Chapter 9
Healthy Aging: The Way Forward

This final chapter summarizes what we have learned and what it suggests about how to respond—individually and collectively.

In the preceding chapters we reviewed much of what is known about the underlying causes of the two most common neurodegenerative diseases, with particular attention to modifiable environmental contributors. We also identified links to a cluster of common Western diseases and environmental threats to healthy aging more generally. This final chapter summarizes what we have learned and what it suggests about how to respond—individually and collectively.

Much of what we discuss in this chapter is not new. It draws on the work of others from the fields of medicine, public health, evolutionary biology, environmental health, and ecology—and it draws on common sense. What may be new, however, is the urgency of adopting a far broader "ecological" vision of what is required to achieve healthy aging. Preventing or slowing the progression of neurodegenerative diseases is an additional reason to take actions that have already been recommended for reducing the risks of diabetes, obesity, cardiovascular disease, and some kinds of cancer. Moreover, interventions that address the structural, systemic origins of these conditions, across the human lifespan, can be designed to benefit ecosystems more generally, thereby linking healthy aging to planetary healing.

No single strategy is likely to be highly effective. Since these diseases are heterogeneous in origin, multiple interventions will be necessary to reduce their burdens. The good news is that interventions likely to be beneficial are achievable and afford multiple entry points into the cascade of events leading to degenerative disease and disability. It may take time to see results, but this should not be used as an excuse to delay.

The apple is a symbol of health (and tempation!).

In this chapter we will summarize our key findings, describe what we mean by an ecological strategy to achieve healthy aging, and conclude with policy recommendations based on such a strategy. It is true that much depends on actions and choices made by individuals. But it is also true that actions of individuals have not been sufficient

to meet health-related goals and create a healthy society. Indeed, some trends are headed in the wrong direction. Our lives are deeply embedded in larger structures that strongly influence or limit individual choices. For this reason, in order to think strategically, we must use an ecological framework or model that includes a more complete reality of the world and how we live in it.

We hope this effort will encourage others to draw their own conclusions and recommend or develop their own strategic interventions in support of healthy living throughout all stages of life. Successfully addressing the expected upsurge in age-related health conditions will require the best efforts from all of us.

Diseases involving excessive oxidative stress, inflammation, and other relevant pathologic mechanisms are not only diseases of individuals but also of communities and societies.

What Have We Learned?

In the preceding chapters we described an emerging, unifying framework for understanding two neurodegenerative diseases and related conditions. The framework has multiple levels, from sub-cellular to society as a whole, as well as multiple dimensions: biologic, social, economic, and cultural.

At the micro-level, key processes of inflammation and oxidative stress play critical roles in the development and progression of Alzheimer's disease and Parkinson's disease. These processes are also linked to diabetes, obesity, cardiovascular disease, and cancer, among others, so that we can begin to think of common mechanisms that underlie prevalent disease patterns and not just individual diseases.

These cellular and sub-cellular processes of oxidative stress and inflammation are influenced by variables at the level of the individual, community, and society: how and where we live, eat, work, play, and travel; social networks; community wellbeing; and income disparities, among others. Individuals can often make choices that will help prevent or slow the onset of neurodegenerative conditions, but community-wide features of the shared environment must also be addressed. Diseases involving excessive oxidative stress, inflammation, and other relevant pathologic mechanisms are not only diseases of individuals but also of communities and societies. And the diseases of old age do not usually begin in old age. They are influenced by many variables throughout the lifespan.

Many technologies introduced in the past 50–100 years drive inflammatory pathways and excessive oxidative stress. Trends in agriculture, food production, and nutrition—including factory farming, fast food, and processed foods—have created a pro-inflammatory nutrient profile. The material economy is infused with toxic chemicals

in products and practices that drive these and other underlying biological aspects of neurodegeneration and many other diseases. Transportation adds significantly to air pollutants that cause inflammation and oxidative stress. Socioeconomic stress and loss of social networks add to the burden. Complex interactions among these variables create the conditions from which today's patterns of disease emerge.

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The Ecological Health Framework

Individual behavior and environmental exposures influence health, but family-, community-, and societal-level features are also expressed in individuals, even at the cellular and sub-cellular levels. Here are some examples:

- Socioeconomic status has an effect on the risk of coronary heart disease, independent of other risk factors such as smoking or diet.[1]
- One study showed that children with asthma in low-income families have higher baseline levels of markers of inflammation than children with asthma in higher income families.[2] Another showed that, among children with asthma, poor children have more symptoms in response to traffic density than better off children in the same neighborhood.[3]
- Children who are small at birth have increased levels of markers of oxidative stress in their blood, and these changes appear to persist into later childhood.[4] Low–birth weight children are also at increased risk of developing diabetes and obesity later in life. This is generally thought to be due to fetal programming that permanently sets neuroendocrine and metabolic systems in such a way that the fetus developing in a nutrient poor environment is less able to adapt to a nutrient- and calorie-rich environment after birth. Some scientists believe that the changes associated with low birth weight also increase the risk of Alzheimer's disease later in life.[5] If this is true, then risk factors for low birth weight—for example, maternal nutrition and adverse maternal fatty acid profiles,[6] maternal age, ethnicity, smoking status, air pollution,[7] [8] and neighborhood characteristics,[9] among many others—contribute to the risk of dementia in offspring decades later.

