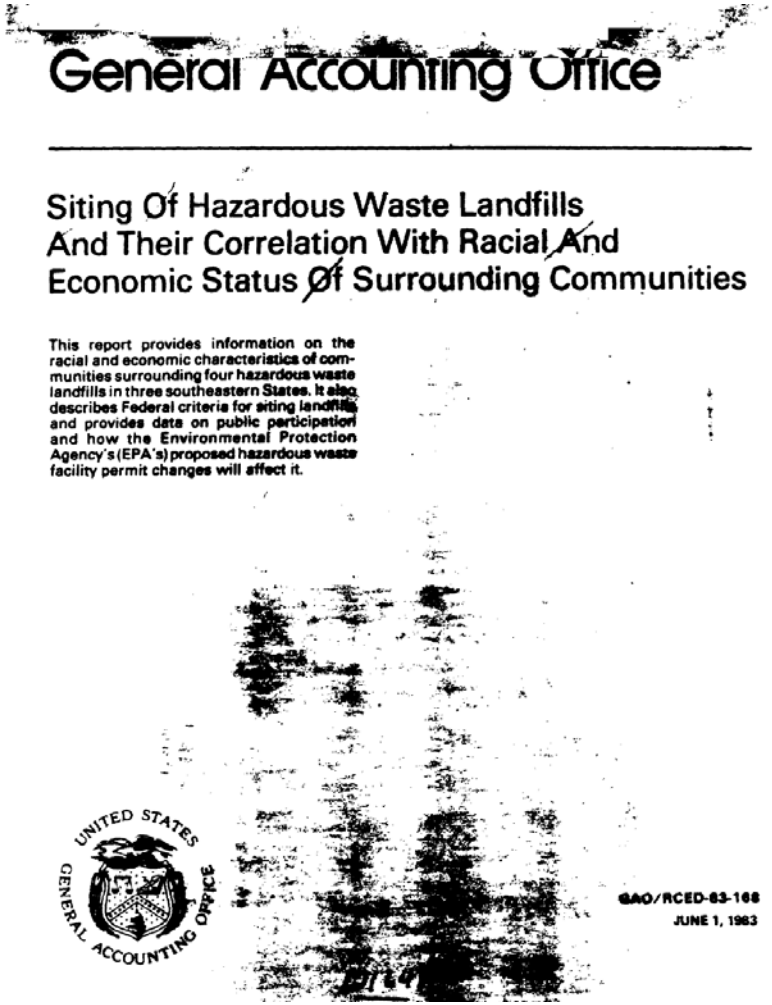
CUMULATIVE IMPACTS: VULNERABILITY, RISK, AND HEALTH

Gina Solomon, M.D., M.P.H.

