

Perspective

# Clinical Ecology—Transforming 21st-Century Medicine with Planetary Health in Mind

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**Abstract:** Four decades ago, several health movements were sprouting in isolation. In 1980, the environmental group Friends of the Earth expanded the World Health Organization definition of health, reminding citizenry that, “health is a state of complete physical, mental, social and ecological well-being and not merely the absence of disease—personal health involves planetary health”. At the same time, a small group of medical clinicians were voicing the concept of “clinical ecology”—that is, a perspective that sees illness, especially chronic illness, as a response to the total lived experience and the surroundings in which “exposures” accumulate. In parallel, other groups advanced the concept of holistic medicine. In 1977, the progressive physician-scientist Jonas Salk stated that “we are entering into a new Epoch in which holistic medicine will be the dominant model”. However, only recently have the primary messages of these mostly isolated movements merged into a unified interdisciplinary discourse. The grand, interconnected challenges of our time—an epidemic of non-communicable diseases, global socioeconomic inequalities, biodiversity losses, climate change, disconnect from the natural environment—demands that all of medicine be viewed from an ecological perspective. Aided by advances in ‘omics’ technology, it is increasingly clear that each person maintains complex, biologically-relevant microbial ecosystems, and those ecosystems are, in turn, a product of the lived experiences within larger social, political, and economic ecosystems. Recognizing that 21st-century medicine is, in fact, clinical ecology can help clear an additional path as we attempt to exit the Anthropocene.

**Keywords:** clinical ecology; planetary health; high-level wellness; integrative ecological solutions; mutualism; personalized medicine; the microbiome; green prescriptions; holistic bio-psycho-social medicine; long-range thinking; non-communicable diseases; dysbiotic drift; socioeconomic inequalities; biodiversity interdependence; cooperation; integration; value systems; cultural shift

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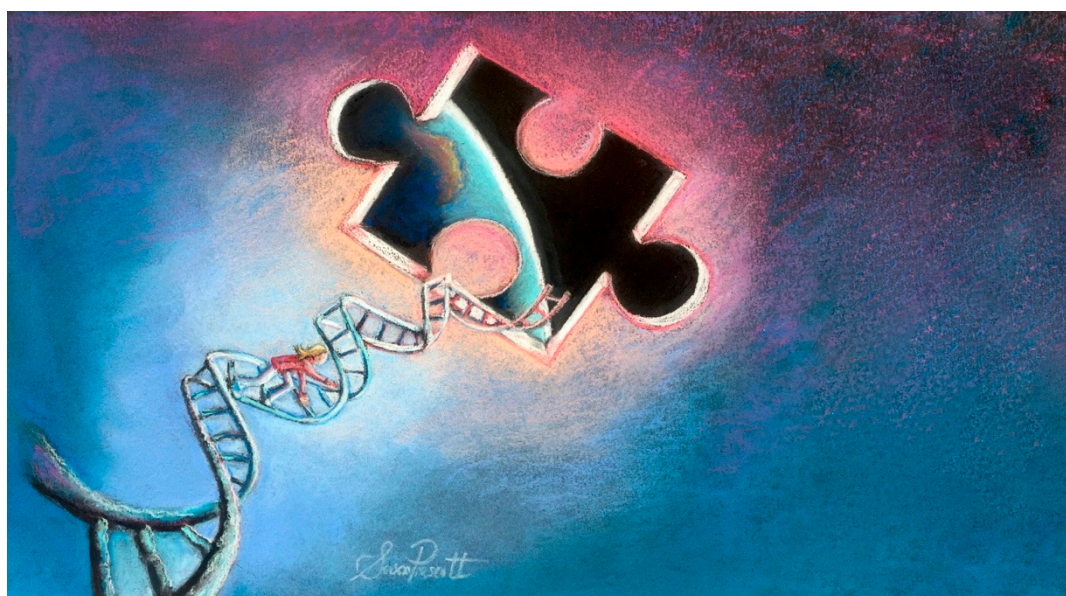
## 1. Introduction