Researchers are increasingly aware that we must look at multiple levels for explanations of diseases and disease patterns. Expanded models, sometimes called eco-social, bio-eco-social, or ecological frameworks or paradigms, are attempts to capture this awareness. These frameworks fundamentally embed health in the context of the larger community, society, and ecosystem.[10] [11] Moreover, the ecological framework not only embodies an expanded, interconnected worldview, but also suggests new approaches to research into the origins of disease and disease patterns, as well as policy interventions likely to improve health.

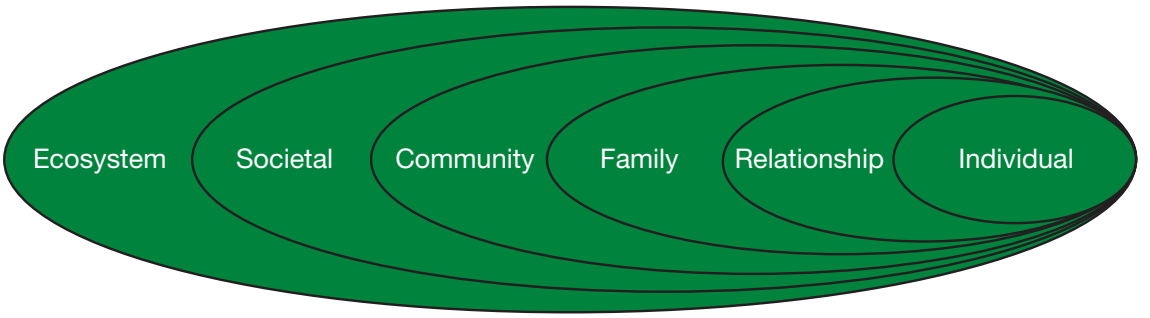

Figure 1: Ecological Model of Health/Disease

This model emphasizes the progressive nesting of individuals within families within communities and finally within ecosystems. Variables at any level can directly or indirectly influence measures of health at any level. Influences may be identifiable in individual markers such as blood pressure, atherosclerosis, and inflammatory mediators. Or they may be identifiable in neighborhood- or community-level markers such as disease patterns or socioeconomic gradient. The ecological framework implies far less distinct boundaries across levels than our medical, public health, and environmental health institutions generally acknowledge.

The causes of cases of diseases in individuals are not necessarily the same as the causes of incidence or patterns of diseases in populations. Patterns of disease are established by the distribution of risk factors throughout a population, but an individual's risk of a disease is influenced by individual susceptibility and the specific aggregation of risk factors in that person. For example, in some people with Parkinson's disease, pesticides are likely to have played a larger role than in others. Similarly, in some people with Alzheimer's disease, air pollution or diet is likely to have played a larger role than in others. Consequently, the effect of population-wide interventions on specific individuals will remain uncertain.

Nevertheless, even modest reductions in risk factors at the population-wide level can have major public health benefits. This is particularly true when a large fraction of the population is exposed to the hazard. Then, even a small reduction in disease risk can

translate into a large number of cases avoided. For example, in 2002 a large controlled study of health effects associated with hormone replacement therapy concluded that treated women had a 26% higher risk of developing breast cancer than controls.[12] (The hazard ratio was 1.26; 95 percent confidence interval 1.00-1.59.)[a] When that information was publicized, prescriptions for hormone replacement therapy plummeted nationwide. Breast cancer surveillance data show a drop in post-menopausal breast cancer incidence beginning soon thereafter, with an estimate of approximately 14,000 fewer cases in 2003 compared to 2002.[13] For each individual woman, the excess risk of breast cancer from the therapy was estimated to be small, but at a population wide level, the impact quite large. Even though some uncertainty persists, most commentators believe that the decline in hormone replacement therapy is responsible for the drop in breast cancer incidence in post-menopausal women.

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Keeping this experience in mind helps when thinking about potential public health benefits of interventions intended to address diseases of aging addressed in earlier chapters. For example, as discussed in chapter 8, although we will never have data from a controlled trial, considerable evidence shows that it is highly likely that pesticide exposures increase the risk of Parkinson's disease. Since a large portion of the general population is exposed to pesticides, even if the increased risk conferred by them were modest, a sharp reduction in exposures would likely result in a decrease in Parkinson's disease within the population.[b]

Similarly, we predict that population-wide shifts toward the Mediterranean diet would significantly decrease the incidence of diabetes, obesity, cardiovascular disease, and Alzheimer's disease. That does not mean that everyone eating a Mediterranean diet will be spared from these conditions. In some people, other risk factors may be determinative, regardless of diet. But from a public health perspective, that kind of dietary modification is highly likely to be beneficial and can easily be supported by the evidence.