CalEPA
California Environmental
Protection Agency

Environmental Justice: Science and History



General Accounting Office

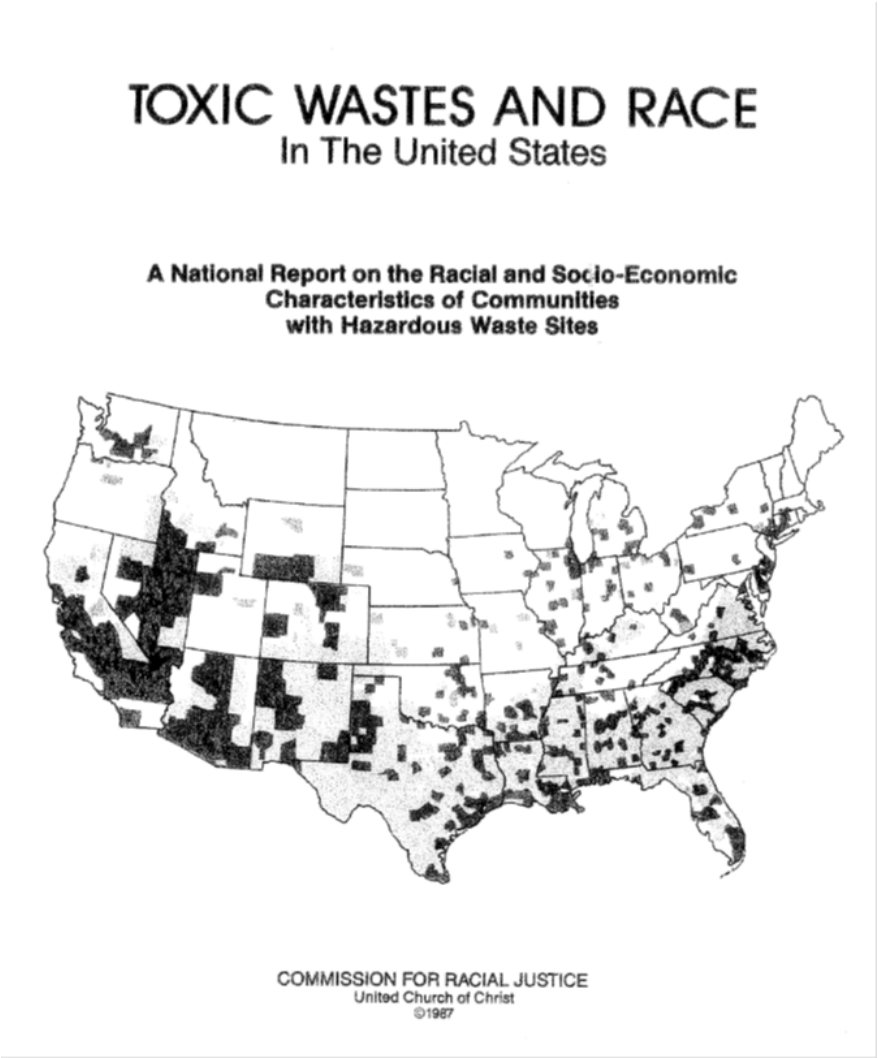
Siting Of Hazardous Waste Landfills
And Their Correlation With Racial And
Economic Status Of Surrounding Communities

This report provides information on the racial and economic characteristics of communities surrounding four hazardous waste landfills in three southeastern States. It also describes Federal criteria for siting landfills and provides data on public participation and how the Environmental Protection Agency's (EPA's) proposed hazardous waste facility permit changes will affect it.

UNITED STATES GENERAL ACCOUNTING OFFICE

GAO/RCED-83-168
JUNE 1, 1983

1983



TOXIC WASTES AND RACE
In The United States

A National Report on the Racial and Socio-Economic Characteristics of Communities with Hazardous Waste Sites

COMMISSION FOR RACIAL JUSTICE
United Church of Christ
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1987

The Drinking Water Disparities Framework: On the Origins and Persistence of Inequities in Exposure

Carolina L. Balazs, PhD, and Isha Ray, PhD

With this article, we develop the Drinking Water Disparities Framework to explain environmental injustice in the context of drinking water in the United States. The framework builds on the social epidemiology and environmental justice literatures, and is populated with 5 years of field data (2005–2010) from California's San Joaquin Valley. We trace the mechanisms through which natural, built, and sociopolitical factors work through state, county, community, and household actors to constrain access to safe water and to financial resources for communities. These constraints and regulatory failures produce social disparities in exposure to drinking water contaminants. Water system and household coping capacities lead, at best, to partial protection against exposure. This composite burden explains the origins and persistence of social disparities in exposure to drinking water contaminants. (*Am J Public Health*. 2014;104:603–611. doi:10.2105/AJPH.2013.301664)

systems are vulnerable to inadequate regulatory protection,[12] and to uneven monitoring and reporting.[13,14]

Studies on equity and the built environment have discussed how historical and structural conditions shape lack of access to safe drinking water. These conditions include selective enforcement of drinking water regulations,[15] noncompliance with federal standards,[16,17] inequities in access to funding,[18] and (the absence of) a communi
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that cost of ser

Wilson *et al. Environmental Health* 2014, **13**:26
http://www.ehjournal.net/content/13/1/26

ENVIRONMENTAL HEALTH

RESEARCH Open Access

Being overburdened and medically underserved: assessment of this double disparity for populations in the state of Maryland

Sacoby Wilson[1,2*], Hongmei Zhang[3], Chengsheng Jiang[1,2], Kristen Burwell[1,2], Rebecca Rehr[1,2], Rianna Murray[1,2], Laura Dalemarre[1,2] and Charles Nancy[1]

Contents lists available at ScienceDirect

Environmental Research

journal homepage: www.elsevier.com/locate/envres

An Index for Assessing Demographic Inequalities in Cumulative Environmental Hazards with Application to Los Angeles, California