“[The physician] must master a new science focused on the effects that the total environment exerts on the human condition...knowledge of environmental biology must therefore become one of the essential bases of medical science and practice”. [1]

In 2015, the Lancet Commission on Planetary Health published its milestone report [2]; the conclusion was simple—the health of human civilization is dependent upon the long-term stability of the Earth’s natural systems. The *Report* underscored the threat (to natural ecosystems) posed by environmental degradation, climate change, biodiversity losses, and the associated over-exploitation of resources. More recently, the Canmore Declaration formally defined planetary health as the interdependent,

sustainable *vitality* of all natural and anthropogenic ecosystems (social, political, and otherwise); moreover, the Declaration underscores that the goals of planetary health include curbing the causes of the global non-communicable disease crisis, and working toward equity in the promotion of high-level wellness [3].

Despite its importance to all branches of science and medicine, the relevance of planetary health to the daily practice of front-line healthcare providers may seem obscure. Although the 2015 *Report* acknowledges that health professionals can play an essential role in planetary health, the only mechanism provided is for physicians and others to help “integrate policies”. Indeed, one of the early pioneers in the planetary health concept, Lancet Editor-in-Chief Richard Horton, has lamented that planetary runs the risk of simply fading into a “recalibrated version of environmental health”, rather than its original intent—in Horton’s words, “an inquiry into our total world” [4]. Planetary health cannot be separated from social and cultural inputs at all scales. It emphasizes Enlightenment principles—a universal humanity, equity, moderation, humane laws, a high level of purpose, decency in conduct, and limitations on war [3]. Indeed, planetary health is the study of behavior and biology. In this context, the ‘omics’ revolution is providing a deeper understanding of the exposome and is, in many ways, making planetary health personal, see Figure 1.



**Figure 1.** The ‘omics’ revolution is making planetary health personal.

Here, we argue that the high-level importance of planetary health can be visualized in front-line healthcare by (re)emphasizing that the prevention and treatment of disease—along with the promotion of vitality—is, in fact, ecologic medicine. We examine some of the history of what was once termed clinical ecology and the early origins of holistic medicine. Although well intended, these initial efforts to envisage health on an ecologic continuum of person, place, and planet lacked an objective science to buttress its suppositions.

As we outline here, timely advances in microbiome and related ‘omics’ sciences have allowed clinicians to visualize the intricate connections between the total lived experience over time—influenced by the state of the Earth’s natural systems, as well as ecosystems of social, political, and economic structures—and ongoing biological changes. As such, we argue that planetary health is manifesting itself in the ecosystems—health determining, biologically relevant ecosystems—at the tip of an intestinal villus and elsewhere in and on the body. Moreover, the emerging research on environmental epigenetics—and transgenerational transmission—underscores the critical nature of this discourse; the clinical relevance of the planetary health concept may be appreciated in research demonstrating rapid biological responses to changing environments [5,6].

It is our contention that a more widespread recognition that each patient encounter—whether for prevention, treatment or wellness visit—is, in essence, clinical ecology, has the potential to transform medicine in the 21st century. The clinical ecology concept is medicine practiced with planetary health in mind; we define clinical ecology as a healthcare approach that considers the interconnected vitality of person, place, and planet. Moreover, healthcare practice as clinical ecology reinforces the undeniable reality of human health and the vitality of natural and anthropogenic ecosystems cannot be separated.

## 2. Historical Background

In April 1965, a small band of medical doctors—allergists by specialty—established an obscure group known as The Society for Clinical Ecology. The move was, according to one of the early founders, “because of a growing dissatisfaction with the national allergy societies as forums for new and broader ideas. These societies were departing from the original broad concept of allergy as altered reactions” [7]. Indeed, the etymological root of the word allergy means “altered reactivity”.

