biomint

biomolecular interactive tutorials

Design Document

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1. About the Project

1.1. Introduction

Enzyme kinetics is the study pertaining rates of enzyme-catalyzed reactions, which drive many essential pathways in biological system. It is first taught to undergraduate science students as a set of threshold concepts laying the foundations for advanced disciplines such as pharmacology and molecular biology. However, courses teaching enzyme kinetics are typically limited to abstract mathematical approaches, unlike many other biochemistry topics which are more grounded in molecular behaviour. Students do not have resources available to correlate the information taught with appropriate mental models of molecular interactions which underlie all aspects of enzyme kinetics, resulting in poorer student interest, conceptual understanding, and knowledge retention - as reflected by their learning outcomes and feedback.

A number of supplemental learning resources for enzyme kinetics exist, but are there is potential to further advance aspects such as integration of visual and abstract knowledge, inquiry-driven design, and pacing / variable control. Taking into account the wealth of pedagogic research, this design document outlines a rubric of pedagogic design principles, based on which an new enzyme kinetics learning tool - BIOMINT (Biomolecular Interactive Tutorials) Enzyme Kinetics - will be designed and produced.

Through the anticipated access and usage of this tool, students may be able to bridge the mathematical and molecular understanding of enzyme kinetics, and better understand, retain, and apply these threshold concepts for their future scientific endeavours.

1.2. Audience

The primary audience of the deliverable from this project will be undergraduate students enrolled in introductory biochemistry. Secondarily, this project will be an additional design reference for the biomedical communication community involved in pedagogy.

1.3. Format

This project will be delivered as an interactive web-based tutorial module. This tutorial will be a multimedia linear experience, and learning content will be implemented with considerations for knowledge integration and scaffolded interactivity.

The tutorial design will be tailored to usage through desktop / laptop computers. Users will be free to access the tutorial from most modern web browsers.

1.4. Objectives

The goal of this project is to help undergraduate Biochemistry students bridge the gap between established visual mental models of molecular concepts to the factors and variables surrounding enzyme kinetics. To fulfill this goal, the objectives are as follows:

- to establish a learning path and contents based on curriculum needs and deficiencies in student understanding;

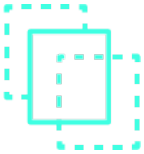
- to design and create discrete visual solutions tailored to each concept introduced, and consolidate them with calculational and plotted models of said concepts;

- to design and create a robust digital platform to house this learning tool, with the aim of intuitive UI and seamless navigational UX; and

- to implement an iterative design process involving ongoing formative assessments.

2. Conceptual Design

2.1. Design Principles



Knowledge Integration

Content design to facilitate user bridging between different conceptual layers, achieved through creation and integration of content across various knowledge modalities: 2D visualizations, 3D animations, graph plots, arithmetics, and text.

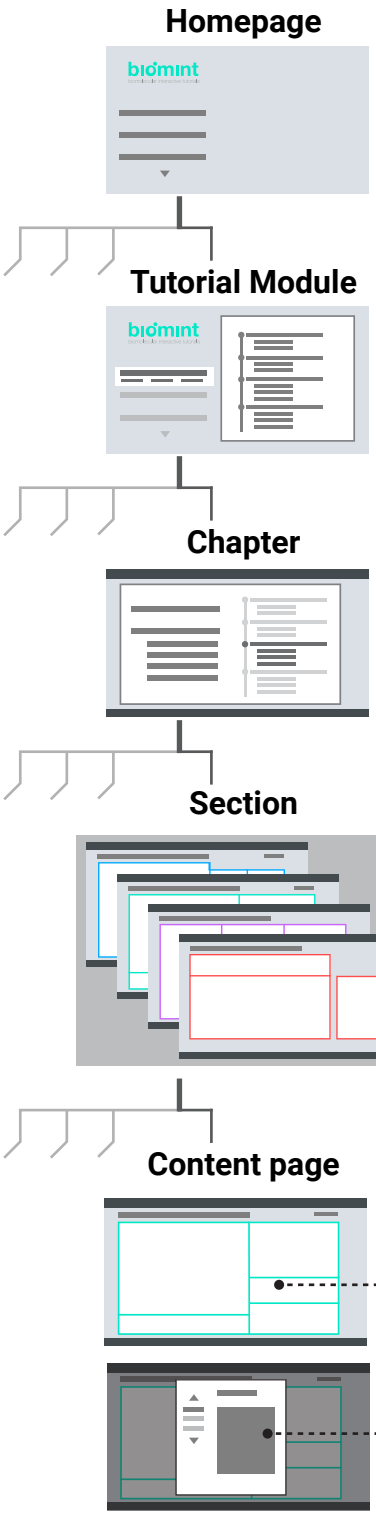
Scaffolded Interactivity

Intentionally constrained UI / UX design to minimize interactive ambiguity and distraction, achieved through clear, state-based primary interactions, nesting toggle-based secondary interactions.

Modularity

Modular approach across processes: in design, programming and asset production, to enhance project development pacing and content consistency.

2.2. Information Architecture



The BIOMINT **Homepage** acts as global navigation across topics in Biochemistry and biomolecular sciences.

- Has no login requirement; progression saved through user's local cache

Tutorial modules (e.g. "Enzyme Kinetics tutorial") are linear experiences each cover a single topic.

- Different Tutorial modules are accessible on Homepage
- Made up of multiple Chapters

Chapters (e.g. "Enzymatic Inhibition") explore main themes in a given topic.

- Represent subsections within a linear Tutorial module
- Made up of 2 or more Sections and a Self-assessment

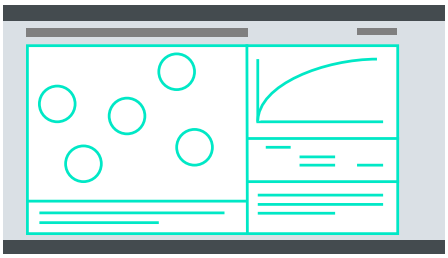
Sections (e.g. "Noncompetitive Inhibition") explore individual concepts or concept clusters.

- Represent subsections within a Chapter
- Made up of 1 or more Content pages

Content pages (e.g. "Noncompetitive Inhibition - Interactive Simulation") contain various types of learnable content directly related to the Section.

- Represent components of a Section
- Categorized into one of several page types (see Page Types section of this design document)
- Made up of **Core content**, as well as **Related Concepts**

2.3. Page Types



Interactive Simulations

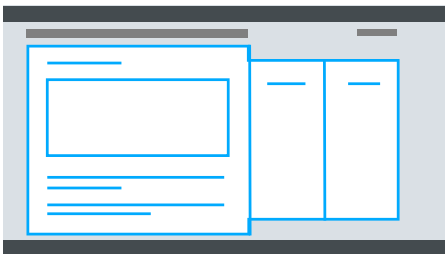
Content page type focusing on multiple modes of representation for a single key concept, for the user to learn through interaction and knowledge association.

- User-controlled molecular states and associated conceptual content
- Multiple modes of representation: Molecular visualizations, Graphical plots, Mathematical equations, Textual descriptions.