JASON G. SU,[†] RACHEL MORELLO-FROSCH,[‡,§] BILL M. JESDALE,[‡] AMY D. KYLE,[†] BHAVNA SHAMASUNDER,[‡] AND MICHAEL JERRETT*,[†]
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Gray *et al. Environmental Health* 2014, **13**:4
http://www.ehjournal.net/content/13/1/4

ENVIRONMENTAL

RESEARCH Open Ac

Assessing the impact of race, social factors and air pollution on birth outcomes: a population-based study

Simone C Gray[1*], Sharon E Edwards[2], Bradley D Schultz[1] and Marie Lynn Miranda[2,3]

Race, socioeconomic status, and air pollution exposure in North Carolina

Simone C. Gray[a,*], Sharon E. Edwards[a], Marie Lynn Miranda[a,b]
[a] *Children's Environmental Health Initiative, School of Natural Resources and Environment, University of Michigan, Ann Arbor, MI, USA*
[b] *Department of Pediatrics, University of Michigan, Ann Arbor, MI, USA*

Risk-Based Targeting: Identifying Disproportionalities in the Sources and Effects of Industrial Pollution

RESEARCH Open Access

Environmental justice implications of arsenic contamination in California's San Joaquin Valley: a cross-sectional, cluster-design examining exposure and compliance in community drinking water systems

Carolina L Balazs[1*], Rachel Morello-Frosch[2,3], Alan E Hubbard[2] and Isha Ray[1]

Sociology of Health & Illness Vol. 36 No. 2 2014 ISSN 0141-9889, pp. 199–212
doi: 10.1111/1467-9566.12126

Environmental justice and health practices: understanding how health inequities arise at the local level

Katherine L. Frohlich[1] and Thomas Abel[2]

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[2]*Department of Social and Preventive Medicine, University of Bern*

Environmental Justice and Regional Inequality in Southern California: Implications for Future Research

Rachel Morello-Frosch,[1] Manuel Pastor Jr.,[2] Carlos Porras,[3] and James Sadd[4]

[1]College of Health and Human Services, San Francisco State University, Sat Francisco, California, USA; [2]Center for Justice, and Community, University of California, Santa Cruz, California, USA; [3]Communities for a Better Environment, Huntington California, USA; [4]Environmental Sciences, Occidental College, Los Angeles, California, USA

Key concepts:

1) Health disparities are linked to social factors and environmental hazards

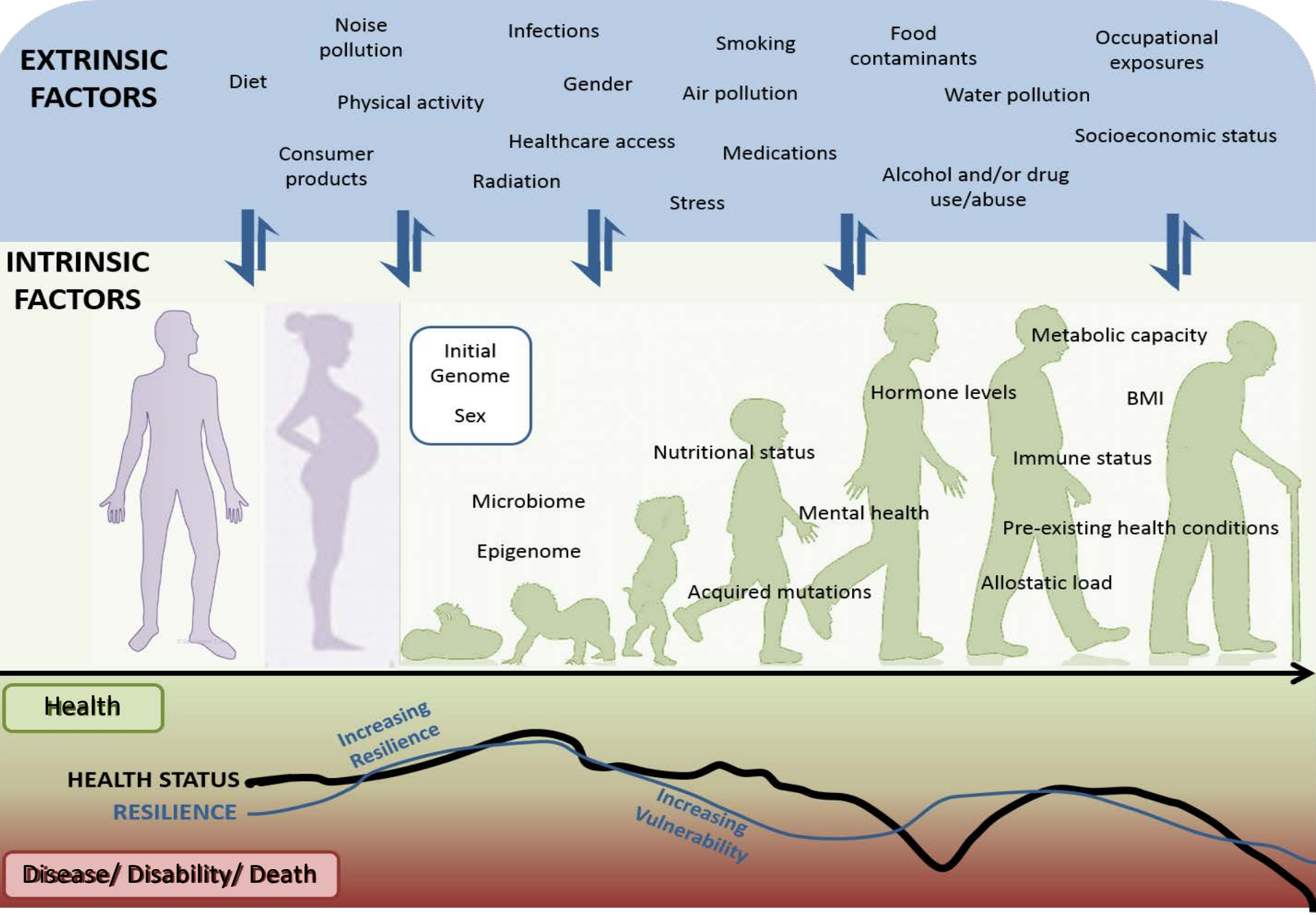
2) Significant inequalities exist in exposures to environmental hazards