Finally, the ecological framework also reminds us that, in some individuals, risk factors of modest size in populations can

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[a] *The report also noted increases in the risk of heart disease, stroke, and blood clots.*

[b] *Changes in exposure patterns will depend on the nature of interventions. Fundamental shifts in agricultural practices will be necessary to protect agricultural workers and communities who are among the most highly exposed groups. Shifts in pest control practices in housing will be necessary to protect tenants who often have little control over pesticide use. Population-wide decreases could shift high exposure groups into moderate level exposures and moderate exposure groups into low level exposures. Reductions in pesticide exposures are also likely to reduce a number of other diseases and disabilities linked to pesticides not discussed herein.*

be much more significant when they occur together with others. For example, poverty, dietary iron deficiency, and lead exposure are independent risk factors for cognitive impairment in children. When they occur together, they act as effect modifiers, meaning that the presence of one or more increases the impacts of another. The consequences of lead exposure are worsened by iron deficiency because lead uptake from the intestine and lead deposition in the brain increase.[14 15] Moreover, a child living in poverty, exposed to lead, and eating a diet deficient in iron is not only unlikely to achieve full neurodevelopmental potential but also may be at increased risk of earlier and more severe cognitive decline later in life.

The ecological framework reminds us that, in some individuals, risk factors of modest size in populations can be much more significant when they occur together with others.

Applying the Ecological Health Model to Aging and Neurodegenerative Disease

Despite remaining uncertainties about which are causes and which are consequences of disease progression, considerable evidence shows that the mechanisms of inflammation and oxidative stress are intimately involved in the cascade of events leading to the onset of Alzheimer's and Parkinson's diseases. An ecological perspective calls our attention to how factors at many levels (individual, family, community, societal, ecosystem) can pathologically upregulate oxidative stress and inflammation and thereby influence risk in individuals and patterns of disease in populations. We can also see why the age-adjusted incidence and prevalence of Alzheimer's disease may vary from one society to another, depending on the distribution of risk factors within them.[c]

Attempts to diagram such a framework, however, often end up with an "arrow salad" in which it appears that everything causes everything else. Such complex interconnections make it difficult to quantify with certainty the extent to which a single variable contributes to a particular outcome.

With conditions like diabetes, cardiovascular disease, cancer, and in all likelihood, Alzheimer's disease and Parkinson's disease,

[c] *It may or may not be true that the incidence and prevalence of Parkinson's disease varies similarly but data are not sufficient to draw any conclusions.*

FOOD *for* THOUGHT

Farm-To-School, Farm-To-Hospital Food Programs

The nature of the American diet has changed dramatically over the past 50–100 years. Most of today's food production and distribution system depends heavily on large inputs of fuel, chemicals, and fertilizer. Trends in chronic disease and ecosystem health are significantly linked to that system through nutritional deficits and imbalances; chemical contamination of food, water, soil, and air; loss of biodiversity and habitat; and hardship in rural communities.

In recent years, efforts to strengthen supply and demand for nutritious, locally produced food have found rapidly growing opportunities in farm-to-school and farm-to-hospital programs. Many schools and hospitals are now featuring fresh farm foods, often certified organic or produced in ways more ecologically sustainable than typical in high-input, industrialized agricultural systems. These programs have several objectives and address multiple problems.

These programs offer reliable, stable markets for small farmers, thereby helping the local economy.

Kaiser-Permanente now hosts more than 20 farmers' markets at its healthcare facilities in several states

Farm-to-school programs improve student nutrition and can help educate students about the links between nutrition and health. This is increasingly urgent given current trends in obesity, diabetes, heart disease, Alzheimer's disease, and cancer, each of which is linked in varying degrees with lifelong eating habits that are established early. In addition, students can learn about the connections between food production methods and the health of ecosystems.

Farm-to-hospital programs provide nutritious food to patients, staff, and visitors. More than 120 healthcare facilities in 21 states have signed "The Healthy Food in Health Care Pledge," committing to increase local purchasing and offerings of fresh fruit and vegetables and meat and milk produced without the use of hormones or antibiotics.

In some cases, hospitals provide space for local farmers' markets, improving access of neighborhood residents to locally produced, nutritious food. For example, Kaiser-Permanente

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now hosts more than 20 farmers' markets at its healthcare facilities in several states. These may be the only readily available source of fresh, nutritious food in neighborhoods with no nearby supermarkets. Programs that bring more nutritious food into hospitals are also a highly visible signal that the medical sector takes seriously the connections between health and nutrition. Finally, these programs offer reliable, stable markets for small farmers, thereby helping the local economy.

These programs do even more. By emphasizing the connections among nutrition, human health, and the health of the land, they add to the incentives and pressures for more widespread, fundamental, and sustainable changes in food production, marketing, and distribution.

Resources:

The National Farm to School Program is a collaborative program of the Center for Food and Justice at Occidental College and Community Food Security Coalition. For more information, see http://www.farmtoschool.org/aboutus.php.

Farm-to-hospital programs are featured in the work of Health Care Without Harm, an international campaign working to transform the health care sector so that it is no longer a source of harm to people or the environment. For more information, see http://www.noharm.org.

we need to rethink what we actually mean when we say that some particular variable "causes" the disease to occur. In multi-factorial diseases single factors are rarely fully explanatory, and proving causation can be difficult indeed. Yet, in order to prevent the onset or progression of these illnesses, individuals and public policy decision-makers often must act without absolute proof of the role of each variable. Sixty years of "tobacco science," during which tobacco company scientists and executives argued that there was no proof that cigarettes caused lung cancer, should have taught us that to wait for absolute proof is to wait too long.