Leaflets

Content page type containing definitions, explanations and diagrams on 2~3 sets of related concepts; condensed into easy-to-read leaflets.

- Collapsable leaflets to facilitate concept grouping during learning
- Combination of simple diagramatic visualizations, definitions and bullet-point explanations to raise interest and minimize unnecessary memorization



Comparative Summaries

Content page type containing an abbreviated, side-by-side summary for a single key concept across a range of conditions, for the user to refresh and consolidate their conceptual understanding.

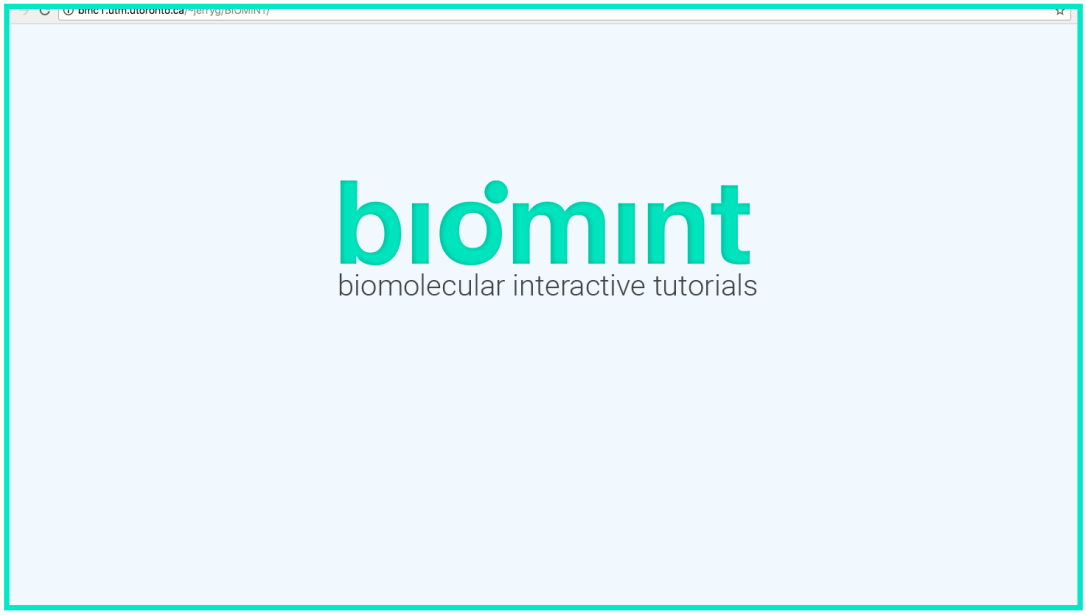
- Tightly coupled content summaries of preceding Interactive Simulations or Leaflets

Knowledge Checks / Self-Assessments

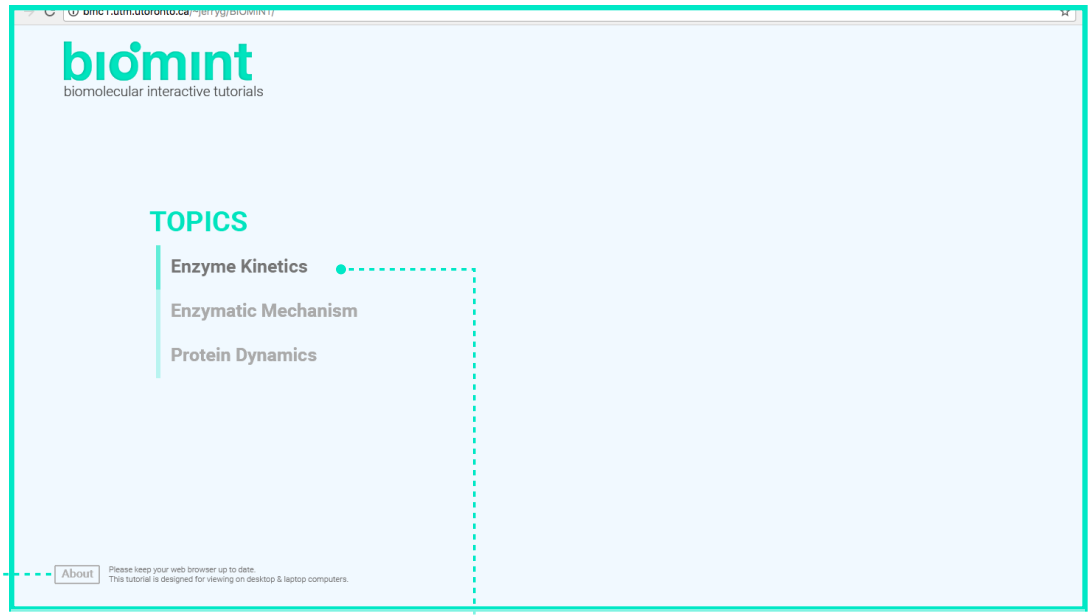
Content page types containing a short series of multiple-choice questions and answer explanations, for the user to apply and integrate their conceptual understanding.

- Explanations are provided for all choices after user submission of their answer, to improve user understanding of the tested concept
- Knowledge Check questions are simpler questions tightly coupled to preceding content pages, while Self Assessment questions are more applied, and test knowledge integration and problemsolving.

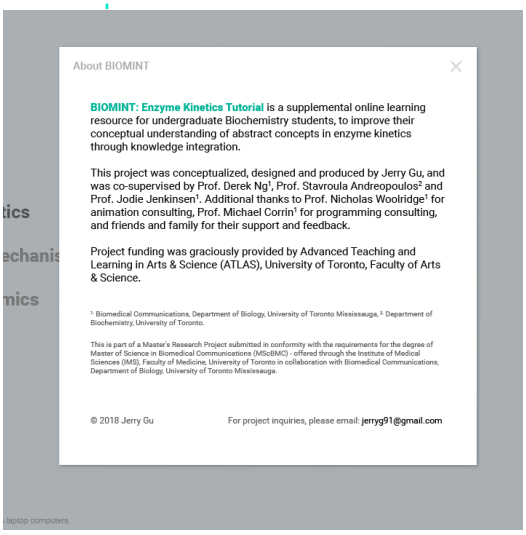
3. Wireframe



A brief animated **splash screen** is shown when users first open BIOMINT, either from a URL, or through a link provided by the course coordinator in the University of Toronto Canvas system.

