advantage of this extension is that we don’t need to use a Shiny server.

* [naquiz repository](https://github.com/nareal/naquiz)
* [naquiz examples and documentation](https://nareal.github.io/naquiz/example.html)

## 3.1 Multiple Choice Questions

### 3.1.1 Basic MCQ

A simple naquiz example looks something like the question below to the reader (click the Markdown tab to see how to write the markdown for it).

## Appearance

Bill Gates was the founder of:

Apple

Microsoft

Facebook

Google

## Markdown

:::::{.question}  
Bill Gates was the founder of:  
  
::::{.choices}  
  
:::{.choice}  
Apple  
:::   
  
:::{.choice .correct-choice}  
Microsoft  
:::  
  
:::{.choice}  
Facebook   
:::  
  
:::{.choice}  
Google   
:::  
  
::::  
:::::

|  |
| --- |
| Caution |
| The nested colon dividers and their counts can look confusing on the page, and missed/extra colons can break the layout of your page.   * The {.question} divider gets **five** colons. * The {.choices} divider that surrounds the choices presented to the reader gets **four** colons. * Each individual {.choice} divider gets **three** colons. |

It presents a series of *radio buttons* from which the reader can choose one option. On clicking the option, the reader receives very basic feedback: a red cross (incorrect) or green tick (correct).

### 3.1.2 Add a “clear answer” button

The naquiz MCQs can be decorated with useful buttons for reader interaction. The example below has a “Clear Answer” button, which unchecks the reader’s selected answer.

## Appearance

Bill Gates was the founder of:

Apple

Microsoft

Facebook

Google

## Markdown

:::::{.question}  
Bill Gates was the founder of:  
  
::::{.choices}  
  
:::{.choice}  
Apple  
:::   
  
:::{.choice .correct-choice}  
Microsoft  
:::  
  
:::{.choice}  
Facebook   
:::  
  
:::{.choice}  
Google   
:::  
  
:::{.button-clear title="Clear answer" button-class="btn btn-xs"}  
:::  
  
::::  
:::::

|  |
| --- |
| Important |
| The button to clear reader answers needs to be linked with the available choices, and so is placed **inside the {.choices} division** of the MCQ. |

### 3.1.3 Add a “hint” button

The example below includes a “hint” button, which the reader can use to get a clue to the answer.

## Appearance

Bill Gates was the founder of:

Apple

Microsoft

Facebook

Google

The company name starts with an ‘M’…

## Markdown

:::::{.question}  
Bill Gates was the founder of:  
  
::::{.choices}  
  
:::{.choice}  
Apple  
:::   
  
:::{.choice .correct-choice}  
Microsoft  
:::  
  
:::{.choice}  
Facebook   
:::  
  
:::{.choice}  
Google   
:::  
  
:::{.button-clear title="Clear answer" button-class="btn btn-xs"}  
:::  
  
::::  
  
::::{.btn-group}  
:::{.button-hint title="Show hint" button-class="btn btn-xs"}  
The company name starts with an 'M'...  
:::  
::::  
  
:::::

|  |
| --- |
| Important |
| We can place additional buttons within a *button group* divider, specified as ::::{.btn-group}, *inside* the question divider (the five colons :::::).  Here, we have linked a {.button-hint} that, when clicked, expands to show the hint text. |

### 3.1.4 Add an “answer” button

We can add a further button to provide students with the answer we’d like them to read, directly.

## Appearance

Bill Gates was the founder of:

Apple

Microsoft

Facebook

Google

The company name starts with an ‘M’…

Bill Gates and Paul Allen founded Microsoft on April 4, 1975.