The good news is that the multiplicity of contributing factors provides multiple entry points for beneficial interventions. The ecological framework shows that many risk factors can be addressed at multiple levels. For example, both increased exercise and decreased caloric intake will help to reduce obesity. These can be addressed through individual behavioral change and through action at the community level to ensure that sidewalks, bicycle paths, parks, safe neighborhoods, and nutritious food are accessible and available to all. In complex systems, although we can never predict all of their results, interventions can be guided by principles, available evidence, and monitoring for consequences—unintended as well as intended.

Knowing about effect modifiers is also helpful for guiding the design of policy interventions. For example, a recent cross-sectional study of 1,375 men and women reports that narrowing of the carotid artery because of atherosclerosis is inversely associated with cognitive function, but only in those participants of low socioeconomic status.[16] In other words, low socioeconomic status is an effect modifier of carotid artery narrowing, increasing its detrimental impact on cognitive ability. One potential explanation for this finding is lack of brain reserve or plasticity in individuals of low socioeconomic status. Whatever the biologic underpinnings, the study suggests that efforts that successfully decrease risks of atherosclerosis will be especially helpful in people of lower socioeconomic status. But it also means that cognitive function can be preserved by decreasing the socioeconomic gradient. We do not need to choose between the two and may actually identify interventions that address both.

We should not hesitate to identify multiple opportunities to reduce the drivers of oxidative stress and inflammation—including diabetes, obesity, chemical exposures, and socioeconomic disparities—at multiple levels, in individuals and the population as a whole.

No risk factor should be exempt. We can confidently predict that, when successful, these efforts will have beneficial effects on multiple diseases and disabilities.

Creating More Stable Conditions for Health

Borrowing from the field of ecology, it may be useful to think of the systems in which we live as basins shaped by certain conditions that tend to be self-reinforcing. Some sets of conditions—represented in Figure 2 as Basin A—are likely to promote health, while others - Basin B - are not. A person or group's location within a given set of system conditions will be a strong determinant of how precarious their circumstances are, and that can change over time. The conditions and residents of healthy Basin A provide ongoing opportunities for primary and some secondary disease prevention. In Basin B, the emphasis must be on early detection and treatment of disease, although there will be some opportunities for secondary prevention.[d]

The system conditions that shape each basin may change. For example, changes in weather patterns, crop failures, armed conflict, economic instability, or epidemic disease can cause abrupt changes in system conditions, making system inhabitants suddenly vulnerable to disease or injury from which they were previously

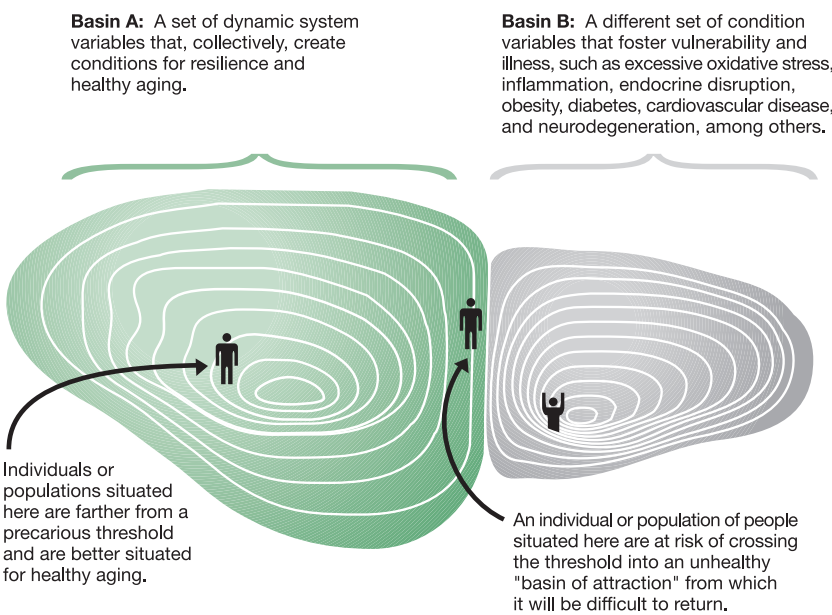


Figure 2:

Graphic depictions of dynamic systems comprised of collections of ecosocial variables in which individuals and communities live. In the field of ecology these are called basins of attraction and the bottoms of the bowls are the attractors.[17] See text for further explanation.

[d] *By primary prevention, we mean prevention of the onset of a disease process. Secondary prevention refers to preventing complications from a disease process that is already initiated.*

buffered (Basin A becomes small and shallow). System conditions can also change more slowly, and as they do, shifts in health and wellbeing are likely, with the most vulnerable being the first to experience consequences of the change.