Some clinicians began to argue that because “factor’s in a patient’s family, home, job, or neighborhood” are central to clinical medicine, and since these factors are “subsumed within the discipline of ecology (Greek, *oikos*; house, study of)”, physicians were, in reality, practicing “Ecologic Medicine” [8]. From the perspective of clinical ecology, each patient and each community is viewed as inseparable from the total lived environment over time [9]. The houses of the houses—the “*oikos*” of social, political, economic structures—each maintain their own ecosystems but are individually and collectively capable of influencing the bio-psychological health of the individual in the clinical setting.

The new *Society*, and environmentally-oriented scientists like Rene Dubos, sought to reclaim the word allergy from its reductionist pigeon-hole. It seemed evident to Dubos and others that many chronic diseases—including many mental disorders—are a product of an “altered reactivity” to the modern environment [10]. Dubos argued that bringing an ecological perspective into the contemporary “treatment room” was also an appreciation of a potential evolutionary mismatch between ancestral experiences and a rapidly transformed modern environment [11]. Coincident with the clinical ecology movement, a separate group of physicians pushed for a more holistic view of the patient, in general.

Some felt the technological successes of 20<sup>th</sup>-century medicine—once-unimaginable benefits to society through pharmaceutical development, surgical techniques, and highly-effective vaccines—had not been without cost to the ‘art’ of medicine. In particular, technological advances were privileging the ‘biological’ over the psychosocial and minimizing the importance of non-technological healing aspects of the physician-patient encounter [12]. Such calls for a truly holistic medicine were built upon the biopsychosocial paradigm first outlined by psychiatrist George Engel. That is, a medical model concerned with the simultaneous attendance to biological, psychological, and social dimensions of illness [13].

At its point of origin, the holistic medicine movement underscored the complex nature of chronic disease—the rising rates of so-called diseases of civilization. The movement urged clinicians to consider the whole person and “indicators of disharmony between the individual and his/her environment” [14]. In the words of psychiatrist James S. Gordon, “the holistic approach to medicine and health care emphasizes the integrity of each person’s physical, mental, and spiritual being, the psychosocial context of health and illness, the importance of health promotion, a respectful partnership between physician and patient, and the actual or potential utility of techniques derived from a variety of healing traditions” [15].

At the same time, environmental groups began campaigns to remind individuals and communities that human health is inseparable from the health of the Earth’s very own natural ecosystems. For example, in 1980, the well-known environmental advocacy group Friends of the Earth expanded upon the World Health Organization (WHO) definition of health to include healthy ecosystems: “health is a state of complete physical, mental, social and ecological well-being and not merely the absence of disease—personal health involves planetary health” [16]. Among the determinants of

health—genetic, behavioral, lifestyle, social, political, economic, etc.—planetary health was described as “the ultimate determinant” [17].

In sum, from the late 1960s through to the early part of the 1980s, three mostly-distinct movements were operating at the borderlands of mainstream healthcare. The primary messages within the clinical ecology, holistic medicine, and planetary health movements were remarkably similar: Health and vitality are a product of the total lived experience over time, the contemporary environment may be producing ‘altered (unhealthy) reactivity’ vis à vis our evolutionary past, and human health and vitality cannot be separated from the sustainable health and vitality of the Earth’s natural ecosystems.

### 3. The Silo

As the holistic medicine movement gained momentum [18,19], its basic tenets enjoyed support from influential physicians and scientists. For example, Jonas Salk (best known for his work in helping to eradicate polio through vaccine development), and Malcolm Todd (former president of the American Medical Association) were frequent guests at holistic medical conferences [20]. In 1977 Salk stated that “we are entering into a new Epoch in which holistic medicine will be the dominant model”; he also distinguished between holistic health and “medicine”—the latter, he said, “refers to the repair of ailing parts, but health is the properly functioning whole” [21].

Salk’s vision included planetary health: “Sophisticated technology, intended to advantages for humankind, sometimes has had unforeseen adverse effects on human health... [environmental degradation] threatens human and planetary health. The latter must also be added to the consideration of biological and sociocultural influences on health throughout the human *life span*” [22]. Thus, the rational approach advocated by Salk was to remove isolated grains of discourse from their storage in separate silos. There is no health without planetary health, nor can it be separated from the biopsychosocial/environmental determinants of health.

