

Book Review, published in *Environmental Science & Policy*, vol. 42, 2014, pages 197-199.

This version: 20 August 2014

Review of: Philippe Grandjean. *Only One Chance: How Environmental Pollution Impairs Brain Development – and How to Protect the Brains of the Next Generation*. Oxford: Oxford University Press, 2013.

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Abstract

Humans have lived with chemical pollution for thousands of years, but the recent proliferation of industrial chemicals poses novel threats. In the new book *Only One Chance*, distinguished environmental health researcher Philippe Grandjean argues for special attention to developmental neurotoxicology, i.e. to the effects of chemical pollution on the developing human brain during pregnancy and in the first few years after birth. Grandjean provides an authoritative account of developmental neurotoxicology and its controversies, drawing on his own research and personal experience. The book is written in clear language accessible to wide audiences, an excellent introduction to an important topic.

Keywords: chemical pollution; industry; toxicology; public health; developmental neurotoxicology

Main Text

Humans have lived with chemical pollution for thousands of years, but the recent proliferation of industrial chemicals poses novel threats. Recent research has identified chemical pollution as a possible planetary boundary [1]. In *Only One Chance*, Philippe Grandjean argues for special attention to developmental neurotoxicology, i.e. to the effects of chemical pollution on the developing human brain during pregnancy and in the first few years after birth. A healthy brain is essential for a successful life. Exposure to neurotoxic chemicals, which Grandjean calls “brain drainers”, can disrupt brain development, with consequences persisting throughout the individual’s life. Thus there is “only one chance” to get brain development right for each new person.

Grandjean is a distinguished environmental health researcher and veteran to public debates about lead, mercury, arsenic, and other pollutants [2]. Grandjean received an MD from the University of Copenhagen in 1973 and has held faculty positions in Environmental Medicine and Environmental Health since 1982. Grandjean is also longtime coordinator of the Children’s Health and the Environment in the Faroes project, documenting the effects of exposure to mercury and other chemicals from marine sources. But while Grandjean is an environmental health specialist, the book is written in very clear, readable prose suitable for wide audiences, including interdisciplinary scholars, the educated general public, undergraduates, or even ambitious high school students. The book mixes review of fundamental science, stories about how the science was produced, stories about the many controversies the science raised, and Grandjean’s commentary and recommendations. It is part science, part intellectual history, and part polemic, reminiscent of Gustaf Speth’s *The Bridge at the End of the World* [3].

The core issue that the book takes on is a structural bias across society that results in a overly permissive industrial chemicals regime. Industry can mass produce new chemicals with at most minimal safety testing, creating widespread exposure to potential toxins. Chemicals are thus “presumed innocent until proven guilty”, in contrast with standard safety testing for e.g. new pharmaceuticals. Meanwhile the burden of proof is put on those who wish to demonstrate that the chemicals cause harm. Industry, regulators, and scientists all aspire for a high degree of scientific evidence (albeit for different reasons). Industry aggressively sows doubt, as has been documented for climate change and other issues [4]. The net result is that it can take decades to build enough of a case against chemicals to pull them off the market. Indeed, the vast majority of chemicals have never been vetted. Meanwhile, people around the world are exposed, with nontrivial effects, especially for developing brains.

The reason that the developing brain is so fragile is that brain cells must move considerable distances from where they are created to their final location in the brain. It’s a delicate procedure, and disrupting it causes cells to end up in the wrong place. Once the cells settle, the brain ends up permanently misshapen. No amount of medicine, education, or other care can make the brain normal (though all of these things can help). In the worst cases of chemical pollution, the infant dies. Survivors often have IQs several standard deviations below the mean and cannot support themselves. These cases involve people in chemical pollution hotspots, but some chemicals diffuse globally, and so everyone is at least somewhat exposed, even people in remote locations. Not all chemicals are neurotoxic, and not all can cause death or diffuse globally. But the book lists 213 industrial chemicals as brain drainers for either developing or adult brains, and emphasizes that many more industrial chemicals have not been adequately tested.

The book opens with an introduction outlining the importance of brain development and the threat from neurotoxic chemicals and the industries that profit from them. Chapters 1 and 2 present key physiology. Chapter 1 details the brain development process from conception through adulthood, emphasizing the fragile criticality of the early development stages. Chapter 2 discusses the placenta, which was once believed to offer the fetus an impenetrable shield; we now know this is false. The stage is thus set for chemicals to disrupt the young brain.

Chapters 3 through 7 discuss specific chemicals. There is a certain irony in the selection of chemicals covered. Grandjean laments that most chemicals are never studied, and calls for research focusing on those most poorly understood. But the chapters cover the most heavily studied chemicals: lead, mercury, arsenic, polychlorinated biphenyls, pesticides, and solvents. Grandjean acknowledges this irony, noting that he has been part of the problem, having himself published over 100 papers on mercury. In my view, some attempt to chart out the broader range of neurotoxic chemicals would have strengthened the book. This would help assess the total global risk from chemical pollution, as called for by the planetary boundaries research [1].

