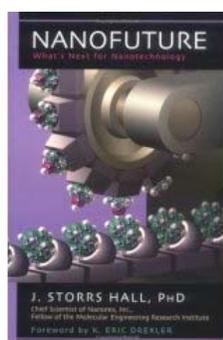


The Bright Nanofuture: A Review of *Nanofuture: What's Next for Nanotechnology*

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Nanofuture: What's Next for Nanotechnology

By J. Storrs Hall

Amherst, NY, Prometheus Books, 2005.

333 pages. \$29.00

I. INTRODUCTION

Predicting the future is a task that has no master, no real successful model, and a poor success record. As Dr. Hall mentions in the second chapter of his book, *Nanofuture*, “[e]very general futurist gets the future wrong to a significant extent.”¹ The problem, as Dr. Hall explains it, is not that the futurist *overpredicts* technological change. Instead, the futurist seems to suffer from the opposite trouble—*underpredicting* technological change.² This picture of futurism may seem odd when the turn of the millennium has basically failed to produce the commonplace space travel and household humanoid robots that were predicted in the middle of the last century. Instead, computing technology is used in a different way (much more similar to the ubiquitous use of computers imagined by Arthur C. Clarke in *2001: A Space Odyssey*) and relatively recently mankind has figured out how to create a humanoid robot that can walk up stairs very slowly.

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¹ J. STORRS HALL, *NANOFUTURE: WHAT'S NEXT FOR NANOTECHNOLOGY?* 28 (2005).

² The first section of chapter 2 in the book handles futurism in detail, and this description of the failures of futurists is based on the work of Gerard K. O'Neill, who “wrote a book of futurism. . . [in which] he reviewed a collection of futurist writings from the previous century and noted that they tended to overpredict political change, but underpredict technological change.” *Id.* at 28.

Another aspect of the future that trips up the predictions of futurists is the *use* of technology in the future. Quoting D.S.L. Cardwell, Dr. Hall reminds us that “[i]t is . . . a truly remarkable fact that on the very brink of an economic-technological revolution unparalleled in history no one foresaw the *universal* motor car and all that it was soon to imply.”³ The problem was not the idea of a motorized carriage, but how it would be used by the populace. Technological development occurs not simply because it *can*, but because there is a popular desire (or military need) to use it in a certain manner. Perhaps the fault of not understanding social change and use of technology lies with the scientists, who tend to write as if they know more about sociology and how it changes than they actually do; or, perhaps more social scientists need to write about the change that might occur in the future.⁴ With this in mind, it is important to look at Dr. Hall’s book with a certain amount of skepticism, especially at the details.

II. SUMMARY

In some ways, *Nanofuture* is a book about the future in the same sense that almost all books describing nanotechnology are about the future. The technology does not exist yet or, where it does exist, it has yet to serve a transformative role in everyday life. Each book about nanotechnology describes a unique vision of what nanotechnology is and will be. Therefore, it is always important to get a good idea of what form of nanotechnology the author is discussing.

So, *nanotechnology* really does have two different meanings. One is broad, stretched version, meaning any technology dealing with something less than 100 nanometers in size. The other is the original meaning: designing and building machines in which every atom and chemical bond is specified precisely.

Dr. Hall chooses the second definition. “When I use *nanotechnology* in this book, I mean the original, atomically precise, sense of the word.”⁵ Establishing his working definition of *nanotechnology*, Dr. Hall then proceeds to outline his view of the development of nanotechnology research from where it currently is to the molecular manufacturing stage. The current stage of research is what many materials researchers have been working on recently—the development of nanoscale materials such as nanoparticles, nanowires, and multitudes of other morphologies. These materials are created through a variety of processes that are being refined extensively, such as self-assembly and molecular beam epitaxy. The bulk of the volume, however, is taken up by Dr. Hall’s descriptive look into what change nanotechnology will give rise to in the future. Dr. Hall describes how nanotechnology will impact a number of everyday activities. In turn, Dr. Hall considers nanotechnology’s impact on the basics of life (food, clothing, and shelter), economics, transportation, space, robotics/AI/swarms of nanoscale robots, international affairs, medicine, and finally our very human nature. Nanotechnology’s revolution, even more so than the industrial revolution, will change everything about everything, at least in Dr. Hall’s vision of it.

The breadth of Dr. Hall’s vision of nanotechnology is staggering. To be sure, this vision is grand and extensive. It includes nanotechnology’s bringing a wide array of developments such as a thin suit that would act as a second skin and cool and heat with very little weight. Further, nanotechnological innovations include a kitchen-top manufacturer that, given the right recipe (software) and ingredients (material) could make very complex devices and objects at an extremely cheap rate (upturning the

³ *Id.* at 28.

⁴ *See, e.g.*, JANE JACOBS, *THE DEATH AND LIFE OF GREAT AMERICAN CITIES* (1961) (providing an especially good example of this).

⁵ HALL, *supra* note 1, at 21.

economic system along the way), commonplace air cars, and self-replicating machines (though, according to Dr. Hall, they aren't as frightening as you might imagine).

Dr. Hall ends his book with a look to the future, comparing the threshold of nanotechnology with that threshold upon which our ancestors stood when they first began forming tools by chipping stones.

