

## THE JIGSAW PUZZLE OF ENVIRONMENTAL HEALTH: A NEW PICTURE EMERGES

[Rachel's introduction: A stunning new report offers a comprehensive view of "environment and health," revealing some of the common mechanisms by which human health is shaped by the natural environment, the built environment, and the social environment -- a perspective that seems likely to recast the whole field of "environmental health" in the next decade or so.]

By Peter Montague

[Review of: Jill Stein, Ted Schettler, Ben Rohrer, Maria Valenti, and Nancy Myers (editor), *Environmental Threats to Health Aging: With a Closer Look at Alzheimer's & Parkinson's Diseases*. Free PDF available at [agehealthy.org](http://agehealthy.org). See also the [review](#) that appeared in Environmental Health Perspectives.]

A stunning new report offers a comprehensive view of "environment and health," revealing some of the common mechanisms by which human health is shaped by the natural environment, the built environment, and the social environment. The report traces environmental influences on human health starting in the womb and continuing across the whole "arc of life" into old age.

It seems to me this perspective will likely recast the whole field of "environmental health" over the next 5 to 10 years.

The report, titled *Environmental Threats to Healthy Aging* (which I will call *Healthy Aging*), offers so many important new ideas (or, more accurately, newly reveals links between familiar ideas), it's hard to know where to begin. Ultimately the report offers a new way of looking at disease, and in the process reveals dozens of ways we could intervene to prevent (or at least reduce the likelihood of, or delay the onset of) the "Western Disease Cluster," (diabetes, cardiovascular disease, [metabolic syndrome](#), [lipid](#) disorders (which used to be known as "cholesterol problems"), and obesity), Parkinson's and Alzheimer's diseases (plus, arguably, asthma and cancer, though the report does not explore these two diseases in detail).

Just the idea that Alzheimer's and Parkinson's could be prevented, or delayed in onset, is hugely interesting and important.

This report will also serve activists: it strengthens the health arguments for policies that cover the full range of "environmental" concerns -- including (but not limited to) toxic chemicals, air pollution, food and agriculture, urban sprawl, transportation, green building, fossil fuels, alternative energy, neighborhood design, and gross disparities of income and wealth, among other things. In essence, **this report offers some new perspectives on every environmental problem.**

### A roadmap of the report

Because of its title, at first glance, the report seems to focus narrowly on chronic diseases that commonly afflict people over 65, with special emphasis on Alzheimer's disease and [Parkinson's](#) -- two devastating neurodegenerative diseases (meaning they damage the brain, slowly ruin your life, and grow worse as time passes). But by the end of the report, you have discovered a new way to think about "the environment," environmental health, and the "causes" of disease.

Fasten your seatbelts. As we follow the roadmap of this report, it carries us from the starting point -- Parkinson's and Alzheimer's -- to some common cellular mechanisms of many diseases (inflammation, oxidative stress and insulin resistance), which then lead us into the common killer diseases of modern life -- the "western disease cluster" -- which includes dementia, diabetes, heart disease, "[metabolic syndrome](#)," lipid disorders (what people used to call "cholesterol problems"), and obesity.

From here, the three mechanisms of disease lead us back into webs of causation that start with some of the 20th century's most important achievements -- fossil fuel combustion for industrial and personal purposes (to make electricity and heat, warm our homes, and power our automobiles -- fouling the air in the process); the industrialization of agriculture and the mass marketing of processed foods; the growth of car-dependent suburbs and the abandonment of cities; the rise of the synthetic chemical industry and the "chemicalization" of essentially every product we come in contact with (including food and food packaging, paper, cosmetics, personal care products, building materials, clothing, paints and other coatings -- you name it). The report shows how all these technologies can give rise to inflammation, oxidative stress and insulin resistance, and thus to the "Western disease cluster."

Now for some details:

(In this section, you may want to consult an online dictionary; we use Merriam-Webster, which is authoritative and offers a medical dictionary on its web site: <http://www.merriam-webster.com/>)

### **Parkinson's**

*Healthy Aging* tells us that symptoms of Parkinson's includes combinations of tremors, stiffness, and emotional changes that ultimately lead to severe disability, including, in many cases, dementia. About 50,000 new cases of Parkinson's disease are reported each year in the U.S. The prevalence of Parkinson's (the number of people living with the disease) is expected to double by 2030, *Healthy Aging* tells us. (The web site [wrongdiagnosis.com](http://wrongdiagnosis.com) estimates that currently there may be 3 to 4 million people in the U.S. with undiagnosed Parkinson's at various stages, but we have no "disease registry" for Parkinson's [in other words, no one's keeping track], so no one knows for sure.)