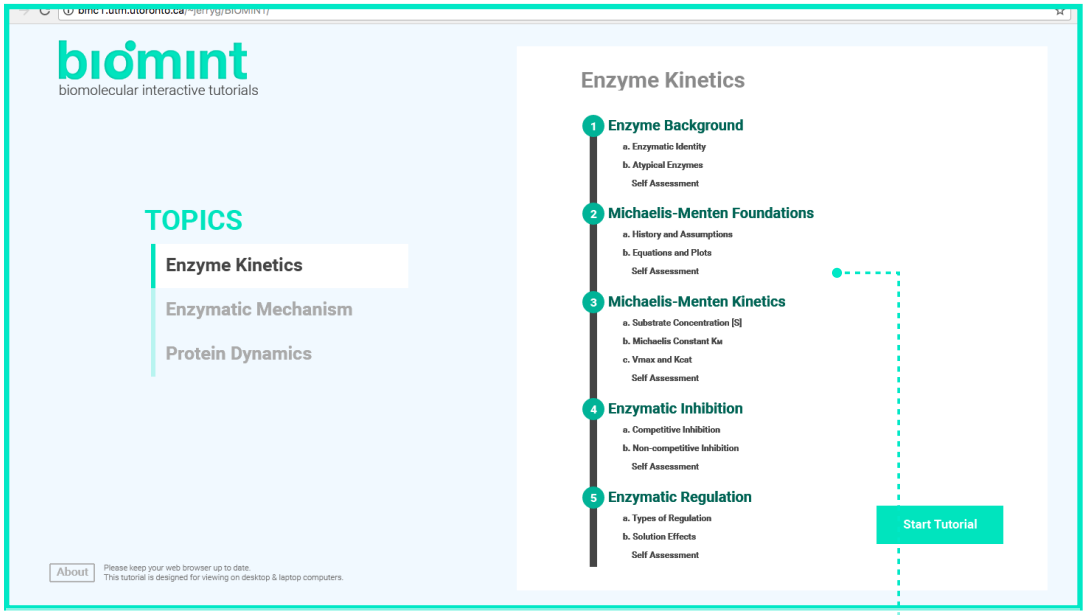


The user arrives at the BIOMINT Homepage. Here they are able to access global navigation across a variety of biomolecular topics. Each topic will contain its own tutorial.



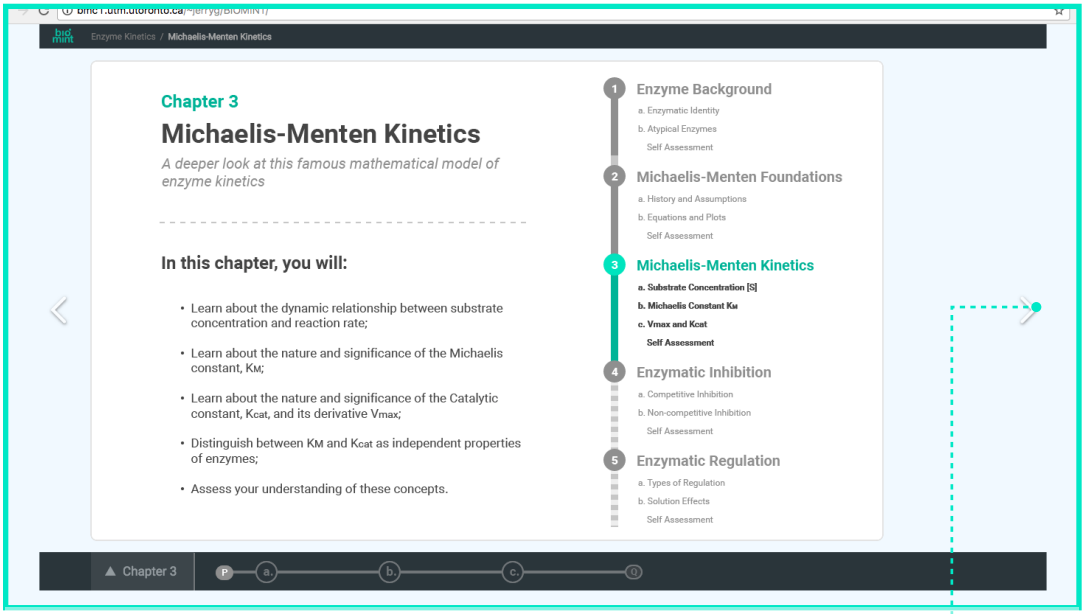
The user can learn about the project rationale, funding and credits by clicking the **About** button.

The user can click a **Topic banner** to access its navigational controls.



With the Table of Contents for “Enzyme Kinetics” tutorial open, the user can view the topic scope covered by this tutorial. They can navigate to any chapter or section within this tutorial tree, or start the tutorial from the beginning.

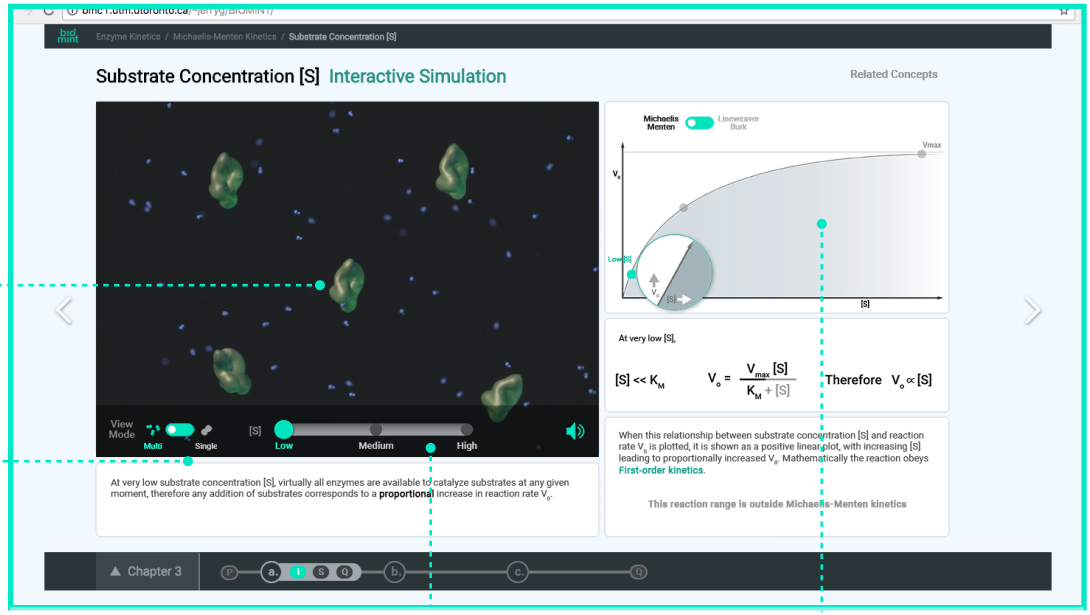
The user clicks “**3. Michaelis-Menten Kinetics**” Chapter link in the Table of Contents.



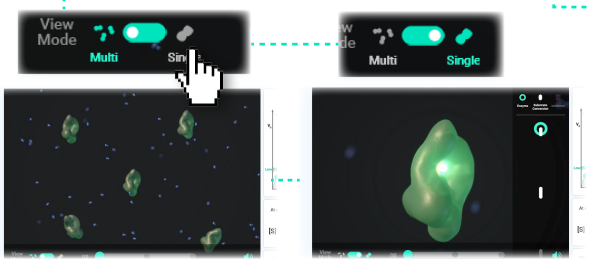
Upon clicking the “3. Michaelis-Menten Kinetics” chapter link in the Homepage Table of Contents, the tutorial skips to the **Chapter Preface** slide. Here the user is given an overview of learning objectives and tutorial progression, before proceeding.

The user also has the option to jump to a section of their choice in this chapter, via the highlighted table of contents.

The user clicks the **Next Page** button to proceed into the chapter content.