The credibility of the messenger—someone who demonstrated proof-positively the benefits of reductionist science in vaccine development—was impeccable. Salk knew better than most the distinctions between infectious versus non-communicable diseases and between states of disease and a properly functioning, vital, whole-person. However, he also underscored ecology as the common thread throughout the distinctions [23].

The logical progression should have been a unified construct, a single movement that at the very least infused significant ecological perspectives into medical education. However, such is not the history of clinical ecology. Instead, clinical ecology morphed into the very narrow line of thinking it once opposed.

By the late 1980s, the term clinical ecology became synonymous with dubious efforts to diagnose and treat sick building syndrome, multiple chemical sensitivities, and other ill-defined syndromes. Rather than a generalized working philosophy that underscores the social, economic, political, biological, psychological, and total environmental determinants of health in clinical practice, the term clinical ecology was co-opted to be “defined as the orientation in medicine in which physicians primarily work with patients to uncover the cause-and-effect relationship between their ill health and food or low-level chemical exposure” [24].

The problem for the fledgling field of clinical ecology was that its laudable theoretical framework was largely operational in the form of unproven (if not disproven) allergy tests. Reliable diagnostics were missing. Moreover, interventions often involved very restrictive avoidance of many foods and in many ways, a retreat from modern life.

Clinical ecologists were certainly knocking on the right doors of theory—suspecting long before others that alterations in the gastrointestinal microbiota, for example, is a factor in chronic disease, even mental health (from New Scientist, 1985):

“The most common problem seems to be a disorder in gastrointestinal function, caused by the presence of abnormal bacteria in the gut. Some [clinical ecology] practitioners go on to



claim that this condition, which they call dysbacteria, can itself have a number of causes from psychoneurotic behavior to repeated or long-term antibiotic consumption". [25]

However, the ability to test theories of dysbiosis—to truly link the outside world with teeming ecosystems on and in the body—was limited by rudimentary culture-technique assessments of microbiota. Without ecosystem context, individual microbial species were broadly vilified or celebrated as detracting or promoting health. Reliable blood and urine tests which might evaluate metabolites of functional responses to environmental conditions were also absent. Moreover, the initial concept of clinical ecology focused its attention almost exclusively on “toxic” chemicals rather than the vision expressed by Dubos who said in 1969: “It is to be hoped that a time will come when [health-oriented] human ecology will be able to pay greater attention to the positive and beneficial effects of the environment than to its pathogenic effects” [11].

By the early 1990s, the term clinical ecology disappeared from the discourse found within mainstream medical journals, seemingly banished for good [26–28]. Patients within its fold were largely written off with a “definite psychosomatic disorder” [24]. The term holistic medicine also suffered a similar short-term fate—no less saddled to pseudoscience, unproven (and disproven) diagnostic techniques/tests and interventions [29]. Indeed, detractors independently labeled clinical ecology and holistic medicine as “cults” [30,31]. The planetary health concept promoted by Friends of the Earth—that health is predicated upon ecological well-being and that personal health involves planetary health—was now far outside mainstream medical practice [32].

#### 4. The Microbiome and Omics Revolution

The last two decades have witnessed a reclaiming of the primary principles of the three independent movements. The strongest (rational) tenets of the holistic medicine movement have slowly found their way into 21st-century integrative medicine [18]. That is, a holistic perspective that neither rejects the westernized biomedicine-dominated paradigm nor accepts alternative therapies uncritically [33].