Two general approaches can maximize the likelihood that individuals and communities will remain in Basin A: 1) move them away from the precarious Basin B threshold or 2) change the shape of Basin A so that it is deeper and wider and fewer people find themselves near the Basin B threshold.

Medical practice tends to focus on moving individuals away from the threshold in basin A and responding once they have crossed into Basin B. Public health practice adds attempts to change the shape and size of Basin A so that fewer people find themselves near the threshold and struggling in Basin B. A combination of individual and system-wide approaches can build resilience, making the unhealthy sink less available and maximizing opportunities for remaining in the health-promoting system. An ecological approach addresses both individual actions and societal conditions.

Human existence requires living within the regenerative capacity of the biosphere.

A large number of changes that have occurred in the U.S. and much of the industrially developed world over the past 50–100 years have sufficiently altered conditions so that more people are living precariously near or beyond threshold conditions that collectively foster many of today's prominent diseases, including those discussed in this report. Our task, then, is not only to respond to the medical and social needs of people in or headed toward basin B, but to try to optimize system conditions so that fewer people find themselves at risk.

Three further premises must guide our decisions:

- Human existence requires living within the regenerative capacity of the biosphere. Objective data overwhelming support the conclusion that human activity on the planet already exceeds that capacity and has for some time.[18]
- Organizing human existence on earth in ways that are sustainable and just and that acknowledge and respect universal human rights is both desirable and possible. In a world of intricate interdependencies, the quality of life of all people must be considered when making decisions. For example, agricultural policies that do not take into account food access and the economic security of farmers in developing countries are neither sustainable nor just. A large body of literature shows that the position of an individual,

Health, Wealth, and Poverty

Nancy Adler from the University of California, San Francisco and many of her colleagues have gathered a wealth of publicly available information describing the medical and public health implications of the socioeconomic ladder and its steepness.[21] Many health disparities are directly related to conditions of life at various positions on the ladder. People at the bottom are often poorly educated, unemployed or in low-wage jobs, have little savings and other resources to rely on, and live in substandard conditions. These lives are stressful. Stress is caused both by adverse circumstances and limited ability to alter them because of lack of control and limited resources. People living lower on the socioeconomic ladder are at higher risk of heart disease, diabetes, obesity, hypertension, and most kinds of cancer. They also tend to have higher levels of markers of inflammation, which is likely to help explain these higher risks.[22 23] For a variety of reasons, people lower on the socioeconomic ladder are also likely to have less education, which increases the risk of Alzheimer's disease/dementia and its consequences. In other words, the diseases of the Western disease cluster are over-represented in people lower on the ladder.

Disparities in health are not confined to people living in poverty. They are present at every level of the socioeconomic ladder.

In the World Values Survey, including forty countries, Americans were much more likely than Europeans (71 percent v. 40 percent) to agree with the statement that the poor could escape poverty if they worked hard enough.[24 25] This may reflect the strong cultural individualism dominant in the U.S. since its origins. It may mean that we generally have little interest in attacking the root causes of poverty with public resources. It may also signal that we have limited interest in using public resources to close the gap at any level. But, the disparities in health are not confined to people living in poverty. They are present at every level of the socioeconomic ladder. Thus, as the gradient becomes steeper and the ladder longer, the disease burden attributable to income inequalities will continue to grow. A decrease in social capital in large groups of people who are marginalized is likely to accompany increasing inequalities. Less social cohesion coupled with the demographic shifts outlined in chapter 1 will almost certainly be a recipe for less healthy aging. We are ill prepared to deal with the consequences of these trends, and yet objective data make clear what lies ahead.

Two kinds of policies are required to eliminate socioeconomic disparities and their health consequences.[26] The first is policies that directly reduce disparities and make it easier for everyone to move up the ladder. Examples include access to high quality education, starting in early childhood; increasing the number of households with adequate income through a variety of means including tax policies; and improving access to opportunities for new or enhanced job skills. A second kind of policy blunts the consequences, including health risks, associated with position on the socioeconomic ladder. This includes, for example, ensuring universal access to health care, ensuring affordable, safe, and healthy housing and neighborhoods; limiting workplace exposures to physical hazards, chemicals, and psychosocial stress, providing for more worker- and family-friendly work environments; providing leave time for family illnesses and emergencies; and ensuring that all individuals and neighborhoods have access to nutritious food.

family, or neighborhood on the socioeconomic ladder is consistently a strong predictor of health. (See "Health, Wealth, and Poverty.) Illnesses and environmental degradation related to poverty and socioeconomic disparities have consequences for society at large, nationally and internationally.

- Disease prevention should be raised to a much higher priority than is reflected in current policies that overwhelmingly direct resources toward early diagnosis and treatment. Primary prevention can have a large return on investment[19] and can reduce the environmental and public health impacts of the healthcare industry itself.[20]

These premises are interdependent and they are not really optional if long term human survival with lives of quality is a goal. Vast and growing numbers of the world's population are entering a period of unprecedented challenges to health, security, and survival. No sector of society or institution can ignore these issues as they plan future activities

Policy Interventions

The following are basic areas we believe must be addressed at societal levels. Important, highly relevant recommendations at a personal and family level follow in *Approaches to Healthy Living*.