## Markdown

:::::{.question}  
Bill Gates was the founder of:  
  
::::{.choices}  
  
:::{.choice}  
Apple  
:::   
  
:::{.choice .correct-choice}  
Microsoft  
:::  
  
:::{.choice}  
Facebook   
:::  
  
:::{.choice}  
Google   
:::  
  
:::{.button-clear title="Clear answer" button-class="btn btn-xs"}  
:::  
  
::::  
  
::::{.btn-group}  
:::{.button-hint title="Show hint" button-class="btn btn-xs"}  
The company name starts with an 'M'...  
:::  
::::  
  
:::{.button-answer title="Show Answer" button-class="btn btn-xs"}  
Bill Gates and Paul Allen founded Microsoft on April 4, 1975.  
:::  
:::::

|  |
| --- |
| Important |
| We can place more than one button in the *button group* divider. Here, we have linked a {.button-answer} that, when clicked, expands to show the hint text. |

### 3.1.5 Placing an MCQ in a custom callout

We have created a custom callout called callout-question which can be used to make MCQ stand out a bit more, with a consistent visual style.

## Appearance

|  |
| --- |
| Question |
| Bill Gates was the founder of:  Apple  Microsoft  Facebook  Google  The company name starts with an ‘M’…  Bill Gates and Paul Allen founded Microsoft on April 4, 1975. |

## Markdown

::: { .callout-question }  
  
:::::{.question}  
Bill Gates was the founder of:  
  
::::{.choices}  
  
:::{.choice}  
Apple  
:::   
  
:::{.choice .correct-choice}  
Microsoft  
:::  
  
:::{.choice}  
Facebook   
:::  
  
:::{.choice}  
Google   
:::  
  
:::{.button-clear title="Clear answer" button-class="btn btn-xs"}  
:::  
  
::::  
:::::  
  
::::{.btn-group}  
:::{.button-hint title="Show hint" button-class="btn btn-xs"}  
The company name starts with an 'M'...  
:::  
  
:::{.button-answer title="Show Answer" button-class="btn btn-xs"}  
Bill Gates and Paul Allen founded Microsoft on April 4, 1975.  
:::  
::::  
  
:::

### 3.1.6 Randomising question values

We can use R or Python to generate random values that can be used to compose questions that are different each time the page is rendered, by inserting a suitable R/Python code block and using the values in the question.

|  |
| --- |
| Caution |
| The values do **not** change when the page is reloaded by a reader. The values are calculated when the pages are rendered.  For values that change when the page is refreshed, or on demand, use an R [Shiny](https://shiny.posit.co/r/getstarted/shiny-basics/lesson1/) or [Shinylive](https://posit-dev.github.io/r-shinylive/) solution, or a solution like [Numbas](https://www.numbas.org.uk/). |

## Appearance

|  |
| --- |
| Question |
| What is the sum of 6 and 20?  -14  26  14  120  You need to add the two numbers 6 and 20  6 + 20 = 26 |

## Markdown

::: { .callout-question }  
  
:::::{.question}  
What is the sum of `r x\_val` and `r y\_val`?  
  
::::{.choices}  
  
:::{.choice}  
`r x\_val - y\_val`  
:::   
  
:::{.choice .correct-choice}  
`r x\_val + y\_val`  
:::  
  
:::{.choice}  
`r y\_val - x\_val`  
:::  
  
:::{.choice}  
`r y\_val \* x\_val`  
:::  
  
:::{.button-clear title="Clear answer" button-class="btn btn-xs"}  
:::  
  
::::  
:::::  
  
::::{.btn-group}  
:::{.button-hint title="Show hint" button-class="btn btn-xs"}  
You need to add the two numbers `r x\_val` and `r y\_val`  
:::  
  
:::{.button-answer title="Show Answer" button-class="btn btn-xs"}  
`r x\_val` + `r y\_val` = `r x\_val + y\_val`  
:::  
::::  
  
:::

## R code

#| show: false  
#| echo: false  
  
x\_val <- sample(1:10, 1)  
y\_val <- sample(11:20, 1)

# 4. WebR Playground

#| context: setup  
  
# Download reporter data  
download.file('https://raw.githubusercontent.com/sipbs-compbiol/BM214-Workshop-3/main/assets/data/reporter\_curves.csv', 'reporter\_curves.csv')  
  
library(palmerpenguins)  
library(tidyverse)

## 4.1 Introduction

This page provides a [WebR](https://docs.r-wasm.org/webr/latest/) cell for use as a playground to experiment with example datasets, and describes how to include WebR on other Quarto pages.