The transition from ill-defined holistic medicine to contemporary integrative medicine has included a planetary health perspective. Integrative medicine not only advocates for a broad lens view of health but a ‘long lens’ as well. For example, three years ahead of the Lancet Commission report, and six years before the Australian Medical Association would implore its membership to embrace planetary health [34], Nancy L. Sudak, MD, (who helped shape the modern integrative medicine from its holistic roots) wrote the following:

“Integrative holistic practitioners intuitively understand that partitioning body from mind and spirit is unnatural; the separation of human health from the health of communities and the planet is similarly shortsighted. Holistic integrative practitioners, who are uniquely oriented toward an expansive worldview, are ideal educators for patients and colleagues about the steps that can be taken to mitigate the ecologic health impacts and advocate for policies and practices that promote resilience at individual, community, and planetary levels”. [35]

These remarkable words from Dr. Sudak underscore that rational holistic medicine and planetary health are one-in-the-same. Yet, there is an ongoing revolution in medical science that may provide paradigm-shifting assistance to clinicians as they attempt to educate patients and communities—and the borderless “global village” at-large—on the connections between personal, public, and planetary health. The direct and indirect relevancy of ecology in clinical practice is being illuminated by innovation in the ‘omics’. Although our focus below is on the microbiome, environmental epigenetics research demonstrates rapid changes in epigenetic processes in response to acute stress [36]. This, combined with separate animal research showing that stress can promote systemic inflammation even in germ-free animals [37], illuminates the complexity of how lived experiences “get under the skin”.

Advances in the study of the human microbiome (microorganisms, and their collective genome residing in an anatomic niche [38]) as well as the oft-related breakthroughs in functional proteins (proteomics), metabolites (metabolomics), gene expression (epigenomics and transcriptomics), and genetic influences on drug/isolated nutrient metabolism (pharmacogenomics) [39] are allowing researchers (and increasingly clinicians) to witness the biological impact of a dynamic environment. When combined at larger scales, these measurements can be utilized by experts in bioinformatics and biostatistics to provide unprecedented levels of accuracy—predicting personalized biological responses—while enhancing clinical care in profound ways [40].

Already, microbiome information gleaned from large datasets has allowed for the implementation of machine-learning algorithms which accurately predict postprandial glucose responses to various types of food; moreover, personalized dietary interventions based on the bioinformatics-derived (predicted) postprandial glucose responses can subsequently maintain healthy blood glucose-insulin balance in human subjects [41]. Similar research shows microbiome-derived machine learning algorithms can accurately predict—far more than labeling claims—whether or not a certain bread is “healthy” for each individual. Microbes (and the functional microbial genes) carried by an individual appear to matter more to glycemic responses than whether or not the bread consumed is artisanal and traditional, or “white” with 33% less fiber [42].

These and other exciting advances in personalized healthcare—including the vast potential of tailored dietary interventions—are not an advertisement for white, industrialized bread. They are demonstrating that microbes matter. Ecology matters. The person “in the waiting room” for their clinical appointment is a multi-species entity [43,44]—sitting there reading a two-month-old issue of *Time* or *Elle*—with a microbial cell to match every human cell. This has moved beyond mere microbial trivia. The microbes on and within the human body carry dramatic numbers of functional genes—the sort that might influence vitality and quality of life, and contribute to, or decrease the risk of non-communicable diseases (NCDs) [45]. Moreover, microbes may directly and indirectly (through metabolic by-products) determine the level of success of medical interventions, including responses to prescription drugs or psychological therapies [46–48].

The clinician must learn to see the patient through the lens of the holobiont; that is, the multicellular eukaryote and the inseparable colonies of persistent symbionts which together form a critically important unit of anatomy, physiology, immunology, growth, and evolution [44].

The functional microbial ecosystems within the towering skyscraper known as a single intestinal villus or the undulations of a colonic fold can be mediated by short- and long-term dietary choices, stress, medication use, sleep, exercise, and total lived experiences [49,50]. Lifestyle, most notably diet, can influence microbial ecosystems at anatomical sites far removed from the gastrointestinal tract [51]. Toxins exposures such as airborne particulate matter [52], tobacco [53,54] and synthetic emulsifiers [55] may also compromise health via microbiome changes. On the other hand, these microbial ecosystems may be, at least to some extent, the tail wagging the dog. The microbial influence may extend its reach to human behavior, including those that otherwise promote vitality or compound the risk of NCDs. For example, various lines of animal and human evidence suggest that microbes can play a role in mood, cognition, and motivations [56–58].