Rather than be prescriptive, we provide a few examples. We hope that others working in these sectors and at all ecosystem levels will participate in co-creating a new framework for health.

1) Nutrition:

Healthy nutrition is essential, beginning with fetal development and continuing through infancy, childhood, adolescence, and all stages of adulthood into the elder years. Lifelong nutrition is strongly connected with health in later years. Our *Approaches to Healthy Living* spell out many dietary recommendations for individuals. What follows are additional important considerations. Given all we know about the origins of the diseases of aging, it is appropriate to focus many of our recommendations on the beginning of life.

Community, Workplace

- Communities should ensure that all residents have access to healthy foods and not live in "food deserts" where they can only

buy processed and packaged foods. Recently, a community in Los Angeles, CA banned additional fast food restaurants and is encouraging healthier alternatives.[27]

- Maternal and child health policies and programs, starting with prenatal education and through programs like Women, Infants and Children (WIC) and food stamps, should prioritize optimum nutrition. Hospital personnel and healthcare providers should be educated about the benefits of exclusive breast feeding for the first six months of life and institute comprehensive supportive programs. No hospital should send new parents home with gift packs containing infant formula. That practice, no matter how well-meaning, is associated with decreased length of breast feeding.[28] Workplaces could be strongly encouraged to make accommodations for mothers to breast feed their infants after returning to work.
- Communities should consider requiring fast-food restaurants to prominently display caloric content of menu items. A recent study shows that this practice results in fewer purchased calories.[29]
- Various school-based obesity intervention programs have been tried.[30] No one program design has proven best and to some extent, optimal programs will depend on specific demographics of the population, school setting, and other local details. For that reason, school boards and officials should undertake a review of available data and adopt programs best suited to their circumstances. School vending machines should not sell unhealthy processed, high-calorie, snack food.
- Healthy food as outlined in the *Approaches to Healthy Living* should be served at hospitals, nursing homes, and other places where the aged and other vulnerable groups spend time.
- Community gardens, farmers markets, food coops, community supported agriculture (CSA) organizations, and "buy local" campaigns help promote local, diversified, sustainable, and nutritious food production and foster community relationships.

National

- Farm policies should not subsidize those foods or agricultural practices that contribute to obesity, diabetes, cardiovascular disease, and cognitive decline. Rather, agricultural subsidies should be directed toward programs and practices that provide sufficient nutritious, sustainably produced food and restore ecosystems that have been degraded by agricultural activities.

- Establish and support a research agenda intended to identify climate-friendly agriculture(s) that use less energy, require fewer inputs, and reduce water use. The specifics of appropriate agricultural models are highly dependent on place. However, certain underlying principles can be established and serve as guides.[31]

International

- Trade policies should foster sustainable food production, worker protection, and replenishment of natural resources.
- Technology sharing between donor and developing states with a focus on sustainable practices should be emphasized.

2) Toxicants:

Chemical trespass, whereby people are exposed to hazardous substances unknowingly or against their will, beginning in the womb and continuing throughout life, should not be tolerated. We should make every effort to prevent exposures, replace toxicants with safer alternatives, and minimize exposures especially to the most vulnerable populations.

People are exposed to hazardous substances unknowingly or against their will, beginning in the womb and continuing throughout life.

Community, Workplace:

- Adopt community-wide policies, including in schools, other public buildings, senior centers, nursing homes and other facilities that support or care for the elderly, that discourage or prohibit unnecessary use of pesticides, including for cosmetic purposes; promote Integrated Pest Management.
- Assess, monitor, and remediate hazardous waste sites; inventory and publicize sources of hazardous emissions.
- Promote lead paint testing and abatement in residences; promote childhood lead screening.
- Workplaces should commit to providing appropriate information and protecting workers by eliminating hazardous materials from use when safer alternatives exist; fully protect workers when hazardous exposures may occur.
- Develop and promote "green" jobs and industries.
- Commit to increasing community waste reduction and recycling efforts; set goals, monitor, adjust strategies.
- Promote public transportation to decrease fuel consumption and air pollution.

National:

- Pre-market safety evaluation of pesticides should require assessment of impacts on the developing nervous system.
- Non-pesticidal industrial chemicals are currently regulated under the Toxic Substances Control Act (TSCA). For more than 25 years TSCA has failed to protect people, wildlife, and the general environment from exposures to hazardous chemicals.[32] In fact, TSCA has helped to create and maintain data, safety, and technology gaps, rewarding ignorance and failing to provide incentives for development of safer materials.[33] National chemical policy reform is essential and elements of reform should include[34]:
  - Require safer substitutes and solutions. Seek to eliminate the use and emissions of hazardous chemicals by altering production processes, substituting safer chemicals, redesigning products and systems, rewarding innovation and re-examining product function.
  - Phase out persistent, bioaccumulative, or highly toxic chemicals.
  - Give the public and workers the full right-to-know and participate: Provide meaningful involvement for the public and workers in decisions on chemicals. Disclose chemicals and materials, list quantities of chemicals produced, used, released, and exported, and provide public/worker access to chemical hazard, use and exposure information.
  - Act on early warnings: Prevent harm from new or existing chemicals when credible evidence of harm exists, even when some uncertainty remains regarding the exact nature and magnitude of the harm.
  - Require comprehensive safety data for all chemicals: For a chemical to remain on or be placed on the market manufacturers must provide publicly available safety information about that chemical. This is the principle of "No Data, No Market."
  - Take immediate action to protect communities and workers: When communities and workers are exposed to levels of chemicals that pose a health hazard, immediate action is necessary to eliminate these exposures. No population should be disproportionately exposed to hazardous chemicals.
- Prioritize clean, sustainable energy production from renewable sources; promote energy conservation