3) Intrinsic biological and physiological factors can modify environmental hazards

4) Extrinsic social vulnerability factors at the individual and community levels can amplify the effects of environmental hazards

Solomon G, Morello-Frosch R, Zeise L, Faust J. Cumulative Environmental Impacts: Science and Policy to Protect Communities. Annual Review of Public Health 37: 14.1-14.14, 2016.

Solomon GM, Faust JB, Morello-Frosch, R, Zeise, L. Integrating environmental justice into public health: approaches for understanding cumulative impacts. Front Public Health Serv Sys Res 5(5):9–14, 2016. DOI: https://doi.org/10.13023/FPHSSR.0505.02.



McHale CM, Osborne G, Morello-Frosch R, Salmon A, Sandy MS, Solomon G, Zhang L, Smith MT, Zeise L

Challenge:

- Difficult to correct environmental injustice without measuring it.
- How can we measure cumulative impacts?
- A tool should be:
  - Participatory
  - Allow comparisons across time and space
  - Semi-quantitative

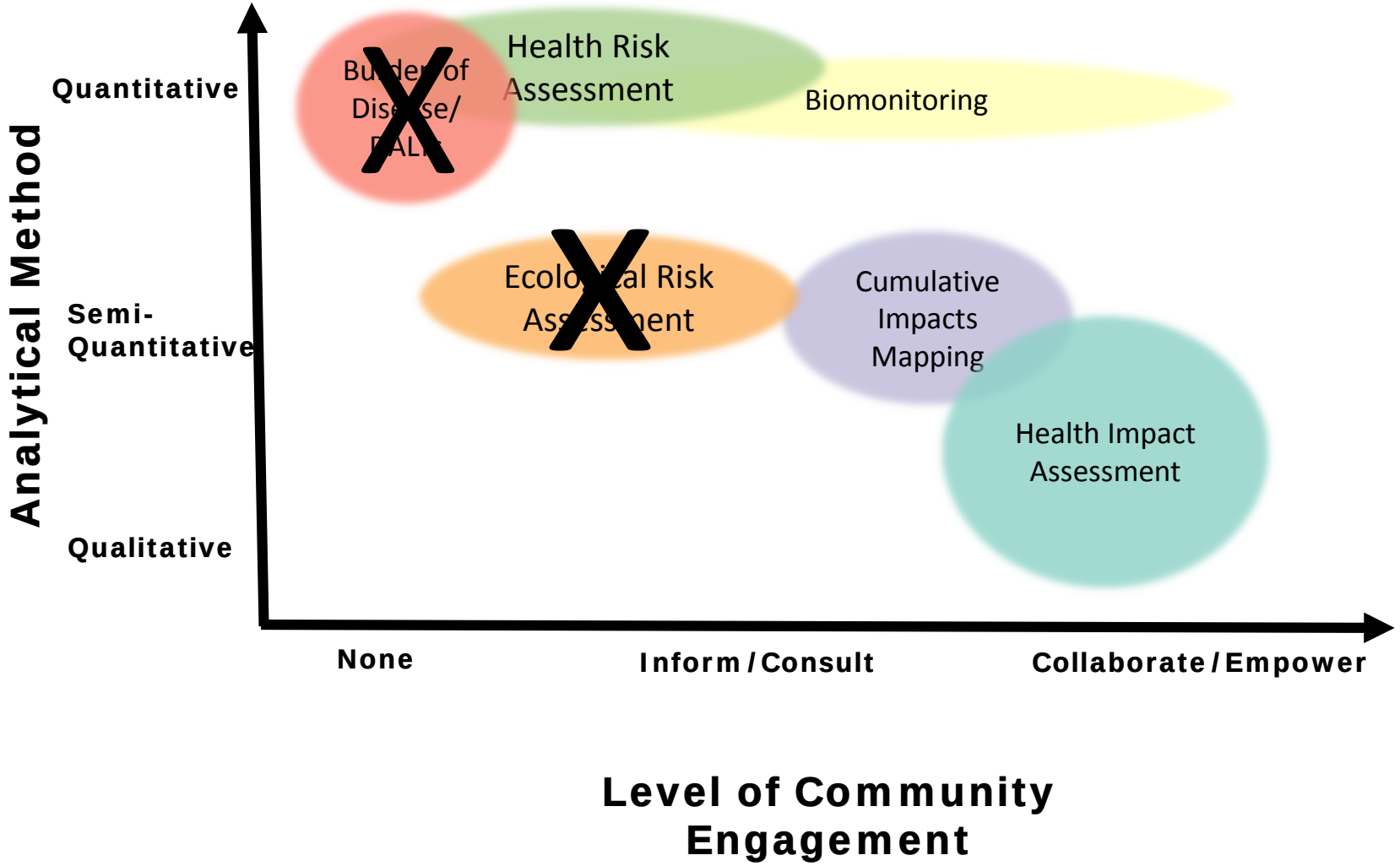
Analytic Dimensions for Cumulative Impacts Analysis

Context	• Project-, policy-, program-, chemical- or plan-based decision (e.g., identify consequences of a specific proposal or activity) • Geography- or population-based decision (e.g., identify overburdened areas or populations for purposes of prioritizing allocation of resources)