In sum, the microbiome revolution is transforming how we view the human “self”; from either side of the faux line between the biological and psychological, the clinical implications are profound. It is no longer tenable to view ourselves as functionally separate from microorganisms “residing” on and within us. In a strange way, it is the teeming, unseen forms of life (up to 100,000 microbes on a single grain of sand [59]) that have illuminated the interconnected webs of all life on Earth. Opportunities to address the grand challenges of our time abound [60].

## 5. Clinical Ecology—Houses of the Houses

The holistic medicine movement of the 1970s was oft-criticized for pushing an almost exclusive personal responsibility narrative; as stated in the *New England Journal of Medicine*, “a convenient

*by-product of [holistic medicine] is that it lets society off the hook. If the individual alone is responsible for his or her own wellbeing, society can continue to encourage us to abuse our bodies and, even worse, can continue to profit from these abuses” [61].* Today, however, the microbiome (and omics) revolution is casting much light on the “causes of the causes”, or more specifically, the *oikos*—“the houses of the houses”. Understanding how ecosystems in the halls of government (and the ways in which they are influenced by multi-national purveyors of ultra-processed foods, tobacco, alcohol, etc.) facilitate the global transmission of unhealthy goods—while contributing to the Anthropocene—has been the work of public health for many years [62–64].

However, straight (biological) lines can now be drawn between the words of McDonald’s founder Ray Kroc (commenting in Time magazine on his massive fortune)—“*I expect money like you walk into a room and turn on a light switch or a faucet, it is not enough*” [65]—and fast-food outlet clustering in already disadvantaged neighborhoods—the public health consequences of such clustering—and the differential *biological* responses to a single fast-food meal [66,67]. Multi-omic data collected over time may help identify distinct categories of psychosocial and social-environmental conditions that favor positive treatment responses (or, conversely work against desired outcomes) [68]. At the heart of this might be the biologically relevant microbes which reflect the lived experiences [69].

The emerging science of the exposome underscores that genes alone cannot explain health disparities; the cornerstone of the exposome perspective is that the total accumulated environmental exposures (both detrimental and beneficial) over time can predict *biological* responses of the “total organism to the total environment”. Thus, the biological response to individual exposures like the consumptions of a single fast-food meal (potentially provoking oxidative stress and inflammation) does not occur in isolation. The exposome emphasizes the long-lasting influence of various positive and negative exposures, especially early in life, can determine measurable biological responses in concert with health, vitality, and disease risk; it also underscores the bidirectional effect of the environment on human subjects and the human influence on all living systems and their genomes [70,71].

The exposome perspective is concerned with positive exposures—a critical point of departure from the original clinical ecology movement which focused its attention almost exclusively on “toxins”. In this way, the exposome is more aligned with humanistic perspectives and the growing body of research in positive psychology [72,73]. The last decade has witnessed a marked increase in research supporting the mental and physical benefits of biodiversity and experience in natural environments (oft-referred to as green space) [74–76]. The interplay of potentially beneficial and detrimental experiences is central to biological buffering and the concept of resiliency; exposure to green space and elements of natural environments—including microbial—appear to play a role in psycho-biological resiliency over the life course [77–79].

Interestingly, in the midst of clinical ecology overselling a theory without proper scientific support, its detractors provided little critical appraisal with the assumption that most patients suffering from ill-defined symptoms had a “definite psychosomatic disorder”. So-called functional somatic syndromes—conditions lacking clear structural pathology (e.g., irritable bowel syndrome, fibromyalgia, chronic fatigue syndrome)—are common in medical practice; symptom overlap is high, with some arguing that these are essentially one generalized syndrome [80]. It is worth pointing out that many NCDs were at one time considered to be psychosomatic (a predominantly psyche-to-soma pathway)—including, but not limited to, migraine, diabetes, rheumatoid arthritis, autoimmune, and asthma/allergic diseases, and, of course, peptic ulcer—once the “crown jewel” of psychosomatics [81–83].