*Healthy Aging* tells us that Alzheimer's is estimated to directly affect nearly 4.5 million people in the U.S. (plus of course it affects their families and friends as well). This number is expected to nearly triple to over 13 million by 2050, as the U.S. population ages.

### **Alzheimer's**

Alzheimer's affects parts of the brain that control thought, memory, and language. Eventually a person with Alzheimer's is unable to carry out daily activities independently, requiring constant care. The risk of Alzheimer's increases with age. About 5 percent of all men and women ages 65-74 have Alzheimer's disease, while nearly half of those age 85 and older may have the disease.

Parkinson's and Alzheimer's are chronic diseases that profoundly affect individuals, families, communities, and society. *Healthy Aging* explains, "People with dementia have lost more than their cognitive ability. They have lost their personhood before losing their lives. People with Parkinson's live with more than shaking limbs and a stiff, unsteady walk. When they can no longer express their emotions on their faces they have lost essential ways of

communicating with lovers, families, friends, and others."

As noted above, the discussion of Parkinson's and Alzheimer's leads to a detailed explanation of two cellular-level features of both diseases -- oxidative stress and inflammation, which are inter-related biological processes. (Later, we learn of a third important contributor to many modern diseases -- insulin resistance.)

*Healthy Aging* points out that, with both Alzheimer's and Parkinson's, people with certain genes will be more likely affected. The report also points out that, even in those cases, interaction with environmental factors would be necessary to manifest disease.

### **Inflammation: The Immune System at Work**

*Healthy Aging* explains inflammation as "the process by which the immune system defends the host from organisms or material perceived as foreign and potentially threatening. As far back as the first century AD, the Roman encyclopedist Celsus identified inflammation as a constellation of four physical signs: Heat, pain, redness, and swelling, or in classical medical language, "Calor, dolor, rubor, and tumor." These signs are readily visible, for example, in the inflammation that accompanies an infected wound or traumatized tissue. They reflect the actions of various cellular and chemical mediators that are part of the immune response. The characteristic signs of inflammation can also occur in the absence of infection or trauma, as in the case of rheumatoid arthritis, asthma, or inflammatory bowel disease. In each of these diseases evidence of an inflamed organ system is apparent, at least indirectly -- namely red, hot joints in rheumatoid arthritis, purulent sputum from inflamed lungs in asthma, and bloody, purulent diarrhea from an irritated gastrointestinal tract in inflammatory bowel disease."

*Healthy Aging* makes the important point that, unlike classic inflammation (redness, swelling, etc.), the inflammation of chronic disease is hidden from view and can only be discovered by blood tests or by examining tissue under a microscope.

### **Oxidative Stress**

*Healthy Aging* describes "oxidative stress" as follows:

"Inflammation is closely related to the process of oxidative stress. Like inflammation, oxidative stress also increases in aging and especially in neurodegenerative diseases like Alzheimer's and Parkinson's disease.

"Oxidative stress is a metabolic state in which excessive levels of highly reactive, unstable oxygen compounds are present in the body, an organ system, or tissue. These unstable oxygen compounds are referred to as oxygen radicals, free radicals, or "reactive oxygen species" (ROS). ROS are normally held in check by the cell's antioxidant systems. Oxidative stress occurs when these defenses are overwhelmed -- due to either increased ROS or a deficiency of antioxidant mechanisms. In either case, damage results. ROS may be produced within the cell (endogenously), or may come from outside the cell (exogenously).

"Exogenous [outside the cell] sources of oxidative stress include air pollution; tobacco smoke; many different industrial chemicals including pesticides, solvents, bisphenol A, alkylphenols, type-2 alkenes, among others; metals; polycyclic aromatic hydrocarbons, PCBs, dioxin, and other pollutants; radiation, anesthetics and a high-oxygen environment...."

*Healthy Aging* says, "In this document we frequently emphasize, among the many potential

responses to environmental stimuli, the role of inflammation and oxidative stress in the origins of many diseases."

The report continues, "From the outset we stress that these [oxidative stress and inflammation] are natural biologic processes that play essential roles in maintaining health. However, toxic chemical exposures, certain kinds of diets, and social stress, among other factors, can chronically up-regulate [increase] inflammation and oxidative stress so that they become initiators or promoters of disease. Indeed, as we will show, **a coherent and compelling narrative links a number of environmental trends with abnormal up-regulation of these micro-level biologic processes.** Moreover, **inflammation and oxidative stress are key players not only in Alzheimer's disease and Parkinson's disease, but also in diabetes, cardiovascular disease, the [metabolic syndrome](#), [lipid disorders](#), and obesity.** We do not mean to suggest that abnormal inflammation and oxidative stress are the only pathological processes of concern. But they are major pathways through which numerous environmental factors are integrated and contribute to a variety of chronic diseases. We will discuss this in some detail." [Emphasis added.]

