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COMMENTARY

The Missing -Omes: Proposing Social and Environmental Nomenclature in Precision Medicine

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INTRODUCTION

In principle, precision medicine incorporates disease prevention and treatment that takes into account individual differences in people's genes, environments, and lifestyles. In practice, research regarding genes attracts more attention and resources than research focused on environments and lifestyles. Such progress-hindering asymmetry may be related to dissimilar naming conventions across scientific domains. We propose a novel "-ome"-based nomenclature that incorporates known social and environmental determinants of human health, and thereby reflects evidence across the full spectrum of scientific endeavors in precision medicine.

When President Obama announced the Precision Medicine Initiative in 2015, he championed the acceleration of an approach "to disease prevention and treatment that takes into account individual differences in people's genes, environments, and lifestyles."[1] The National Institutes of Health (NIH) moved quickly to develop plans for enrollment of a national cohort of more than 1 million individuals[2] and announced its ambitious infrastructure plans including four geographically dispersed enrollment centers in July 2016.[3]

The excitement about precision medicine among scientists, clinicians, and the private clinical technology sector contrasts with recent criticism that more than 15 years of burgeoning precision medicine research has not had a measurable effect on population morbidity or mortality, and has drawn research support away from other matters of public health importance.[4,5] While precision medicine may take a generation or longer to achieve a population-level return on investment, it is certainly a valid critique that current precision medicine approaches have far more to do with genomes than with environments and lifestyles. Even though methylation patterns in epigenetics are known to be linked to environmental and lifestyle factors in some cases, the scientific emphasis and public excitement remains principally on the genome rather than the causes. If this limited focus persists, it will undoubtedly impair the ability of precision medicine to fully optimize personal and population health outcomes.

Today's comparative underattention to environmental and sociobehavioral determinants of health runs contrary to established evidence about major sources of human morbidity and mortality. Social and environmental factors have profound and persistent bearing on individual health that far exceed the impact of genes alone, and for that matter outweigh the impact of healthcare delivery.[5,6] As expressed by James Marks of the Robert Wood Johnson Foundation in 2009, "Our zip code may matter more than our genetic code, our school files may be more telling than our medical files, … and the places we play may be more crucial than those where we get treated."[7]

What, then, explains the unbalanced research emphasis on intraorganismal (and predominantly intracellular, if not intranuclear) factors as compared with determinants of health outside the organism? Answers to this question likely relate to the often more-competitive-than-collaborative silos of medicine and their suboptimal connection to public health, investment in and attention to biological sciences vs. social sciences, and funding streams through the NIH vs. the National Science Foundation.

The imbalance may also be rooted in asymmetric nomenclature within the field of precision medicine. In science, names of phenomena function as ways to convey consistent meaning, connect investigators across disciplines, and advance knowledge through shared understanding. Initiatives in genomics, proteomics, and metabolomics dominate the current dialogue about precision medicine and its potential applications. In contrast, the vast majority of factors related to environmental and social determinants of health (e.g., poverty, neighborhood, education, race/ethnicity) do not have corresponding terms in the lexicon of -omes and -omics. The suffix "-ome" is of Greek origin meaning "mass," as in "biome" (coined about 100 years ago) to indicate the aggregate sum of biological factors. The suffix "-omics" refers to measurements and data from a corresponding -ome—e.g., genomics and genome. The lack of shared naming conventions essentially—albeit unintentionally—displaces social and environmental considerations from core efforts to promote precision medicine. Although terms currently used in some cases to describe

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Table 1 Domains of Precision Medicine – Proposed Nomenclature

ENDOME* Within the organism	***ECTOME* Outside the organism**
Genome - genetic information	Environmental factors
Proteome - proteins expressed by a genome	*Aerome* – air *Hydrome* – water *Terrome* – soil *Nutriome* – consumed food *Biome* – flora and fauna (including microbiota)
Metabolome - small-molecule chemicals within a biological sample	
Transcriptome – messenger RNA molecules in a cell or population of cells	
Secretome – secreted organic molecules and inorganic elements by cells, tissues, and organs	Social factors
Translatome – messenger RNA fragments present in a cell	*Philome* – family & social support network *Allolome* – other human beings not in the *Philome* *Legome* – educational achievement & opportunities *Econome* – economic circumstances *Ethnome* – culture, including race/ethnicity *Actome* – physical activity *Home* – living environment, including neighborhood
Foldome – folded structures of proteins	
ORFeome – open reading frames in the genome	
Glycome – carbohydrates in a cell, or full complement of sugars in an organism	
Regulome – regulatory components in a cell	
	Health care factors
	Iatrome – health care experienced by a person *Therapome* – therapeutic care *Preventome* – preventive care *Pharmacome* – pharmaceuticals