International:

- Support the United Nations Environment Program's Strategic Approach to International Chemicals Management (SAICM). SAICM was developed by a multi-stakeholder committee and supports the achievement of the goal agreed at the 2002 Johannesburg World Summit on Sustainable Development of ensuring that, by 2020, chemicals are produced and used in ways that minimize significant adverse impacts on the environment and human health.[35]
- Support efforts to sharply curtail green house gas emissions, mitigate climate change, and reduce hazards associated with energy production.

3) Exercise, Physical Activity

Regular exercise and physical activity is essential to good health and should be encouraged and supported at all ages.

Community:

- City programs, planning, and development should reflect an understanding of the health-promoting, disease-preventing qualities of regular exercise and provide safe recreational areas for all ages and neighborhoods. Development and maintenance of green spaces and parks based on design principles that have been demonstrated to work will increase their use for exercise.[36]
- Physical education should be promoted and protected in school curricula. Exercise should be part of regular routines at facilities that support and care for elders. Nursing homes, assisted living, and other care facilities should incorporate outdoor exercise areas into their designs.
- City planners should explore options for discouraging driving in towns and cities; build bike paths and commit to sidewalk maintenance, repair, and lighting. Public transportation systems should complement and interface with pedestrian walkways and bike paths.
- Employers should be encouraged to promote walking and cycling to work and to provide opportunities for employees to walk and exercise during breaks.

National:

- Search for and eliminate transportation subsidy programs that might create disincentives for physical activity and exercise.

4) Cross-cutting Solutions

Some policy interventions are cross-cutting, addressing multiple risk factors simultaneously. For example:

- Encouraging more localized, diversified, and sustainable food production rather than factory farming would enhance nutrition, strengthen local economies, reduce reliance on pesticides, and minimize the use of fossil fuels for long distance transport. This would reduce air and water pollution as well as greenhouse gas emissions.
- Transitioning to clean, renewable energy and reducing fossil fuel consumption in general would drastically reduce air pollution and its multiple adverse health impacts, while undercutting a host of harmful chemical exposures related to production, transport, and use of fossil fuels. Prioritizing the development of energy-efficient mass transit systems that interface with bike paths and sidewalks would save energy while minimizing air pollution and combating obesity.
- Reducing use of toxic substances in the home, workplace, and community through "safer substitute" programs and green product design can reduce exposures that contribute to neurodegeneration and many other chronic diseases, reduce ecosystem and wildlife contamination, and create new jobs.
- Reducing socioeconomic disparities and making certain that all people have access to affordable health care, as a right and a matter of decency, will reduce the general chronic disease burden and help to alleviate its consequences for individuals and society.

These recommendations are only examples of interventions that would help to address the oncoming wave of age-related chronic disease. They obviously cut a wide swath through many features of contemporary society and sound like part of a more comprehensive environmental public health agenda—yet they are exactly what's needed. Enough evidence is in to make that case.

We do not underestimate the breadth of these ideas. The ways that we are growing our food, what we are eating, the toxic chemicals we are exposed to, the way that we are organizing and building our houses and communities, moving around, working, and spending leisure time are directly related to the chronic disease burden that we face—individually and collectively. This suggests many opportunities for interventions which alone may only be piecemeal, but collectively add up to real change.

Resistance is certain. Interest groups benefiting from the status quo will lay blame elsewhere and conflate scientific uncertainties with "junk science."[37] [38] They will demand absolute proof before acceding to demands for preventive action. The proposed ban on additional fast food restaurants in a Los Angeles community drew criticism for intervening in personal choice, singling out one kind of restaurant, not going far enough, and failing to address other causes of obesity.[39] Yes indeed, obesity is a result of many variables, and we can only hope that this effort will be combined with others to address the problem further in this burdened community. But they deserve credit for taking this on as an urgent public health concern requiring more than handing out pamphlets about healthy eating habits.