* [WebR documentation](https://docs.r-wasm.org/webr/latest/)

## 4.2 Playground

## Appearance

# Use this WebR cell to experiment with using R. You can do almost anything  
# by typing in this code cell that you can do in R, including plotting graphs.  
#  
# Why not try the command:  
#  
# plot(penguins)  
#  
# and click the "Run code" icon?

## Markdown

```{webr-r}  
# Use this WebR cell to experiment with using R. You can do almost anything  
# by typing in this code cell that you can do in R, including plotting graphs.  
#  
# Why not try the command:  
#  
# plot(penguins)  
#  
# and click the "Run code" icon?  
  
```

## 4.3 Examples to try

## Palmer Penguins

The penguins dataset contains data about three different species of penguins. You can use the R commands below to investigate the data:

glimpse(penguins) # look at the format of the dataset  
plot(penguins) # plot a visual overview of the dataset  
  
# Plot the count of penguins in each species as a bar chart  
ggplot(penguins, aes(species, fill=species)) + geom\_bar()  
  
# Break down the distribution by species in a facet plot  
ggplot(penguins, aes(species, fill=species)) + geom\_bar() + facet\_wrap(~sex)  
  
# Make a box and whisker plot of penguin body mass by species:  
ggplot(penguins, aes(x=species, y=body\_mass\_g, fill=species)) + geom\_boxplot()  
  
# Plot the body mass for each sex side-by-side  
ggplot(penguins, aes(x=species, y=body\_mass\_g, fill=sex)) + geom\_boxplot()  
  
# Investigate correlation between body mass and flipper length:  
ggplot(penguins, aes(x=body\_mass\_g, y=flipper\_length\_mm)) + geom\_point()  
  
# Colour datapoints by species:  
ggplot(penguins, aes(x=body\_mass\_g, y=flipper\_length\_mm, colour=species)) +  
 geom\_point()  
  
# Fit a linear regression to each species separately:  
ggplot(penguins, aes(x=body\_mass\_g, y=flipper\_length\_mm, colour=species)) +  
 geom\_point() +  
 geom\_smooth(method="lm")

## Plot reporter curves

One of our [BM214 workshops](https://sipbs-compbiol.github.io/BM214-Workshop-3/) involves a WebR-supported interactive exercise involving simulated reporter curves.

Here, we have downloaded some data from the online repository and made it available as though it was a dataset on the filesystem, reporter\_curves.csv.

# Load reporter experiment data  
data <- read.csv("reporter\_curves.csv")  
  
glimpse(data) # Summarise the data format  
  
# Plot absorbance against concentration as a facet plot  
ggplot(data, aes(x=conc, y=abs\_ratio, color=sample)) + geom\_point() +  
 geom\_line() + facet\_wrap(~sample)

## Other datasets

R comes with a number of example datasets you can practice with, including:

* mtcars: fuel consumption and other statistic for 32 automobiles
* Titanic: the fates of passengers from the maiden voyage of the ocean liner *Titanic*

You can see a full list by running the command

library(help = "datasets")

## 4.4 Setting up WebR

There are three important elements to including WebR on a Quarto page: the YAML header, the setup code block, and the WebR cell.

You can see an example of how to set up WebR on any Quarto page by inspecting the .qmd source for this page.

### 4.4.1 YAML header

To use WebR on a Quarto page, you need to include an appropriate YAML header at the top of the page:

---  
webr:  
 packages: ["tidyverse", "palmerpenguins"]  
filters:  
 - webr  
---

Packages to be imported into WebR should be specified in the list, as tidyverse and palmerpenguins are, here. The webr filter must be loaded.

### 4.4.2 WebR setup block

There is a special R code block needed to prepare the WebR instance. For this page, the code block

```{webr-r}  
#| context: setup  
  
# Download reporter data  
download.file('https://raw.githubusercontent.com/sipbs-compbiol/BM214-Workshop-3/main/assets/data/reporter\_curves.csv', 'reporter\_curves.csv')  
  
library(palmerpenguins)  
library(tidyverse)  
```

declares that it has the setup context, so will be run when the WebR instance starts. The download.file() call pulls the reporter\_curves.csv file from a GitHub repository and makes it available in WebR, as if it were a real file, with the name reporter\_curves.csv. The last three lines import R packages into the WebR environment.