So, starting with Alzheimer's and Parkinson's, we have been introduced to underlying mechanisms (inflammation and oxidative stress) that are features of these two neurodegenerative diseases **and** of all the most common chronic diseases.

Now we are introduced to a third contributor to this cluster of diseases -- insulin resistance.

### **The Insulin Cascade**

(Warning: Get ready to check the [Merriam-Webster medical dictionary](#).)

*Healthy Aging* says, "Insulin is a powerful metabolic hormone affecting virtually every tissue in the body. Key insulin actions include facilitating the uptake of glucose [sugar] from the blood, synthesis of glycogen (a complex of many glucose molecules stored in muscle and the liver), production of nitric oxide by endothelial cells lining the inner blood vessel (allowing blood vessels to dilate, keeping them agile and healthy), and the inhibition of triglyceride synthesis (suppressing levels of serum triglyceride as well as VLDL, a lipoprotein that carries much of the triglyceride in the bloodstream). The insulin cascade activates signaling molecules that trigger key cellular actions of insulin.

Insulin signaling is disrupted in the states of insulin resistance and diabetes. The disruption of the insulin cascade provides a mechanism for the observed cluster of diabetes-associated diseases. Disruption of the insulin signaling cascade causes:

\*\* Failure of glucose uptake, (due to dysfunction of the glucose transporter), causing hyperglycemia (elevated blood sugar).

\*\* Disinhibition of VLDL synthesis, causing elevated levels of VLDL and triglycerides in the blood.

\*\* Disruption of endothelial nitric oxide production (in the inner lining of blood vessels), causing a loss of vascular agility and flexibility and leading to vascular disease in the heart, brain, and peripheral arteries.

"Emerging evidence suggests that dysfunction of the insulin cascade has adverse effects on neurological health. Thus, insulin resistance and diabetes are increasingly seen as contributing to the risks of Alzheimer's disease and cognitive decline," says *Healthy Aging*.

*Healthy Aging* makes clear that there is evidence connecting insulin resistance with Alzheimer's, dementia and the "Western disease cluster" but not with Parkinson's disease.

### **The Three Environments**

Having connected inflammation and oxidative stress to Parkinson's and, along with insulin resistance, to Alzheimer's **and** to the "Western Disease Cluster," *Healthy Aging* examines how the [three environments](#) that we all inhabit -- the natural, built, and social environments -- are each involved.

*Healthy Aging* says, "Our interest in the origins and patterns of Alzheimer's disease and Parkinson's disease led us into expansive terrain encompassing many aspects of the natural, built, and social environments. It became clear that we needed to consider these diseases in a social, cultural, and historical framework while trying to understand their biological underpinnings. We also found links to a cluster of other diseases and conditions and, therefore, needed to examine broader disease patterns and even the way that we name and classify diseases."

This is a point worth emphasizing. *Healthy Aging* suggests that traditional ways of looking at disease (you're either "sick" or "not sick") may be preventing modern medicine from understanding and diagnosing neurodegenerative disorders. Diseases like dementia/Alzheimer's, occur on a continuum -- you don't necessarily "have them" or "not have them" -- as you grow old, you are likely to have "less of them" or "more of them" (though of course some people will have "none of them," at least "none of them" that are discernible). Furthermore, diseases like dementia/Alzheimer's are not necessarily single diseases. Likewise with Parkinson's disease and the symptoms of parkinsonism. As *Healthy Aging* says, "Multiple pathologic mechanisms are likely to converge to cause a common clinical syndrome."

The presence of "multiple causal factors" makes it difficult to assign precise "cause and effect" relationships, but it **also** means there are many steps we can take to prevent, reduce the likelihood of, or delay the onset of, these diseases.

For two centuries, science has been examining smaller and smaller biological units -- the individual human, the individual organ (liver, brain, etc.), the bacteria or virus, the cell, the gene, and so on. This reductive approach -- reducing problems down to the simplest, smallest level -- has been extremely successful. However, it does not tell the whole story. Whole organisms living in the natural, built and social environments -- as we all do -- behave in ways that cannot be explained (or understood) by an examination of cells or genes. The whole organism, the whole person, is more than the sum of its parts. (Recognizing this, Barry Commoner created the Center for the Biology of Natural Systems at Washington University in St. Louis in 1966 to study whole organisms and biological systems.)

Therefore in biology and in medicine, reductive science misses much that is important -- even essential -- to understanding: an individual's interaction with his or her environment (diet, chemical exposures, social status and other emotional relations with family, friends, and larger community). *Healthy Aging* starts with a narrow focus on the health of people over 65 and ends by showing how health after age 65 begins in the womb before we are born: "We can think of age-related changes in brain function as being on the trajectory of an arc that begins decades earlier during fetal development."

