Complexity. A guided tour, by Mitchell, M.; Oxford University Press, New York, 2009,
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Melanie Mitchell's expanded version of her invited Ulam Memorial Lectures, "The Past and Future of the Sciences of Complexity," successfully meets the ambitiously stated goal of introducing "nonspecialists to the vast territory of complexity" (p. xii)[1]. Mitchell adopted the role of tour guide in an attempt to introduce new readers to some of the core historical and current sites of interest and samples of the biographical and cultural history of the sciences of complexity. For the traveller who is already somewhat familiar with the landscape, there are few new insights to be gleaned. These are contained mostly in the second half of the book as open questions and ideas that require further development. However, the book does present opportunities for these travellers to revisit and renew old acquaintances in a refreshing manner. The tour is divided into five excursions (sections) covering the breadth of the terrain across its 19 chapters. That being said, this is a tour and not a field expedition into the territory. Readers looking for details or depth on the most recent advances are advised to look elsewhere. Her extensive and up-to-date bibliography (up to 2007) is perhaps a good starting point.

Part 1, *Background and History* (Chapters 1 to 7), and Part 2, *Life and Evolution in Computers* (Chapters 8 and 9), are the first stops on the tour. They constitute one of the most succinct, accessible, and reader-friendly introductions to a wide range of foundational concepts, controversies, and researchers across a variety of complex (adaptive) systems drawn from physics, biology, and computer science. These include chaotic dynamics; linear and non-linear models; the logistic equation; period-doubling; Feigenbaum's constant; information theory; the theory of computation; quantum uncertainty; Gödel's theorem; Turing machines; the second law of thermodynamics; evolution, heredity, and the modern synthesis; the mechanics of molecular genetics; competing measures of complexity (complexity as size, entropy, algorithmic information content, logical depth, thermodynamic depth, statistical, fractal dimension, and degree of hierarchy); von Neumann's self-reproducing automaton; artificial life; and genetic algorithms. Mitchell set up the necessary knowledge nuclei, laying out essential conceptual hubs with which the remainder of the book connects, in a breezy 142 pages. These sections are pedagogically satisfying, introducing, exemplifying, and elaborating necessary concepts like *fractal dimension* and *fitness functions* only at the points where they become necessary to the unfolding narrative and utilizing only sufficient mathematics—and if necessary, equations—to illuminate the content. This will appeal to the many non-technical to whom the book is primarily pitched. She deferred deeper mathematical explanations to the endnotes.

Whereas Part 2 develops important ideas relating to modelling life and evolutionary processes in silico, Part 3, *Computation writ Large* (Chapters 10 to 14) moves to examine the extent to which nature computes. With the same effectiveness and economy as the two first Parts, Mitchell presented a concise and potent introduction to cellular automata and the work of Stephen Wolfram which opens the door to a discussion of computation/information processing in the immune system, ant colonies, cellular metabolism, and unresolved questions around what constitutes consciousness and how meaning might be made in living and artificial intelligence systems through analogy and conceptual slippage. The final chapter in this section is devoted to providing important caveats and clarifications of the purposes and limitations of idea models in the complexity sciences using research on The Prisoner's Dilemma and its extensions regarding the evolution of cooperative behaviour to exemplify.

The final major excursion, *Network Thinking* (Chapters 15 to 18), provides a foundation for novice readers on advances in Network Theory. Mitchell described the significance of Network Theory for the complexity sciences as providing "a novel language for expressing commonalities across complex systems in nature, thus allowing one area to influence other, disparate areas" (p. 252). Applications of concepts, such as small world networks, scale-free networks, power law distributions, preferential attachment, scaling, random Boolean networks, and resilience, are applied in discussing biological examples which include brain function, genetic regulation, metabolism, epidemiology, and ecological food webs. As in the previous section, Mitchell did not shy away from presenting important skeptical, alternative, or oppositional positions. This deliberate attention to the ongoing controversies is one of the features that make this text stand apart from others in this field. She portrayed the reality, undecidedness, and complexity of an as yet nascent field in which many terms, including complexity itself, are not well defined and where concepts are still contested and require further evidence. Additionally, she highlighted important open problems such as understanding the origins of power-law distributions across disciplines; determining how, why, and *if* evolution creates complexity; and hinted at the significant impact that future work in this area is likely to have across all knowledge domains and in social and political life. This is the section most likely to stimulate those new to the field and inspire renewed inquiry from those already working in it.

In bringing the tour to a close, Mitchell as a guide offered a timely historical warning for complexity scientists, which perhaps also applies to those of us who employ complexity in education, namely the overshadowing, fragmentation, and loss of enthusiasm for parental disciplines, such as cybernetics and general systems theory, which she suggested had more "extent than content … ranged over too disparate an array of subjects, and [whose] theoretical apparatus was too meager and cumbersome" (p. 297) to achieve their ends. She also identified what she believes is needed, "the right vocabulary to precisely describe what we're studying…that not only captures the conceptual building blocks of self-organization and emergence but can also describe how these come to encompass what we call *functionality*, *purpose*, *or meaning*" (p. 301, italics in original), a goal previously identified in relation to complexity in education by Davis (2004) and which perhaps the field needs to continue to address in a focused way.

There have been many excellent introductions to the various "sciences of complexity" (Johnson, 2001; Waldrop, 1992) written over the last quarter-century by pioneers in the field. Mitchell's adds another, though one that pays attention to some of the pedagogical and conceptual difficulties that have limited interested readers' understanding, especially in education, of the content, controversies, and significance of the complexity sciences—especially in their potential to radically alter the reductionist ethos in science, transform the disciplinary divides among academic disciplines, and change the way we think about social institutions and relationships, particularly those in school. The book will be of interest to students and instructors at the upper undergraduate and graduate levels across a wide range of disciplines including curriculum studies and teacher education. The freshness of the book's presentation of the core ideas of the main branches of the complexity sciences, its deliberate attempt to foreground the ongoing debates in the field, its reminders of the limitations of models, and its pointing out important future directions that the field might take is likely to render it an oft-recommended starting point and perhaps one of this generation's standard introductions to the exciting worlds of the sciences of complexity. It should be considered an important supplementary text to any of the current texts which attempt to marry complexity and education (e.g., Davis, Sumara, & Luce-Kapler, 2008; Doll, Fleener, Trueit, & St. Julien, 2005).

References

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Notes

[1] In responding to a request for a one-line definition of the term 'Complexity' I offer that it is the study of 'complex systems' which are ambiguously bounded, dynamically adaptive, nested, dispersed collectives involving (sufficiently) large numbers of agents whose variations (similarities/redundancies and differences that *might* matter), relations, and interactions within a given medium/environment give rise to ambiguously bounded yet perceptually/physically coherent phenomena whose relations and interactions with other dynamically adaptive, nested dispersed collectives of ambiguously bounded yet coherent phenomena give rise to yet other collectivities. Many of these systems exhibit emergent properties (i.e., properties that are perceptible and enacted at the level of the system as a whole which are not seen to belong to individual agents but which arise through the collective interactions of the agents). They are an example of what is called self-organization. Complex systems are living/learning systems in the sense that learning/living might be considered to be the facility of a system to adapt and respond to changes in a dynamic environment while maintaining its dynamic coherence in its environment.