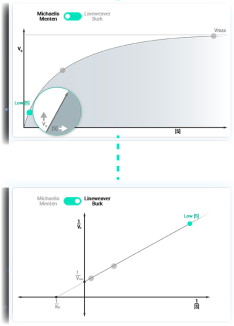


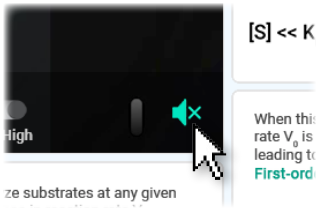
The user arrives at the **Interactive Simulation** page of the “Substrate Concentration [S]” section (see Page Types to learn more).



Molecular Visualization view mode can be toggled between Overview and Closeup.

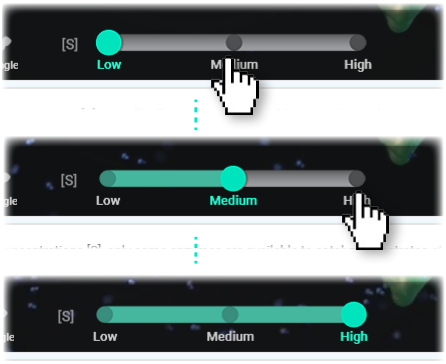
Graphical Plot representation can be toggled between different plot types.

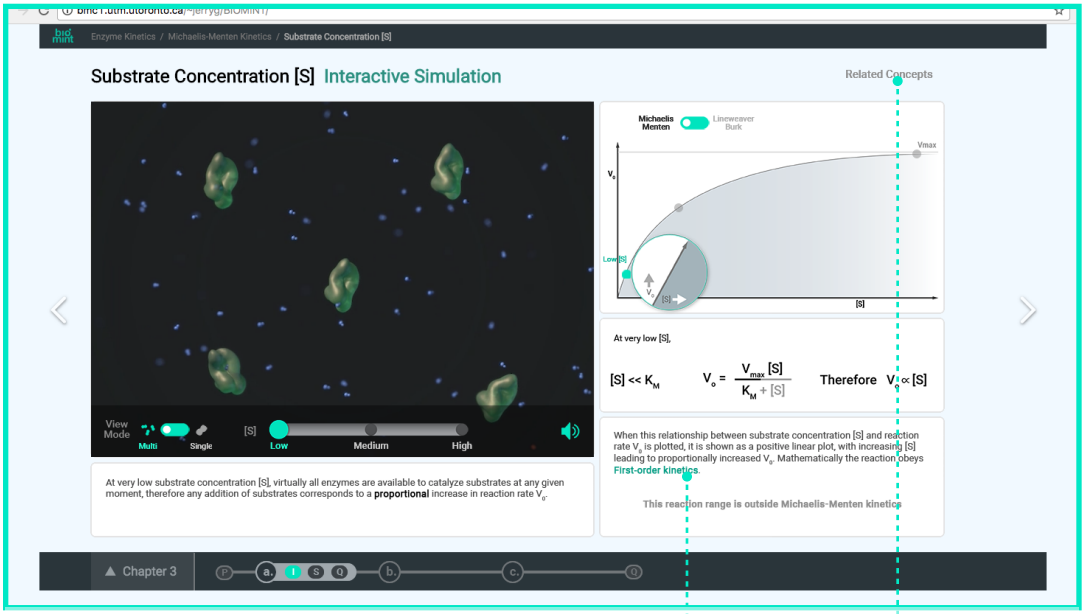




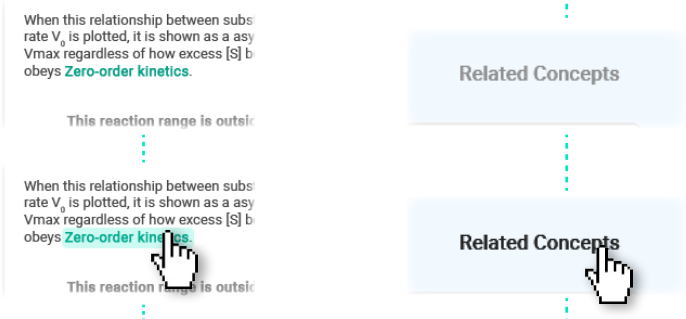
Molecular Visualization animation can be **muted / unmuted** with a mouse click; this setting persists for the entire session.

All content on this pagetype are reactive to the user-controlled reaction state, using the Variable Slider Control.

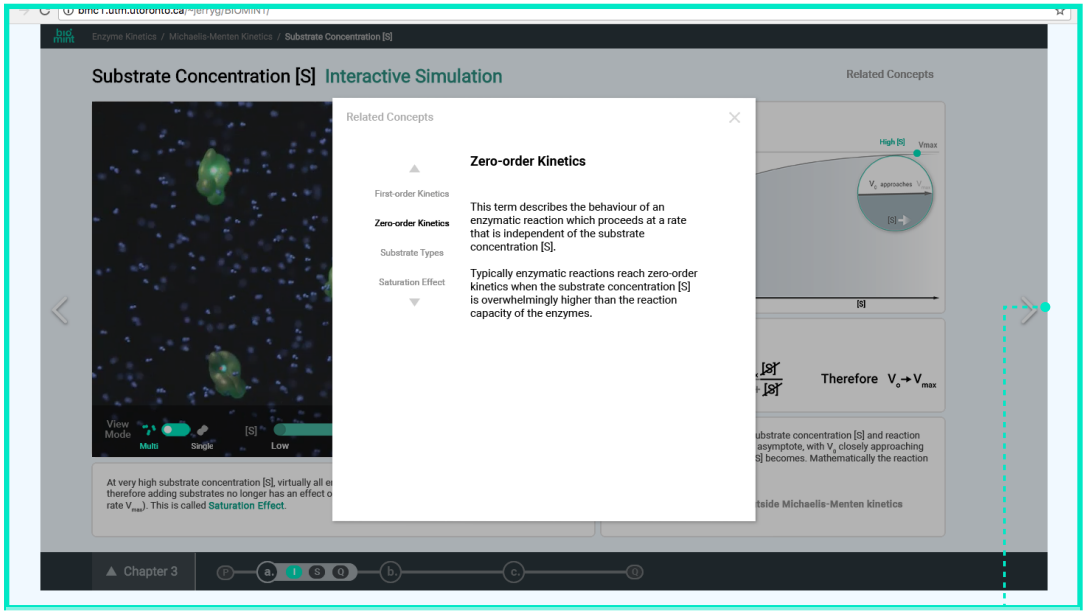




The user is able to access **Related Concepts** in pagetypes such as this, to learn more about key terms, or read about miscellaneous information related to the core concept.