The functional medicine model transcends the older psychosomatic paradigms and considers the word *function* to be aligned with the evolving understanding that disease is an endpoint and function is a process. Moving from “functional somatic syndromes”—once thought exclusively psych-to-soma in origin—to a definition of Functional Medicine that derives from the unique interaction of an individual’s genome with their environment and lifestyle is rooted in the development of systems

biology. Functional medicine incorporates the holistic model, yet remains rooted in the 21st-century understanding of metagenomics, proteomics, metabolomics, and systems biology [84].

Systems biology enables translation from bench to clinic [85] and provides the scientific framework from which a revised understanding of the term “function” in medicine has originated; it allows for harmonization of the mechanistic reductionist perspective with that of the descriptive phenomenologist perspective that together create the unique approach that resides within clinical ecology.

The fundamental idea of functional medicine was described in the *Lancet* in 1871:

“[regarding] the term “Functional Medicine”...what I mean by it is this: that whenever we come to treat a case, to prescribe drugs or particular diets, rest or action, we should first of all consider what function of the body it is that is improperly performed...it may be, and indeed generally is, the case that more than one function is (it may be several are) astray. We have, then, further to consider whether it is possible or convenient to attempt to rectify all these at once; and, if not, we have to decide which we should begin with”. [86]

In the 21st century, the clinical ecology perspective demands that we also ask if functions (vital ecosystems) at scales of place and planet are “astray” and pressing upon the patient in the waiting room.

## 6. Practical Implications

**“Modern medicine will become really scientific only when it has learned to manage the biological and psychological forces that operate as vis medicatrix naturae and when it has really committed itself to the doctrine that, in human life, the health of the body is linked to the health of the mind.” [87]**

In the face of global challenges—an epidemic (some say pandemic) of NCDs, environmental degradation, climate change, biodiversity losses, and an increasing disconnection from the natural world—it is no longer sustainable to isolate ecology from clinical medicine. There is an urgent need to bring an ecological mindset into the clinical encounter. Clinicians are tasked with not only educating patients and the public at large on the realities of the Anthropocene, and to describe how these grand challenges filter into the clinic, but to simultaneously map out interventions that are good for person, place, and planet.

Since over 80% of disease mortality in westernized nations is determined by modifiable variables—and indeed so too, are the collective grand challenges of the Anthropocene determined by larger-scale behaviors—in the clinic, this means a deeper layer of thought concerning “lifestyle” guidance. Personalized dietary plans can be constructed with the clinical endpoint (depression, for example [88]) and planetary sustainability in mind [89–91]. Thankfully, with the health benefits of whole plants foods (and the avoidance of ultra-processed foods [92]) those are often overlapping conversations [93–95]. The clinical ecologist will be concerned with how to best educate patients on the uptake of a diet for personal and planetary health; emerging research on healthy plant-based foods suggests that emphasis on health alone may be less effective than messaging and education on taste [96].

In addition to dietary prescriptions based on microbiome bioinformatics [97], other microbe-derived therapies are on the horizon. Already, probiotics, prebiotics, and postbiotics (e.g., heat-inactivated microbes or microbial parts) are being utilized for personal and public health benefit [98–103]. Fecal microbiota transplant, already of known value in *Clostridium difficile* infection [104], may provide benefit in various extra-intestinal NCDs [105,106]. Metabolites of microbial activity are being linked to NCDs, including cardiovascular disease [107]. The known health benefits of colorful, phytochemical and fiber-rich fruits and vegetables may be mediated by an interaction between fiber, phytochemicals (turning out to be far more important than the near-pejorative term “antioxidants”) and gut microbes [108].

Questions still abound and researchers have miles to travel before clinicians have the full promise of the microbiome revolution at their fingertips. Remediation, whether in the gut ecosystem or urban brownfields, is a complex endeavor wherein unintended consequences can occur [109,110].



The message, for now, is that there are many ways in the total lived westernized experience can provoke dysbiosis over time. Thus, “rebuilding the gut microbiota ecosystem” may be an essential consideration in the 21st-century clinic, with application in many NCDs [111].