Stressors	• Chemical stressors (e.g., pollutants in air, water, soil, food, products) • Biological stressors (e.g., internal and external microbiome) • Social stressors (e.g., discrimination, poverty, violence) • Physical stressors (e.g., noise, radiation, housing quality)
Vulnerability	• Intrinsic factors (e.g., age, existing health conditions, genome) • Extrinsic factors (e.g., socioeconomic vulnerability, access to health care)

Current Approaches

Approach	Quantitative?	Chemical/ Nonchemical	Participatory?	Facilitates comparisons?
Biomonitoring	Yes	Chemical	Potentially	Yes, exposure only
Cumulative Risk Assessment	Yes, generally	Chemical	No, generally	Yes
Ecological Risk Assessment	Potentially	Both	Potentially	Generally no
Health Impact Assessment	No, generally	Both	Yes, very	Generally no
Burden of Disease/DALY	Yes, very	Both	No	Yes
Mapping	Semi-	Both	Yes, potentially	Yes

Cumulative Impacts Assessment Tools: Levels of Community Engagement



BIOMONITORING California Matters

- Measures hundreds of chemicals in people
- Can compare with other communities or national averages
- Measurement of change over time (worse or better?)
- (New) Ability to do non-targeted testing

But……

- Some chemicals can't be biomonitored
- Can't identify the source of exposure
- Doesn't evaluate intrinsic vulnerability or extrinsic non-chemical stressors

Cumulative Risk Assessment

✓ Chemical groups (PCBs, dioxins, PAHs, organophosphate pesticides)