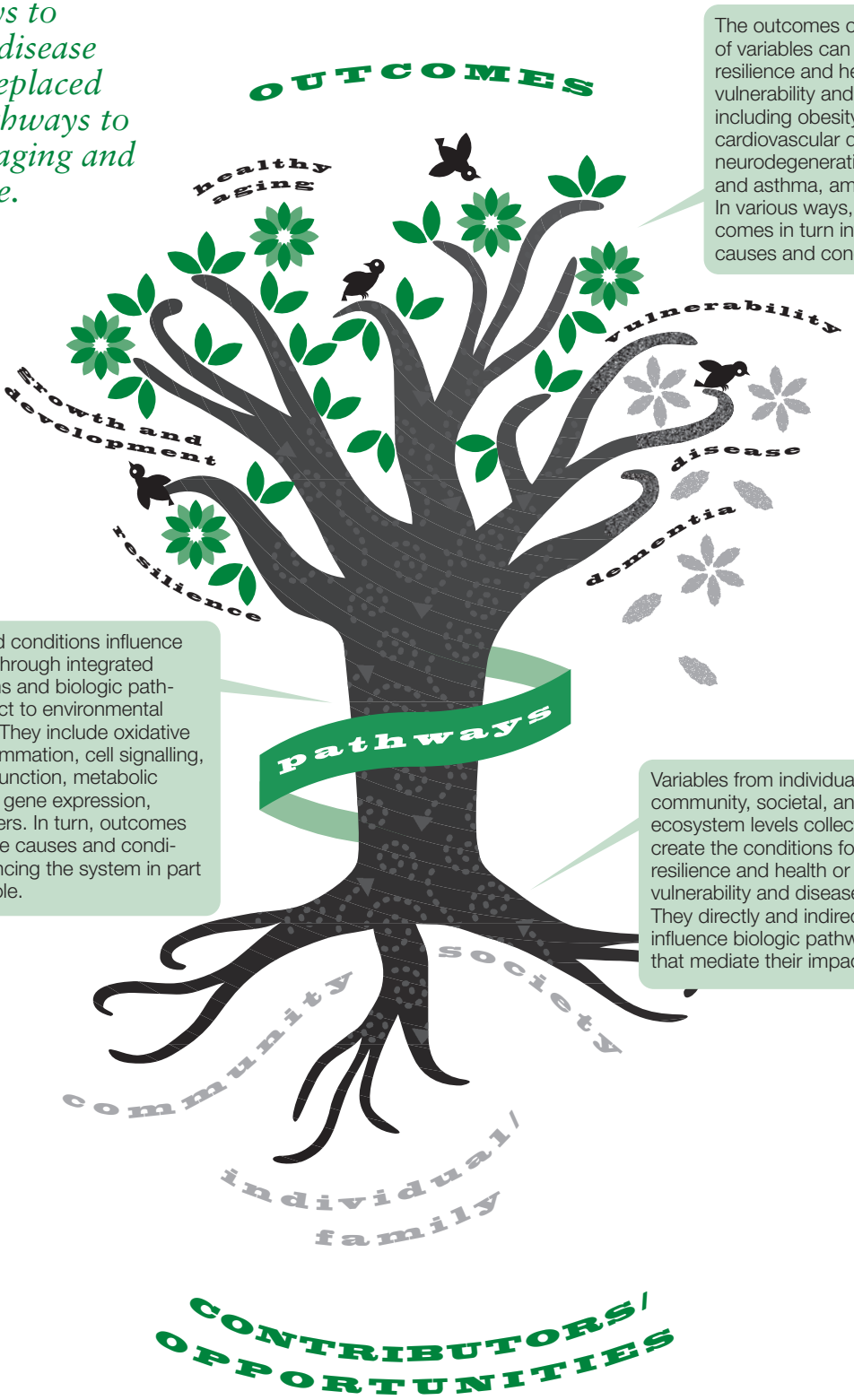
Our synthesis concludes that primary prevention ... is a real possibility and now is the time to get on with it—from many directions.

Many medical and public health planners are putting their hopes in silver bullet pharmaceutical interventions to slow or treat diseases of aging like Alzheimer's disease. Our synthesis concludes that primary prevention of much of this disease burden is a real possibility and now is the time to get on with it—from many directions.

Myriad factors contribute to resilience and health or alternatively, to vulnerability and disease. Excessive and prolonged levels of oxidative stress, inflammation, endocrine disruption, mutagenesis, and other pathological processes from exposures to toxic chemicals, social stress, and nutritional imbalances can be integrated into the lifeblood flowing though individuals and communities, or it can be otherwise. Pathways to chronic disease can be replaced with pathways to healthy aging and resilience (see figure).

The public health, economic, social, environmental, and security consequences of the choices that we make are increasingly clear. The health of this and future generations depends on acting wisely—with foresight and humility. It also depends on our summoning the political will and power to create the change that needs to happen if we are to pass on to future generations a world in which they can live lives of quality.

Pathways to chronic disease can be replaced with pathways to healthy aging and resilience.



The outcomes of this mix of variables can vary from resilience and health to vulnerability and disease–including obesity, diabetes, cardiovascular disease, neurodegeneration, cancer, and asthma, among others. In various ways, these outcomes in turn influence root causes and conditions.

Causes and conditions influence outcomes through integrated mechanisms and biologic pathways subject to environmental influences. They include oxidative stress, inflammation, cell signalling, endocrine function, metabolic status, and gene expression, among others. In turn, outcomes can become causes and conditions influencing the system in part or as a whole.

Variables from individual, community, societal, and ecosystem levels collectively create the conditions for resilience and health or vulnerability and disease. They directly and indirectly influence biologic pathways that mediate their impacts.

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OUTCOMES
healthy aging
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