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INTRODUCTION

Mapping Biology Knowledge addresses two key topics in the context of biology, meaningful learning and the role of knowledge mapping in promoting meaningful learning. Chapter 1 provides an overview of several common strategies for spatial knowledge representation, Chapters 2–6 discuss some of the key considerations in learning for understanding, and Chapters 7–10 describe several metacognitive mapping tools and the research that informs their use.

Please note that the chapters are written in different voices and thus have different styles, tones and ways of referring to the authors, depending upon the particular authorship of each chapter. A brief description of the chapters is given below.

Road maps are regularly used by travelers on land, sailors use their charts when they go to sea, and scientists often rely on spatial knowledge maps when they practice science. Science maps range from the long-established periodic table (now available in many delightful and useful forms as internet hypertext documents) to biochemical pathways to the newer human genome maps. Likewise, semantic or word-based knowledge maps are often used by students, teachers and researchers as learning, teaching, knowledge navigation, and assessment tools. *Chapter 1, Introduction to Knowledge Mapping* by Fisher, provides an overview of word-based knowledge mapping including concept maps, cluster maps, webs, semantic networks, and conceptual graphs.

The domain of biology is vast, the depth of knowledge in many areas is awesome, and the knowledge structure of the field is both complex and irregular. In addition, biology knowledge is assimilated from many different sources, both formal and informal. For these and perhaps other reasons, knowledge mapping seems to be particularly useful for those interested in mastering biology. These issues are examined in *Chapter 2, The Nature of Biology Knowledge*, by Wandersee, Fisher and Moody. This chapter also considers the “two cultures” influencing biology education, scientists and science educators.

In many biology courses, students become so mired in detail that they fail to grasp the big picture. Overemphasis on detail accounts in part for the fact that relatively few Americans understand how trees “construct themselves from thin air” (Schnepps, 1997b), even though nearly all have studied photosynthesis at least once and often several times. Yet memorizing trivial detail is not a goal of science learning. A more useful approach is for the learner to construct a well-ordered overview of the big ideas and their interrelations, combined with skill in knowing how to find more information as needed. *Chapter 3, Knowing Biology* by Wandersee and Fisher, describes a little-known *system analysis* of biology as one example of a high-level

overview (Miller, 1978). It presents the human mind as an expectation-generator that will hold onto information it perceives valuable for anticipating future events and that will discard information it perceives as irrelevant. The “need to know” principle can be helpful in deciding the level of detail students must have in a given situation.

It is now well established that students’ minds are not blank slates and that students’ preconceptions or naive conceptions can present major impediments to learning. This is especially true in a field like biology where there is a lot of folk knowledge and personal experience. *Chapter 4, Student Misconceptions in Biology* by Fisher and Moody, reviews this widely researched phenomenon.

Meaning-making is achieved in part through mindful learning, the use of fluid and flexible thinking. *Chapter 5, Meaningful and Mindful Learning* by Fisher, reviews Langer’s (1989, 1997) seven myths of education, including ideas such as overdrilling (rote learning) and “work now, play later.” This chapter prompts teachers to examine their commitment to “coverage” of “facts” at the cost of meaning-making and development of thinking skills.

Most of our thoughts lie below the surface of conscious awareness, just as most of an iceberg is submerged beneath the sea. And just as only the tips of icebergs are visible to us, so only the tips of our thoughts are available to conscious knowing. And to carry the analogy one step further, just as an iceberg sunk the unsinkable *Titanic*, so subconscious thoughts can sink or at least subvert a lesson. This is the topic of *Chapter 6, Language, Analogy, and Biology* by Wandersee. This chapter concludes the examination of meaning-making, looking at how biology jargon and analogies can help or hinder understanding.

Metacognitive tools serve as support systems for the mind, creating an arena in which we can make our knowledge explicit, reflect on its organization, and polish its edges. These tools are also useful for building and assessing students’ content and cognitive skills. Concept circle diagrams are metacognitive tools that can help students build their skills in categorizing, which is essential to constructing knowledge hierarchies and to learning complex information. This topic is presented in *Chapter 7, Using Concept Circle Diagramming as a Knowledge Mapping Tool* by Wandersee.

If you want to see where you have been and where you are going, get a map. This advice is as basic for students learning science as it is for travelers on the road. *Chapter 8, Using Concept Mapping as a Knowledge Mapping Tool* by Wandersee, describes Novakian concept maps. The chapter is organized using Frequently Asked Questions (FAQs).

Ideally, just as we can look into a mirror to see our faces, so it would be nice to gaze into a clever machine to examine our minds. Unfortunately, this clever machine has yet to be developed. However, the SemNet® software provides a crude approximation, allowing us to see explicitly see how we and our students think about a given topic at a given point in time. *Chapter 9, SemNet® Semantic Networking* by Fisher, provides an overview of the SemNet® tool in the classroom.

Textbooks are integral components in biology teaching and learning. Mapping tools can be used by readers to increase their access to the content of a text and by writers and other interested people to analyze the structure of a text. *Chapter 10, The*

Paradox of the Textbook by Moody, provides a historical overview of biology texts and illustrates one approach to analyzing the importance of a topic, in this case evolution, in texts over time.



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