### 4.4.3 The WebR code cell

The minimal WebR code cell looks like this:

```{webr-r}  
```

but it is more helpful, and more usual, to include some example code or comments, as in the example below:

## Appearance

# You can use `R` as a calculator  
  
1 \* sin(1)

## Markdown

```{webr-r}  
# You can use `R` as a calculator  
  
1 \* sin(1)  
```

# 5. Custom Callouts

This page demonstrates the use of the [quarto-custom-callout](https://quarto.thecoatlessprofessor.com/custom-callout/) extension to provide bespoke callout blocks.

* [quarto-custom-callout repository](https://github.com/coatless-quarto/custom-callout)
* [quarto-custom-callout examples and documentation](https://quarto.thecoatlessprofessor.com/custom-callout/)

## Introduction

Quarto provides a number of built-in callout blocks, including:

|  |
| --- |
| Caution |
| The caution callout  ::: { .callout-caution } The caution callout ::: |

|  |
| --- |
| Important |
| The important callout  ::: { .callout-info } The important callout ::: |

|  |
| --- |
| Tip |
| The tip callout  ::: { .callout-tip } The tip callout ::: |

but these do not cover all the cases we might want to use callouts for. It is possible to change the titles of these callouts, such as:

|  |
| --- |
| Custom title |
| The tip callout with a custom title  ::: { .callout-tip title="Custom title"} The tip callout with a custom title ::: |

|  |
| --- |
| Not the caution callout |
| ::: { .callout-caution } ## Not the caution callout ::: |

but customising the colour and icon of a callout is more difficult. The quarto-custom-callout extension allows us to make our own callouts.

## Defining a new callout

To make a new callout, add a new entry in \_quarto.yml in the custom-callout block with the name of the callout. For instance, to add a new case study callout, we could use the code below:

custom-callout:  
 callout-case-study:  
 title: "Case Study"  
 icon-symbol: "🔍"  
 color: "#FFA500"

and ensure that the custom-callout filter is called in \_quarto.yml:

filters:  
 - custom-callout

|  |
| --- |
| Callout naming convention |
| We have chosen to give all of our callouts for this template the prefix callout- for continuity with the builtin callouts, and to aid with literate programming/self-documentation. Please keep to this convention when you define your own callouts. |

|  |
| --- |
| Tip |
| Notice that the icon-symbol field accepts unicode icons and emojis. |

## Custom callouts in this template

We have defined the custom callouts below:

|  |
| --- |
| Case Study |
| For describing case studies  ::: { .callout-case-study } For describing case studies ::: |

|  |
| --- |
| Challenge |
| For presenting a challenge to readers  ::: { .callout-challenge } For presenting a challenge to readers ::: |

|  |
| --- |
| Data Analysis |
| For describing datasets and data analysis  ::: { .callout-data } For describing datasets and data analysis ::: |

|  |
| --- |
| Discussion Questions: |
| For introducing discussion points  ::: { .callout-discussion } For introducing discussion points ::: |

|  |
| --- |
| Microbe Profile |
| For summarising the properties of a microbe  ::: { .callout-microbe } For summarising the properties of a microbe ::: |

|  |
| --- |
| Question |
| For presenting a single question to readers  ::: { .callout-question } For presenting a single question to readers ::: |

|  |
| --- |
| Questions |
| For presenting multiple questions to readers  ::: { .callout-questions } For presenting multiple questions to readers ::: |

|  |
| --- |
| Great job! |
| For general encouragement  ::: { .callout-thumbs-up } For general encouragement ::: |

|  |
| --- |
| Callout-todo |
| For highlighting where we still need to do some work  ::: { .callout-todo } For highlighting where we still need to do some work ::: |

# References

Knuth, Donald E. 1984. “Literate Programming.” *Comput. J.* 27 (2): 97–111. <https://doi.org/10.1093/comjnl/27.2.97>.