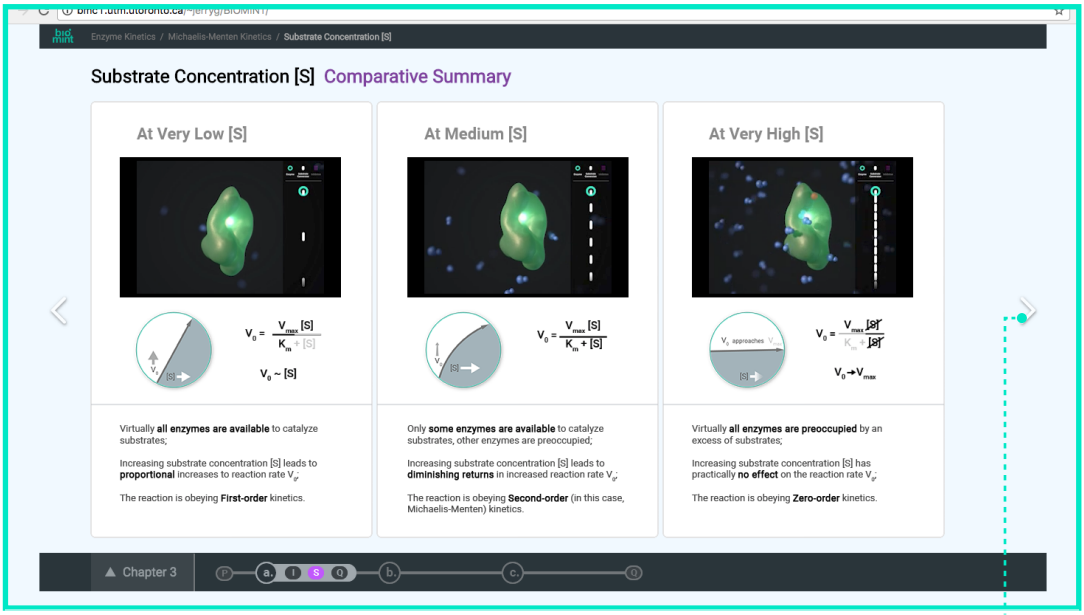
Related Concepts can be accessed through clicking key terms in the page content (highlighted in Mint Teal), or through the Related Concepts button to the top-right of the page.



Upon accessing the Related Concepts, the information is shown through a pop-up lightbox. Multiple Related Concepts are typically accessible, and can be scrolled through by up/down arrows.

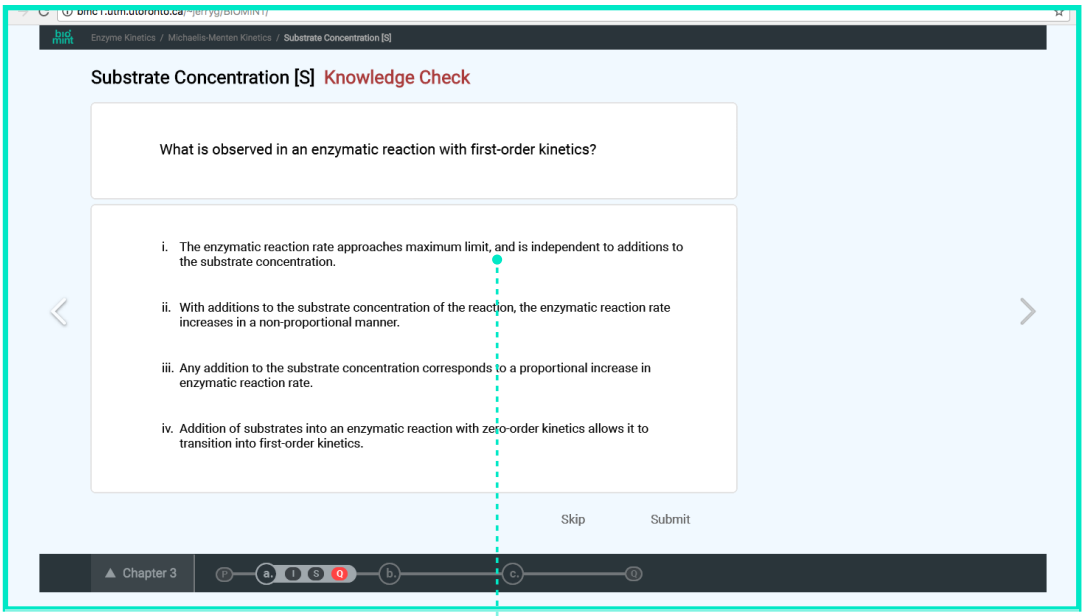
The user closes the Related Concepts window (by clicking the “X” or clicking the dimmed region).

The user then clicks the Next Page button to continue in the tutorial.

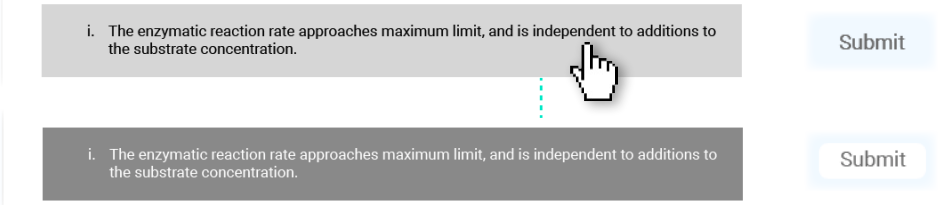


The user arrives at the **Comparative Summary** page of the “Substrate Concentration [S]” section (see Page Types to learn more). It is a static summary of the learning content shown in the previous page(s).

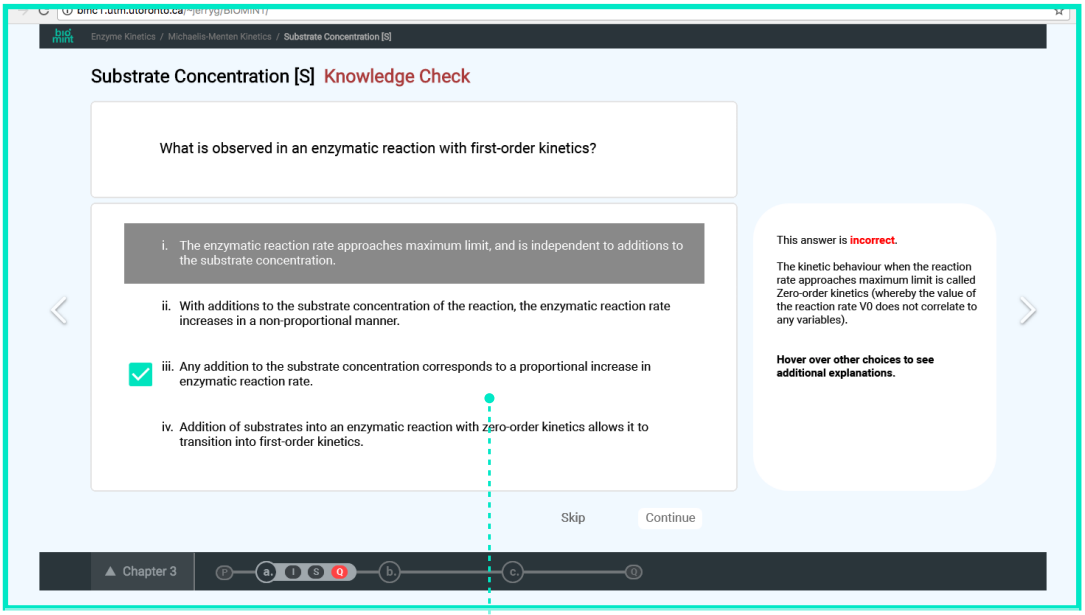
The user then clicks the Next Page button to continue in the tutorial.