It's all a matter of perspective. Either we have overrun our natural niche, jammed the globe, and have nothing left to hope for but to fight over the dwindling resources. Or, we stand at the threshold of the universe, at the dawning of the age of true intelligence, and the human adventure is just beginning. The choice is yours.⁶

III. CRITIQUE

Dr. Hall's book is not really a pop-culture science book, even though it is aimed at a general audience. Instead, it seems intended to force the reader to think about technology in an entirely different manner than is commonly done. In the bright, new, nanotechnology-enabled future, technology is all the things that it could be—convivial, intuitive, capable of solving problems with ease, pervasive, and inexpensive. For someone unfamiliar with the concept of nanotechnology and the ideas that drive it, *Nanofuture* is an excellent start. It provides a very broad outlook at what nanoscale technology might be able to do and forces the reader to think about some basic issues that occur when working with materials on an atomic scale. It is often so very difficult to grasp the minute size that is being dealt with by researchers in nanotechnology. Dr. Hall does an excellent job of forcing this understanding through to even the most lay of readers.

However, for someone familiar with nanotechnology, the ideas behind its development, and the scientific debate surrounding it, Dr. Hall's analysis can be frustrating; and his technological concepts, far from being new, seem ordinary and in line with the usual predictions of molecular manufacturing. Probably due to the sheer breadth of the issues covered, no single issue is given the kind of deep consideration for which the reader is yearning. The foreword of the book is written by K. Eric Drexler, author of *Engines of Creation*, and this seems fitting, yet also slightly frustrating. Much of Dr. Hall's book is spent rehashing the ideas in *Engines of Creation*, providing little to none of the critical eye at the work contained therein. Extremely little attention is paid to the arguments that discuss either the difficulties or the limitations that may be needed to achieve molecular manufacturing. Many readers will know of the most popular of these discussions—for example, the many discussions of molecular manufacturing by Nobel Laureate Richard Smalley and Dr. Drexler presented in the pages of *Chemical & Engineering News*.⁷ Dr. Hall may believe that Dr. Smalley was wrong in his assessment, but the words of a Nobel Laureate and pioneer of nanoscale research need to be considered for a complete analysis.

The book also suffers from some lack of seriousness when it comes to non-scientific topics. Dr. Hall's consideration of the economics and patents shows only a cursory knowledge of the subject.⁸ Also

⁶ *Id.* at 288.

⁷ See e.g., Rudy Baum, *Point-Counterpoint: Drexler and Smalley Make the Case for and against 'Molecular Assemblers'*, 81 CHEM. & ENG'G NEWS 37 (2003) (presenting open letters written by both Smalley and Drexler).

⁸ For example, at one point, Dr. Hall writes the following:

"A patent is simply and purely a grant of monopoly. Why would a supposedly enlightened government, which has laws against monopolies in other forms, grant them? The original idea was the opposite: you wanted the inventor to publish a description of the invention instead of keeping it secret. To induce him to, you offered, legally, some of the protection that he would have gotten by keeping the secret, enough to get a good head start on the competition."

HALL, *supra* note 1, at 146. Hall then continues as follows:

frustrating is Dr. Hall's consideration of the ethical dilemmas of what is generally referred to as post-humanism (that is, utilizing technology to alter human abilities). The general answer that Dr. Hall provides to the ethical questions concerning nanotechnology is that individuals change and humans have changed; therefore, it should be acceptable for future change to occur.⁹ These issues deserve a more serious consideration as we develop a technology that can precisely manipulate molecules and atoms and can design materials, items, and devices on the smallest possible scale.

IV. CONCLUSION

Nanofuture: What's Next for Nanotechnology will be of interest to those looking for an introduction to the concepts of nanotechnology and molecular manufacturing. It is comprehensive and broad in its consideration of nanotechnology's potential impact to society. Although it is not a book on nanotechnology related law, it has many descriptions and ideas that may be of interest to journal readers. However, as a discussion of nanotechnology and how it will impact society (what will be "next for nanotechnology"), it is best used as a jumping-off point rather than a comprehensive text on the subject.

"It's not a bad idea, if it were done right. But it isn't. Because the patent office makes money on each patent issued, it has an incentive to patent any silly thing. Suppose the invention is obvious enough that it's easier to reinvent it from scratch than to search the patent records, interpret, and adapt the record of the patented version. Then the economic effect of the monopoly grant is a pure, unalloyed loss to society. Even if it were relatively costly to reinvent the gadget or whatever, that cost would have to be balanced against the social cost of the monopoly rent of the patent."

⁹ The following passage is illustrative:

"Are you the same person you were ten, twenty, forty years ago? People grow and change. Literature in which the characters don't develop is considered flat and second rate. We are autogenous creatures, creating ourselves as we go along. Nanotechnology will give us the ability to improve ourselves, a noble pursuit, but one fraught with enigma and danger."

Id. at 287. He then continues,

"Living in a biological brain puts bounds on the variation we can achieve. In simple terms, we grow and learn, but we remain, willy-nilly, human. Even so, technologies that we adopt to extend our capabilities have changed us in ways we didn't anticipate. Simply compare the culture of today with that of a century ago. Our outlook is considerably more cosmopolitan, mostly due to transportation and communications. Our sexual mores have undergone a major transformation, due in some part to automobiles and contraceptives."