But the core themes of these chapters are why it takes so long to regulate the chemicals and how much harm is meanwhile caused. In this context it is appropriate to focus on the most prominent chemicals, because these are the ones with stories to tell. Grandjean shares his ample personal experience as a researcher who has been caught up in contentious policy debates. The excitement of discovery is given meaning by the human lives that will be improved. The grief from meeting debilitated victims becomes frustration and anger in the face of dishonorable if not outright dishonest industry practices. While on this emotional ride, we also learn ample toxicological science.

Chapter 8 covers the costs of neurotoxic chemicals. Grandjean laments the standard monetary cost measurements, as they inadequately capture the human suffering, but he

acknowledges that these measurements are politically useful, and do indicate major costs, on the order of \$2 trillion worldwide for lead alone, from lost income, medical expenses, and other losses. Here Grandjean appears outside his core expertise, and mainly reviews the existing literature by economists and others. But it is an insightful survey, touching on important topics like the relationship between IQ and GDP.

Chapter 9 pulls together Grandjean's critique of the social structures that conspire (intentionally and otherwise) to prevent industrial chemical regulation. Preventing regulation is a worthy investment for profitable industries. Industry profits are invested in rhetoric to sow doubt, sponsorship of friendly researchers and their conferences, and more. Grandjean was personally attacked in a \$25 million tuna industry ad campaign impugning Grandjean's mercury research. Grandjean notes that the \$25 million was more than he had received in mercury research grants throughout his whole career, indicating the heavily uneven playing field. But Grandjean also faults scientists for their cautious language that overstates remaining uncertainty, and for their failure to stand up for themselves and their work. The book represents Grandjean's effort to do more in this regard.

Chapter 10 concludes with Grandjean's recommendations. The main recommendation is rooted in the precautionary principle: placing the burden of proof on industry to demonstrate chemicals' safety and not approving chemicals until there is evidence of their safety. This proposal would undoubtedly face fierce industry resistance, though it is comparable to what the pharmaceutical industry already has. Grandjean does not go into details, but I believe some regulatory program along these lines can be justified in such terms as robust decision making [5] and the economics of catastrophe [6]. In robust decision making, policy decisions must be robust (must perform well) across a wide range of possible outcomes, including the possibility of a chemical being toxic. In the economics of catastrophe, policy decisions, evaluated in cost-benefit terms, are often dominated by the need to avoid even a small probability of a very large loss, such as widespread loss of human capability due to chemical pollution. The bottom line is that until we can rule out worst cases, we should be compelled to act.

This suggests the question: what are the worst case scenarios? At this time it is difficult to rule out the possibility of civilization-ending global catastrophe. Civilization needs intelligence to succeed; enough neurotoxics might be able to cause failure. And precedent may exist: Grandjean cites evidence that lead poisoning contributed to the fall of Rome [7], though this evidence is disputed. For today's global civilization, we should be especially wary of the many chemicals that are persistent (i.e. do not decompose quickly) and that spread globally through air, water, and food chains (bioaccumulation).

But here lies a bit of a paradox. Despite the growing onslaught of neurotoxics, IQs have steadily risen worldwide, a trend known as the Flynn effect [8]. Grandjean mentions rising IQs in passing but does not consider its significance for his argument. Simply put, rising IQs suggest that the cognitive harms of industrialization are outweighed by the benefits. And there are clear benefits for brain development, in particular improved nutrition and reduced disease burden (young bodies struggle to develop brains properly while fighting disease). Even the visual stimuli from televisions and computers may help. While there may be opportunities to improve cognition even more through regulating neurotoxics, it is not immediately obvious whether it is better for cognition by delaying new industrial chemicals through a more precautionary approach.

Part of the problem, of course, is a lack of information about so many chemicals. Improved transparency requirements would enable scientists and the public to know what chemicals people

are exposed to, and in doing so would facilitate risk analysis in the public interest. In this context, Grandjean proposes an international center to fund and coordinate neurotoxicology research, in the model of the International Agency for Research on Cancer. It is easy to see that this could be quite helpful.

In summary, Grandjean has written an excellent introduction to developmental neurobiology, industrial neurotoxics, and the great controversies they create. While the book lacks the macro-scale analysis needed for careful policy formulation, it does provide a rich intellectual history that can help get people from diverse backgrounds up to speed. It is thus easy to recommend this book.

Acknowledgments

Tony Barrett, Robert de Neufville, Grant Wilson, and an anonymous reviewer provided helpful comments on an earlier draft. Any remaining errors or shortcomings are my own.

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