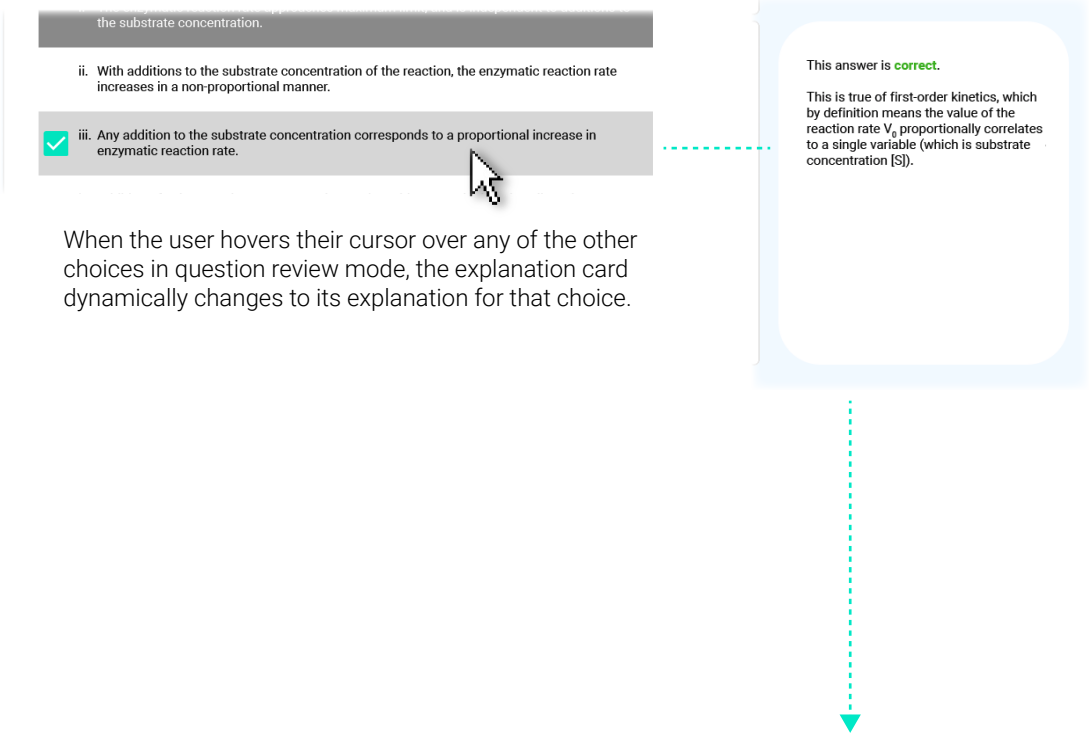
The user arrives at the **Knowledge Check** page of the "Substrate Concentration [S]" section (see Page Types to learn more).



The "**Submit**" button is grayed and disabled on entering the page. When the user makes a selection from the question choices by clicking the choice, the "Submit" button is highlighted and enabled.



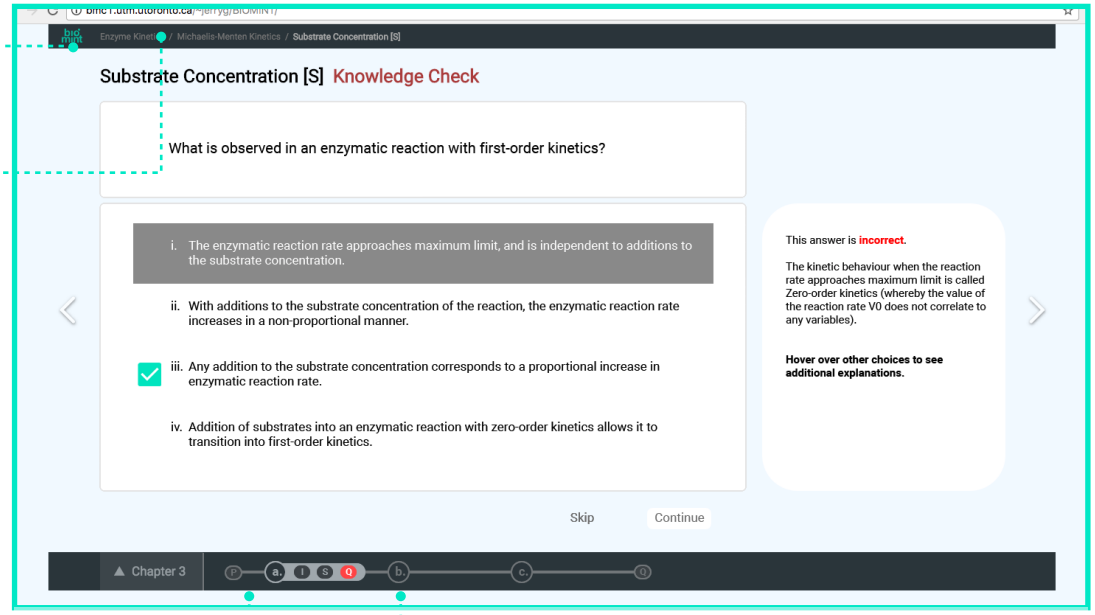
Upon submitting a chosen answer, the user enters question review and is shown if they answered correctly. A new card appears with an explanation about their answer. They are prompted to hover over all the choices to see explanations for them as well.



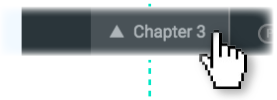
When the user hovers their cursor over any of the other choices in question review mode, the explanation card dynamically changes to its explanation for that choice.

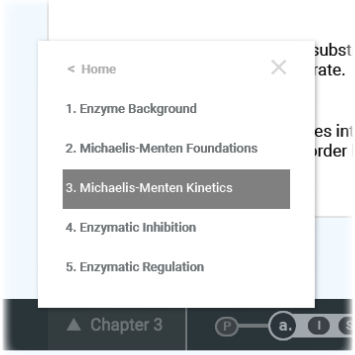
Back to Homepage button

Navigational breadcrumbs

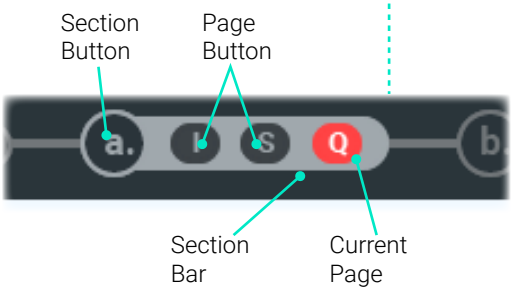


The user would like to navigate to “Atypical Enzymes” section in another chapter, and explores the navigation UI in the bottom portion of the BIOMINT viewport.