*Domains within the endome are select examples previously described and named in published literature, with descriptions/definitions.

the impact of environmental factors ("epigenetics")[8] and the influence of social factors ("exposome")[9] share aspects of etymology with the dominant -omes today, their names are overly general and are rooted in a perspective of the genome being the paramount determinant of health.

Therefore, we propose a more comprehensive system of nomenclature of -omes that recognizes known influences on human health specified in the Precision Medicine Initiative. We suggest specific -ome-rooted labels for new domains that have not previously been described as such (**Table 1**). To construct this system, we follow three principles. First, we observed that -omes that have already been described (e.g., genome, transcriptome, cellome) are all manifest within an organism. Therefore, we classify internal -omes as components that aggregate to the *endome*, and we classify external -omes as belonging to the *ectome.*

Second, we propose -ome nomenclature for major aspects of social and environmental influences on health (**Table 1**). As with the majority of existing -ome labels in the endome, we have drawn on Greek and Latin roots for the majority of the proposed -omes in the ectome. We also suggest the term *iatrome* to describe healthcare itself as a determinant of health, whether positive (e.g., timely access to care that includes evidence-based practices) or negative (e.g., clinical services that do not reflect the standard of care). Within the iatrome, there are specific subdomains including the *pharmacome, therapome,* and *preventome* to distinguish different elements of healthcare.

Third, we propose nomenclature that characterizes relationships among multiple -omes of the nomenclature system. Interactions among two or more -omes are *interomous*—e.g., "Studies of endome–iatrome interactions lead to interomous insights about the impact of healthcare on individuals' health." The sum total of interomous effects for an individual is called a person's *idiome*—e.g., "Her *idiome* is strongly influenced by inherited risks for hypertension in her *genome* and by her experiences of discrimination from others in her *allolome*, although support within her *philome* offsets these effects somewhat."

For precision medicine, we believe that symmetric -ome nomenclature will help standardize the ways in which scientists and clinicians can describe, define, capture, and analyze the comprehensive set of factors that affect human health—and, in turn, accelerate precision medicine as the revolutionary approach that its proponents envision. Importantly, the -omics corresponding to the -omes that we propose in the ectome must be as rigorous as measurements in the endome. Fortunately, environmental scientists, social scientists, and health services researchers have already developed and validated many measures: for example, measures of waterborne toxins in the *hydrome,* social support in the *philome,* and health services utilization in the *therapome* are well established. Just as with -omes in the endome, in all -omes of the ectome there are opportunities for scientists to innovate better measures than those that exist today. We welcome the scientific community to contribute to sharing and advancing the common language of -omes and -omics at https://omecentral.org, which we have designed to serve as a dynamic reference source going forward.

We hasten to add that our model is almost certainly incomplete. Just as the movement toward precision medicine was advanced when the term *genome* was coined, and terms such as proteome and metabolome were added to the scientific lexicon decades later, we recognize that the inevitable progression of science will lead to new insights and the need for new components in this nomenclature.

We also realize that some environmental and social scientists may resist our proposal to label factors in their disciplines with the common -ome root. However, given the dominant public research funding paradigm that supports biological sciences in the United States, and the inevitably meaningful nature of labels of phenomena to convey importance and garner attention, we believe that our proposal broadly and symmetrically elevates the importance of health-influencing factors with the use of a standard "-omic" nomenclature.

Ultimately, with the newly designated endome, and the newly named components of the ectome, we hope to open the door to more balanced scientific activity in biological and social sciences, and to broader awareness and deeper public dialogue about the promising development and applications of precision medicine in the immediate and distant future. The success of precision medicine, as a major national clinical and scientific initiative, will rest on balanced attention to endome and ectome factors, and on further development of an -ome-rooted model that iteratively reflects collective understanding across the full spectrum of scientific endeavor.

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