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Book and Media Review

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Review of *Molecules: The Elements and the Architecture of Everything*

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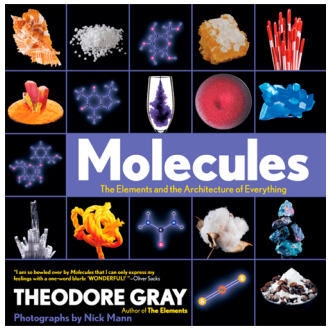
Molecules: The Elements and the Architecture of Everything; by Theodore Gray. Black Dog and Leventhal Publishers: New York, 2014. 240 pp. ISBN: 978-1579129712 (hardcover). $29.95.

Picking up where he left off with his books, *Mad Science*[1] and *The Elements*,[2] Theodore Gray continues with another lavishly illustrated book—*Molecules: The Elements and the Architecture of Everything*. Stressing that all matter is made up of the elements and more importantly, their compounds, Gray implicitly demonstrates that chemistry is the central science. Each page has descriptive text and all the illustrations are described with sidebars. The illustrations include diagrams—atomic and molecular—as well as photographs of compounds and commercial products or materials containing or composed of chemicals.



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Gray describes this book as more of an expanded chemistry set (which are surprisingly still available) than a textbook. He begins with a brief description of atoms and atomic theory and progresses to orbitals, atoms, atomic and wave theory, bonding, and then on to compounds. Ionic compounds are briefly described and the myriad compounds of carbon are introduced with molecular diagrams of the 50 compounds possible (not all known, of course) using only hydrogen and one through four carbon atoms. The "architectures" of atoms composing molecules are illustrated with line drawings and molecular models. A large number of known compounds contain just a few elements: carbon, hydrogen, oxygen, nitrogen, sulfur, sodium, potassium, and phosphorus.

Chapter 2 covers names, beginning with the alchemists and proceeding through common names and systematic names. The evolution of names and primary examples of them are illustrated with salts, acids, obscure names such as "spirit of wine", aldehydes, organic acids, and esters. Some of the commercial examples and their often-exotic containers are illustrated.

Chapter 3, "Dead or Alive" describes the historical debates on describing substances as organic or inorganic. The definition of "organic" has evolved over time from "compounds of life" to most compounds containing carbon and hydrogen (with some exceptions, of course). The layperson's terminology of "all organic, chemical free" is debunked as fallacious. Infamous commercial claims are illustrated (including "organic salt"). Gray posits that the origin of the chemical does not matter, it is still the same chemical. Oil and water, polar and nonpolar properties, and soaps are described in Chapter 4. Natural and artificial soaps and detergents are included and lavishly illustrated. Gray mentions the possible involvement of soaps in the precell origin of life. Oils, mineral and vegetable, are covered in Chapter 5, including cooking oils and fats and concluding with waxes.

Rocks and ores and their processing are covered in Chapter 6 with a detailed example of iron ore. Ropes and fibers, more mundane materials, are described in Chapter 7. Both natural (plant and mineral) and synthetic polymers are included.

A discussion of organic chemistry resumes in Chapters 8 and 9. The first, "Pain and Pleasure", covers analgesics, including aspirin, NSAIDs, acetaminophen, opiates, and gabapentin. A wide variety of sugars and nonsugar or artificial sweeteners are covered next. Particularly valuable are detailed descriptions of the various sugars and sugar alcohols including sources. Next come sugar mixtures, including starches and syrups, especially HFCS (high fructose corn syrup), which is actually quite similar to honey. This again raises the "natural" versus synthetic debate. For example, if erythritol is used as a filler for stevia, the commercial product Truvia cannot be labeled "natural" because erythritol is produced by fermentation of corn, which is considered a "process". A discussion of "super sweeteners", both natural and synthetic and always controversial, concludes the chapter.

Controversies surrounding artificial versus natural chemicals are covered in Chapter 10. The quote "molecules don't know where they come from" is exemplary. Comparative toxicities are also discussed, including the use of lead acetate in progressive hair dyes, especially for men, the potential toxicity of glycyrrhizin, a natural sweetener from licorice, and synthetic versus natural vanilla. Of course the latter is more flavorful owing to trace components other than vanillin and is, most interestingly, "radioactive" as it contains carbon-14. Gray points out that if lists of ingredients were required for "natural" foods as they are for processed foods, the labels would often be incredibly long (asparagus is used as an example). The "intent" of foods to be used as human foodstuffs, with the exception of mother's milk, is a nonissue. Fortified foods, including iodized salt and vitamin D in milk, are essential for proper nutrition. The chapter concludes with a discussion of vitamins.

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Controversies continue in Chapter 13, "I Hate That Molecule". Many chemicals are indeed toxic (but all chemicals have some degree of toxicity), but many on the "bad" lists are there more for political and misinformed reasons. Thimerosal, a mercury-containing antibacterial added as a preservative to vaccines, is used as a primary example. It was falsely blamed as a cause of childhood autism, leading to debates on the value of childhood vaccinations in general. The risks of being vaccinated are far less than not having vaccines. In addition, thimerosal is not used in single dose vaccines. The benefits of removal of lead from gasoline are described, as well as reduction in use of CFCs (chlorofluorocarbons). Of course, the debates and controversies of the anthropogenic production of carbon dioxide and its contribution to climate change continue to be waged. Aspects of the various fossil fuels are discussed. The sources and other uses of chemicals are illustrated by the spurious and unfounded claims of the danger in the use of a chemical—azodicarbonamide—also being used in the production of shoes as well as a bread dough enhancer (the blogger "Food Babe" versus Subway). The situation is similar for lye, a toxic and corrosive chemical used in the production of foodstuffs and soaps: the origin does not really matter. The chapter concludes with a discussion of the history of use and exposure to asbestos and the occurrence of spurious claims for exposure as opposed to the legitimate cases.

Chapters 11 and 12 cover the more esthetic aspects of chemicals, aroma and color. These aspects of chemistry have been a "hook" that has attracted many to the study of and career in chemistry (including this reviewer). They are also a source of avid interest to nonchemists. Many odorants are carboxylic esters and their natural occurrence as well use in perfumery are described. Pheromones, animal and insect attractants, as well as animal repellents are discussed (the use of game animal attractants is particularly humorous). Hazard-indicating gas odorants are described as well the variability of the odor of urine after eating asparagus and the literal "smell of money". The discussion of color begins with a brief introduction to the electromagnetic spectrum and progresses to dyes, both natural and synthetic. The color of foods and food colorings are covered next. Chapter 12 concludes with coverage of pigments for art and other painting. The final chapter, Chapter 14, "Machines of Life", gives a brief introduction to nucleotides, DNA, RNA, the genetic code, and protein coding.

Overall, this book is a wonderful rendition of descriptive chemistry, so often lacking in chemistry courses. Informed discussion of such topics as natural versus synthetic and of hazards are particularly valuable. This book is heartily recommended, at a remarkably low price, for beginning courses in chemistry, both high school and collegiate, especially nonmajor courses. I did find a couple of errors. Fructose is actually 1.7 times sweeter than sucrose, not glucose as stated. Coal is primarily carbon, not higher hydrocarbons (which are indeed present). However, these do not detract from the overall impact of this book.

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Notes

The authors declare no competing financial interest.

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