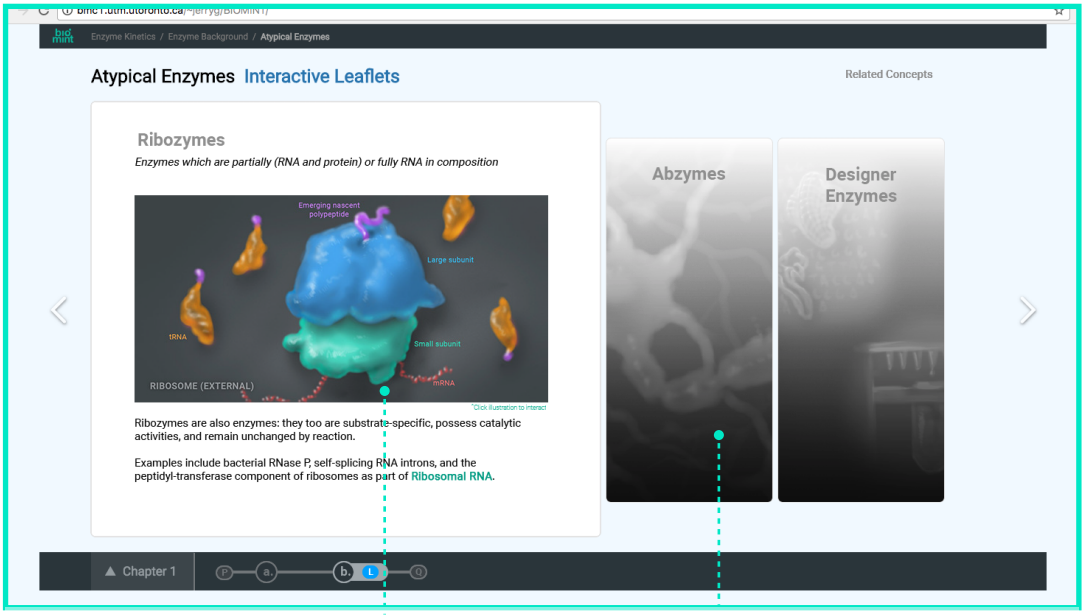


The user can quickly navigate between Chapters in the tutorial by clicking the Chapter link to the bottom left of the page to open the **Chapter List** pop-up window.

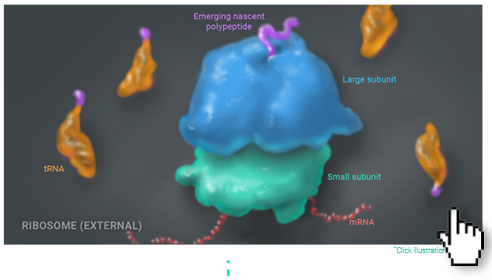


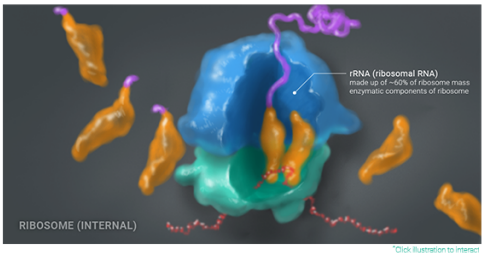
The **Chapter Progression Bar** to the bottom-centre of the page dynamically changes based on the Chapter the user is in. Using this bar, the user can quickly navigate between Sections, and between pages within Sections.

The user navigates to “Atypical Enzymes” section in “Enzyme Background” chapter.



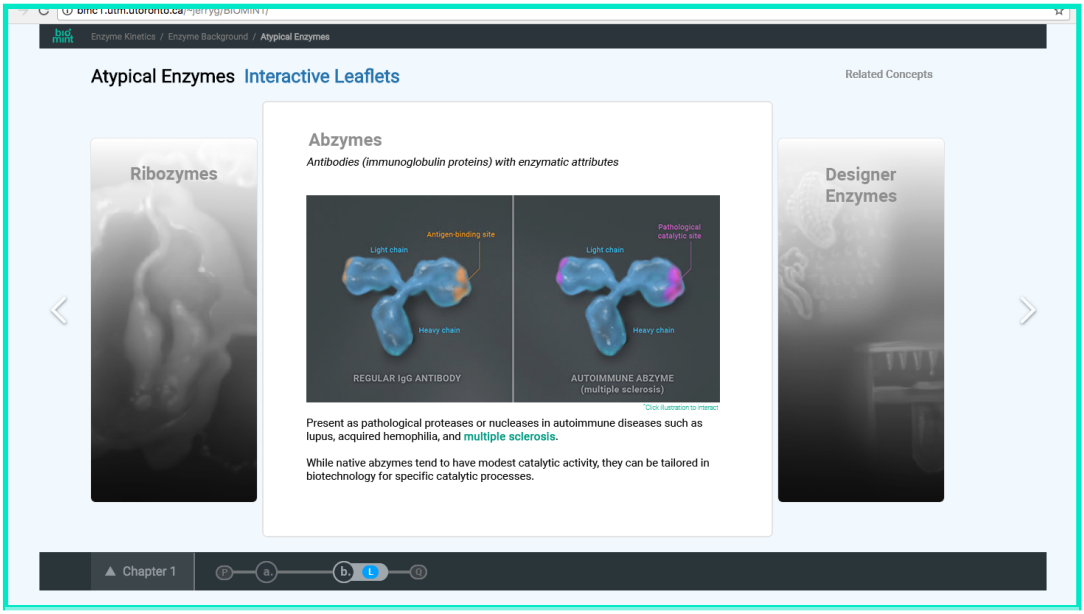
The user arrives at the **Leaflet** page of the “Atypical Enzymes” section (see Page Types to learn more).





Leaflet figures are designed to embed two layers of visual information. The user can interact with the leaflet figures by toggling them.

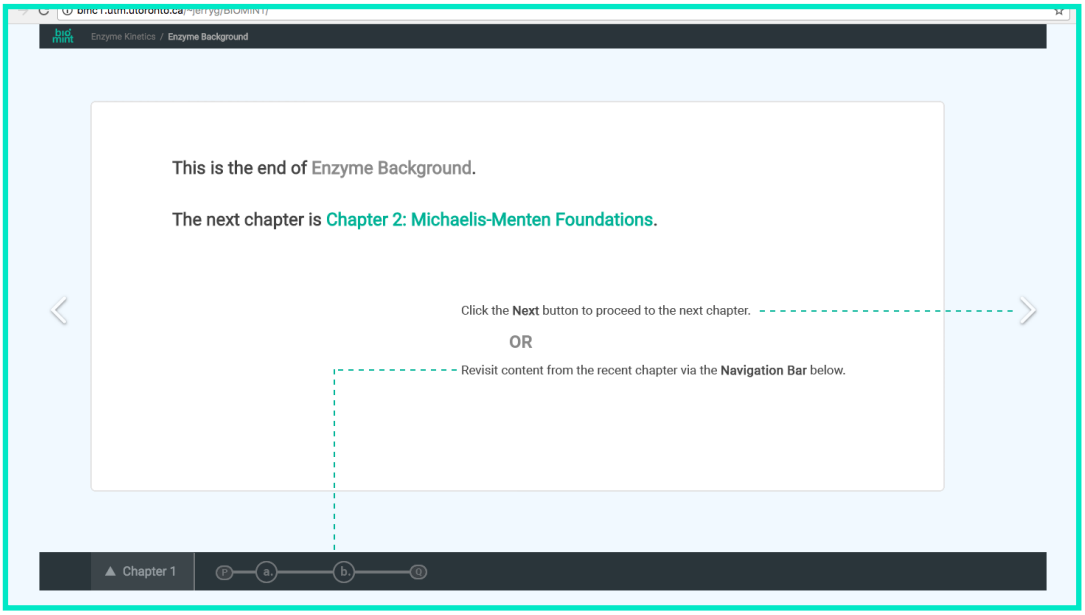
The user can switch to a different leaflet on the page, by clicking a closed leaflet cover.