As volumes of international research on the microbiome and omics are translated for clinical use, and more refined interventions are honed, the clinical ecology perspective can be put into practice with relatively simple assessments. Significant amounts of research already demonstrate that personal connections to the natural world (easily assessed with validated instruments such as the Nature Relatedness [112], Nature Connectedness [113], and Connectivity with Nature [114] scales) are associated with physical and mental health [115,116]. Indeed, research indicates that connection with nature may be a fundamental human need [117].

The emerging research on soil-based interventions (e.g., handling a mossy soil-plant composition) demonstrates that ecological considerations are not confined to capsules. Indeed, daily contact with external microbiomes may influence internal ecosystems [118,119]. This suggests another pathway (beyond what is described as social and psychological) by which personal, school, and community gardening provide their health benefits [120,121]. While clinicians wait for this area of scientific inquiry to mature, it would seem reasonable to incorporate nature relatedness scales in clinical practice.

Remarkable studies are demonstrating the public health value of ‘greening’ vacant and urban blighted land. Restoring such land improves real and perceived safety among residents [122]. Indeed, residents that experience an increase in greenness near the home when the vacant lots are transformed into small green spaces reported marked reductions in feelings of depression—especially so in residents of disadvantaged areas [123]. In the planetary health context, it is essential that clinicians are aware of such research and engage with the ecological implications.

Utilizing nature relatedness scales opens up a door to provider–patient discourse on possible routes to health and vitality (determining how much active/passive time a patient spends in the outdoors, and the writing of “Green Prescriptions” [124–126]); since nature relatedness is also associated with pro-environmental and pro-social attitudes and behaviors—likely because experience in/with the natural world promotes concern for planetary health [127–130]—assessments allow for discussions concerning a collective “treatment” of personal and global problems, actively engaging both clinician and patient in planetary health [131]. Clinicians now have an opportunity to track nature relatedness with functional aspects of health.

However, simply viewing nature as a “pill” with a “dose-response curve” is not the endgame of clinical ecology as the “family practice” arm of planetary health. Indeed, this may run counter to its very goals [132,133]. Clinical ecology can only be realized with input from ecologists, geographers, and related experts. On the other hand, the wider relevancy of the oft-narrowly defined study of the “house” (*oikos*—ecology) to clinical care may be enhanced by the perspectives of healthcare experts—especially those with a particular interest in the lines between psychological assets like nature-relatedness and biological responses to the total environment. Social epidemiologists, well versed in how the environment gets “under the skin” and “into the gut”, are ideally positioned to provide a scaffolding to the discourse [134].

## 7. Conclusions

“[when we] learn to understand the experiences of man in terms of multidirectional relations, and with a simultaneity that is free of the naiveté and artificiality of straight line sequential causality . . . when we have come to such an understanding, psychosomatic medicine will be truly holistic. But then, may I whisper it softly, it will no longer be psychosomatic medicine. It will be medicine such as Hippocrates could comprehend, and Paracelsus might celebrate—a keen reflection on the interrelations of Microcosm and Macrocosm”. [135]

If there was ever a time when health professionals needed an effective means to demonstrate how health and biodiversity are connected at macro, meso, and micro scales, the microbiome and omics revolution has arrived not a moment too soon. As we attempt to exit the Anthropocene and imagine a new,

symbiotic way of existence, the ability to visualize the biological underpinnings of the personal, public, and planetary health continuum is a remarkable asset. It has the potential to, at once, truly personalize healthcare, and at the same time undo the untenable status quo that otherwise maintains grotesque social inequities and the global spread of products that are unhealthy for person, place, and planet.

The ability to biologically witness these underpinnings—not simply theorize as when the term clinical ecology was first en vogue—will help to underscore that in the 21st century, all healthcare providers are, in effect, clinical ecologists. The need for ecologic perspectives in medicine is now obvious [136]. It's time to (re)claim the vital term clinical ecology—a label that once represented a fringe field focused on sick building syndrome. The structure that human society and all terrestrial life live upon—planet Earth—is sick. The evidence-base for *that* “sick building” is voluminous and scientifically undeniable. There is no time to waste.

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