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**Editorial**

# Exposome: a new field, a new journal

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> I would like to suggest that there is need for an 'exposome' to match the genome . . .
>
> Christopher Wild.[1]

Over 15 years ago, Dr. Christopher Wild introduced the word *exposome* to the scientific community, articulating his vision for a field that provided the environmental complement to the genome. Five years after that seminal publication there was little progress toward establishing an exposome field with no manuscripts even mentioning the word. After 2010, there was notably more activity with the US National Academy of Sciences hosting a workshop on the topic[2] and the European Commission issuing a call for research centers on the exposome.

The following decade witnessed the exposome crawl from its primordial swamp and evolve into something that started to resemble a scientific discipline or field. Dr. Wild has referred to this as "the angry teenager years" for the exposome. The exposome has been in its adolescent stage for the past several years, but it has been a confused adolescence. Exposome-related projects and manuscripts wandered somewhat aimlessly in the scientific wilderness, something I have witnessed firsthand.[3] Is it part of epidemiology? Is it exposure science? Is it toxicology? Is it biology? Is it chemistry? Is it physics? These struggles in identity and scientific approaches parallel the sort of existential crisis described by Thomas Kuhn in *The Structure of Scientific Revolutions*.[4] The confusion and disorder often presage a pending transformation within a given discipline or field.

## Do we really need a new field?

Is the exposome a new field? Examining various grants, projects, programs, and publications revealed to me all of the components needed to view the exposome as a unique field. Simply adding the suffix -ome or -omic onto a scientific topic does not establish it as a modern discipline, but there is something fundamental about the exposome. Let's go back to the simplest of equations about our phenotype.

$$\text{Phenotype} = \text{Genotype} + \text{Environment}$$

$$P = G + E$$

If we want to solve for E, we can subtract G from both sides, rearrange, and we are left with

$$E = P - G$$

Essentially, once one subtracts the genetic component from the phenotypic manifestations, one is left with E. We have incredible clinical, cellular, and molecular characterization of the phenotype (P), and the extraordinary advances in genomics and genetics provide a deep analysis and understanding of G, but we are left with a rather fuzzy description of E. Generally, E is defined as the environment, but the environment is enigmatic from a scientific standpoint and does not lend itself to a systematic evaluation of its constituent components. Exposome is the superior definition of E and it provides the proper foil to G. When you consider where we are in our ability to systematically analyze our genome (G), our ability to analyze all of the nongenetic drivers (E) of phenotype (P) is woefully inadequate. Historically, we have been unable to deliver a correspondingly comprehensive analysis for the environment that fits into the *biomedical* framework. This is the essence of the exposome: providing a more comprehensive definition of E that is coupled to how our biology responds to said exposures. Of course, there are significant G x E interactions and there is even a role for the exposome in genetic diseases. While we have been tinkering in our characterization of E, geneticists have delivered tools and approaches to comprehensively analyze our genome, from genome-wide association studies (GWAS) to deep-sequencing. Unfortunately, the analysis of the environmental drivers of human health has lacked a similarly comprehensive approach. The exposome is poised to deliver the comprehensive and systematic analysis of the environmental drivers that is desperately needed.

## Do we really need a new journal?

If one accepts the above argument that the exposome represents a critical driver of human health and disease, ie, necessitates a comprehensive and systematic analysis, then there must be a forum to facilitate dialogue on a global scale. When one fuses multiple approaches together the result often does not neatly fit into an exposure science journal, an epidemiology journal, a toxicology journal, or a bioinformatics journal. Several journals have sponsored special sections or issues on the exposome, but they exist within existing disciplinary journals that do not provide a tailored fit. If the exposome is going to be truly transformative, the output of such endeavors merits a scientific home that is worthy, welcoming, and willing to consider manuscripts that dare to do the seemingly impossible.

I have quoted Edwin Land of Kodak Camera fame in the past.[5] He stated, "Don't undertake a project that is not manifestly

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important and nearly impossible." Land was a natural entrepreneur who didn't have to worry about a curriculum vitae or a tenure and promotion committee. Academic scientists who undertake projects that are manifestly important and nearly impossible tend to suffer one of two potential fates. They may wildly succeed within a reasonable amount of time and be rewarded with tenure, promotion, grants, and awards, or, as too commonly observed in the halls of academia, they may not have the needed output and fail to land the coveted promotions and recognition. For the most part, junior faculty shy away from the "nearly impossible" and bide their time until they have received tenure to pursue higher-risk, innovative, and potentially transformative projects.