Upon opening another leaflet, the first leaflet automatically closes.

Users can also access Related Concepts in leaflet pages.

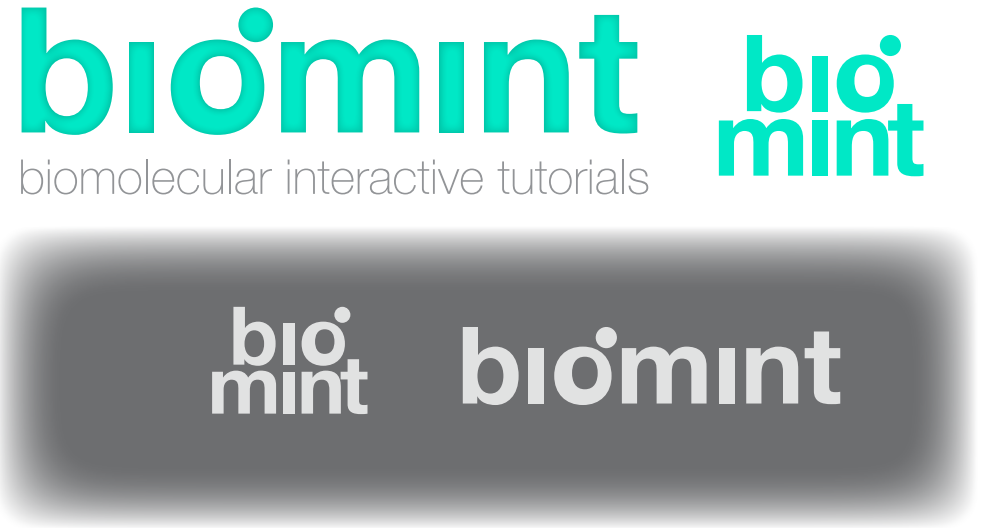
The user continues through this chapter.



The user reaches the end of a chapter; here they are prompted to either revisit content in the chapter, or continue into the next.

4. Style Guide

4.1. Brand & Logo



The brand name is **BIOMINT**, an acronym for “Biomolecular Interactive Tutorials”. The logo takes on a warm vibrant teal as its accent colour, as a nod to the abbreviated brand name. The very same teal accent is also used throughout the tutorial content to highlight interactivity, key terms, and visualization focus.

The minimalistic iconography of the BIOMINT logo focuses on its letter "O", which hints toward interaction between two molecules - perhaps between a substrate to its target enzyme. In the animated logo, the dot above the “O” appears with a delay.

Alternatively, the BIOMINT logo comes as squared (two lines, collapsed) and value-inverted variants, where applicable.

4.2. Colour Palette

User Interface

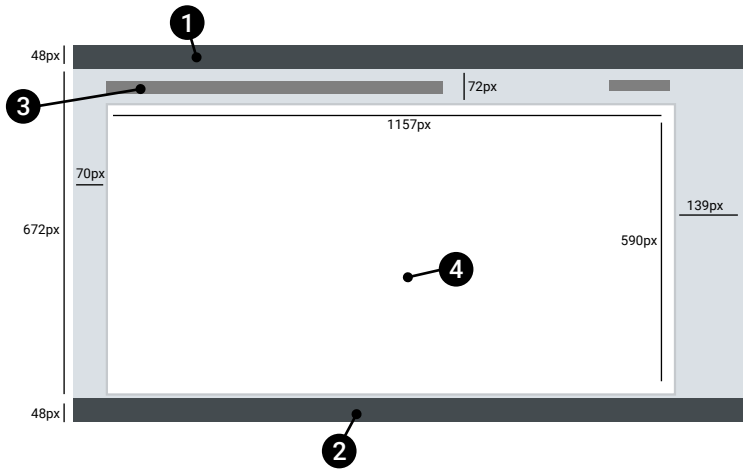
00E8C6 00A58D	Accent
BFBFBF 7F7F7F	Deselected Element
444B4F	Header / Footer
DAE0E5	Backdrop
FFFFFF	Card

Page Themes

72BCB1 00E8C6	Interactive Simulation
6CABD7 00AAFE	Leaflet
B18DC2 C963FC	Summary
DA8A8A FF4D4D	Knowledge Check
CCA57A FF9F17	Self-Assessment

4.3. Layout

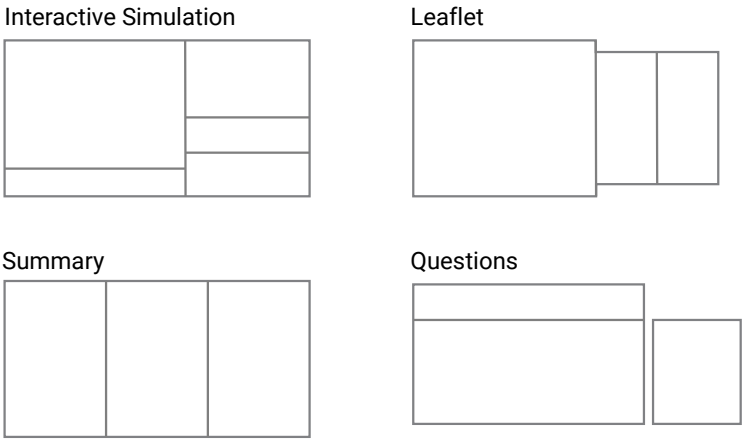
The BIOMINT Enzyme Kinetics module is designed to be viewed in web browsers at modern desktop or laptop screen resolutions. The viewport is fixed at 1366 px by 768 px (w / h) in dimensions.



Page template

1. Header bar
2. Footer bar
3. Page subheadings
4. Content region

Tutorial content is populated on top of Card elements. Each card is a rounded rectangle with 6 px corners and 1 px border (border colour Hex: E7E7E7). Gutter width between any adjacent cards is 7 px. Each pagetype uses its own Card arrangement within the confines of the content region.



4.4. Typography

Topic Heading
(Roboto, reg, 17pt)

Chapter Heading
(Roboto, reg, 17pt)

Page Heading
(Roboto, reg, 25pt)

Subheading
(Roboto, reg, 24pt)

Body Text (Roboto, reg, 13pt)

Labels (Roboto, reg, 12pt)

Questions (Roboto, reg, 20pt)

Choices (Roboto, reg, 17pt)

Explanations (Roboto, reg, 15pt)

4.5. Interactable Elements

Action	Type	States
Previous / Next Page	Button	
Go to Homepage	Button	
Molecular View Mode	Toggle	
Previous / Next Term	Button	
Molecular State	Slider	
Graph Type	Button	
Submit Answer	Button	
Close Lightbox	Button