So *Healthy Aging* carries us from the "Western Disease Cluster" back to conditions in the womb, and then connects those conditions to social and economic changes that occurred

during the 20th century -- industrialization of agriculture, mass marketing of processed foods, expansion of the chemical industry into every part of our daily lives, sedentary lifestyles, suburban sprawl, abandoned cities, fossil-fueled sources of heat and power, growing disparities between rich and poor, increasing stress, and so on. Thus *Healthy Aging* connects the arc of life, starting in the womb and ending in old age, with the social and industrial conditions of modern life, emphasizing the role of cellular biology (such as inflammation and oxidative stress) as the bridge that connects them all.

On the one hand, *Healthy Aging* is a highly-technical medical text aimed at specialists. On the other hand, it harbors within it a low-key, scientific manifesto declaring a new way of looking at disease, and a challenge to the environmental movement to learn to see the world in quite a different way.

This new perspective is desperately needed, but will probably have to be introduced creatively, in dozens of different ways, before it becomes widely accepted. Most clinicians (doctors who see patients) -- especially family medicine doctors, generalists -- already have too much to do. Insurance companies allow them 15 minutes with each patient, no more. So many find themselves on a rat-wheel of scheduled overload. Just keeping up with the flood of new studies and new information is difficult at best. It would be asking a lot to expect clinicians to accept a new medical paradigm, especially one that asks for a new blend of medical practice (treating disease in the individual) with a public health perspective (changing conditions in the community to affect community health -- improving school lunches, making neighborhoods more walkable, eliminating chemical exposures to the extent possible, reducing inequalities in opportunity, income and wealth -- all the things public health practice tells us will pay huge benefits by preventing disease -- including all the diseases in the western Disease Cluster plus Parkinson's and Alzheimer's).

Likewise, the environmental movement will not immediately adopt the perspective of the "[three environments](#)," though eventually it will.

So I see *Healthy Aging* as a potent seed document -- a first explanation of new perspective on disease. All the pieces of this report have existed before -- but they've never (to my knowledge) been put together the way they are here. This is new and exciting, but it strongly implies a need for new approaches; it rocks the boat; as such, will be ignored by some, resisted by others, and only fully accepted as time passes.

From this important seed document, I expect new work to grow in several directions:

- (1) many new detailed studies of the role of oxidative stress, inflammation and insulin resistance as common elements in every part of the Western Disease Cluster plus Parkinson's and Alzheimer's;
- (2) many more medical studies of disease in relation to the three environments (natural, built, and social) -- and eventually even acknowledgement by the environmental movement that there **are** [three environments](#);
- (3) many much simpler articles written for a general audience explaining what this new approach to disease means for the lives of ordinary people (and for the strategies of activists) and why the environmental movement should finally forge a strong partnership with the public health community (the rationale is simple: they need each other);
- (4) simpler articles explaining what this new approach to disease means for public-health policy-makers aiming to reduce the social and dollar costs of disease by modifying the three environments.

This report offers an amazing set of insights that will alter medical and public health practice, and will reorient the environmental movement, once the ideas have been spread around sufficiently. This, then, is the task ahead -- to get these ideas into editorials in medical and public health journals, into medical and public health school curricula, into the popular press (including op-eds, but also into editorial board meetings of media outlets), into school board discussions and into kids' classrooms, into state health and environmental agencies, and into the work of environment and public health activists as they try to reorient industrial agriculture, food (processing, packaging and marketing), the chemical industry, cosmetics and personal care products, pharmaceuticals, transportation, urban and neighborhood planning and design, green building, and so on.

Environmental health can no longer be viewed as "one chemical, one disease." As Sandra Steingraber described it when she released her own [path-breaking report](#) on causes and consequences of early puberty in girls, environmental health is a "huge jigsaw puzzle."

The *Healthy Aging* report connects many more pieces of that immense puzzle, and, as a result, a new picture is emerging of the relationships between 20th century technologies, the three environments, disease, and health -- all tied together by emerging understandings of common pathways to disease such as inflammation, oxidative stress, and insulin resistance.

It may well be that there are other common biologic pathways to disease besides inflammation, oxidative stress and insulin resistance. But what is important about this perspective is that, if we set a goal of reducing each of the factors that create inflammation (or any of the other final common pathways to disease), we can expect to see many kinds of benefits, reducing many chronic disease conditions simultaneously.

As we lose our simplistic picture of one-chemical-one-disease (or any other single cause), we are learning to appreciate -- and tease apart -- "webs of causation" -- which allows us to see that there are dozens or hundreds of interventions that can improve health and well-being in individuals, families, and communities. This is important. Really important.