*Exposome*, the journal, wants daring science and submissions from investigators who understand that the exposome is manifestly important and attempt to perform experiments that are seemingly impossible. We are not requesting that investigators cut corners, but rather that they re-engineer the corners. Indeed, rather than working outside of the box, we want science that transforms the box into a buckyball, Möbius strip, or something out of a Mandelbrot set. We need creativity if we are going to deliver the type of science that will transform our understanding of how our complex environment influences our health. The accumulation of biological changes that come from a lifetime of complex exposures necessitates an integrated and systems-level analysis that blends the dynamic external forces with the corresponding internal biological responses.[6]

Unfortunately, the explosion of journals in the past several years has created an apparently unsustainable professional burden of requests for submissions, reviews, and reading. The proliferation of low-quality journals has threatened the integrity of academic publishing. Sketchy peer review, low-quality publications, and manipulation of citation metrics undermine the integrity of science. Based on these observations, I have come to the simple conclusion that *we don't need more journals, we need better journals*. We need journals that uphold the scientific norms of the field. We need journals that do not engage in predatory practices to increase profits. We need journals that are supported by the top scientists in the field. We need journals that have a rigorous review process. We need journals that enforce ethical standards. We need journals that promote and facilitate data sharing.

The goal of *Exposome* is not to dictate the terms of this emerging field, but rather to provide a forum for engagement, agreement, disagreement, and perhaps a bit of controversy. Those in the field are aware that I have strong views on the topic, but I recognize that those views are just that—my views and opinions given the setting in which I conduct my research. I may be wrong about many things, but the importance of the exposome to human health is not one of them. The Associate Editors and Editorial Board Members bring a broad range of expertise and views on the topic and they will be key drivers of what the journal will become. These world-class scientists were not selected based upon their ability to agree with me, quite the contrary. These are the scientists that I have observed challenging the status quo, pushing the boundaries of the science, and were confident in telling me that my own interpretations or views were wrong. We aren't trying to provide a singular dictionary definition of a word, we are trying to foster the development of a new field. This requires a community of investigators with a broad range of expertise and opinions who have a willingness to confer, debate, and collaborate to advance the field.

The Journal will take a human-anchored approach to the exposome, but that does not mean we will only publish papers from human studies. Understanding the influence of the built environment, climate disruption, pollution, noise, and physical and social stressors will require a broad array of studies.[7] Thus, we may see manuscripts that use remote sensing, cellular systems, organ-on-a-chip models, animal models, or computational models. As long as the work is conducted with the goal of better understanding the impact of complex exposures on human health we will be open to such submissions. But the onus is on the authors to frame their work in the exposome ethos—one that embraces complexity and strives to be comprehensive and systematic.

## Why now?

The discussions to launch a new journal started over 2 years ago. I appreciated the rigor of the process that Oxford University Press used in determining whether or not to start a new journal. The decision was not made lightly. It was clear that the exposome needed an academic home. In 2020, the European Commission committed over 100 000 000 euros to the Human Exposome Network, and a wide variety of exposome programs, centers, and research projects have been launched on every continent. These efforts will be yielding a massive amount of data and ultimately scientific stories in the form of manuscripts.

Further, large-scale projects, such as the UK BioBank and the US NIH All of Us program have completed or are working on the genomic sequencing of all of the participants. This is impressive scientific progress but largely ignores the exposome. Part of the goal of the Journal is to show the scientific community that the exposome *can be defined, that it can be measured, and that it can be quantified*. We want to demonstrate that the exposome can be integrated into a multiomic framework that exists in biomedical research community. We want to demonstrate that it can be integrated into models that capture satellite-based remote sensing, monitoring stations in our cities, and personal sensors to capture the complex exposures we are facing.

We need this new field. We need this new journal. We need your participation. The exposome is no longer wandering aimlessly in the forest. It has found a place to call home. Welcome home, exposome. This is your journal.

## References

1. Wild CP. Complementing the genome with an "exposome": the outstanding challenge of environmental exposure measurement in molecular epidemiology. *Cancer Epidemiol Biomarkers Prev*. 2005; 14(8):1847–1850.
2. The National Academies. *The Exposome: A Powerful Approach for Evaluating Environmental Exposures and Their Influences on Human Disease*. The National Academies; 2010.
3. Miller GW, Jones DP. The nature of nurture: refining the definition of the exposome. *Toxicol Sci*. 2014;137(1):1–2.
4. Kuhn TS. *The Structure of Scientific Revolutions*. University of Chicago Press; 1962.
5. Miller GW. *The Exposome: A New Paradigm for the Environment and Health*. Academic Press; 2020.
6. Jones DP, Park Y, Ziegler TR. Nutritional metabolomics: progress in addressing complexity in diet and health. *Annu Rev Nutr*. 2012; 32(1):183–202.
7. Vermeulen R, Schymanski EL, Barabási A-L, Miller GW. The exposome and health: where chemistry meets biology. *Science*. 2020; 367(6476):392–396.