✓ Chemical mixtures (e.g., diesel exhaust)

☒ Exposures + intrinsic vulnerabilities

❑ "Exposome" (e.g., all exposures)

❑ Exposures + non-chemical stressors

💣 All exposures + intrinsic vulnerabilities + non-chemical stressors

New Technologies to Measure Exposure

DAILY BULLETIN

AIR POLLUTION

News Sports Entertainment Lifestyle Obituaries Opinion Special Reports

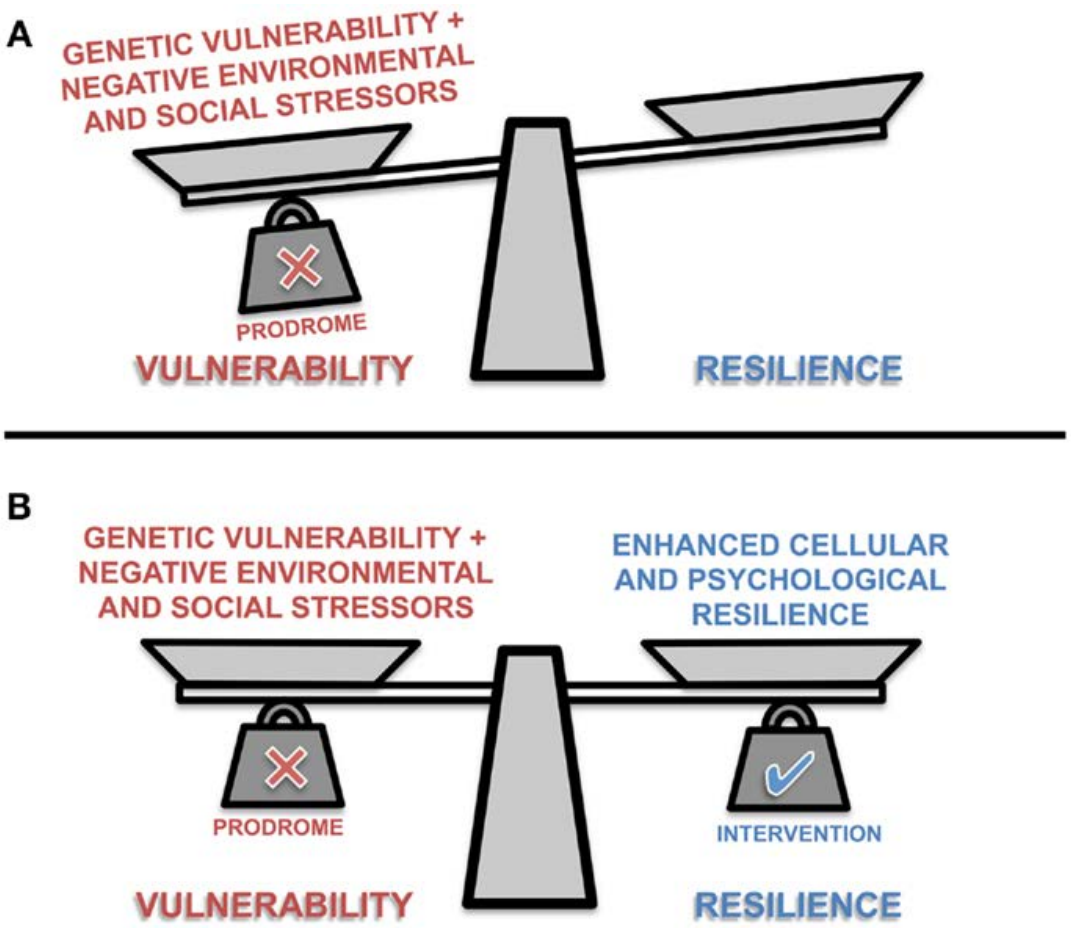
Home News Air pollution

How you can measure air pollution at your home, school and improve public health

Vasileios Papapostolou, air quality specialist, demonstrates a hand-held air pollution measuring device during the spec test at the AQMD's Air Quality Sensor Performance Evaluation Center in Diamond Bar on Thursday, August 11, 2016. (Photo by Watchara Phomicinda/ Southern California News Group)

Future: Biological Markers of Health

- Allostatic Load
- Telomere Length
- Epigenetic Changes



Walker AJ, et al. Front. Psych, April 2014

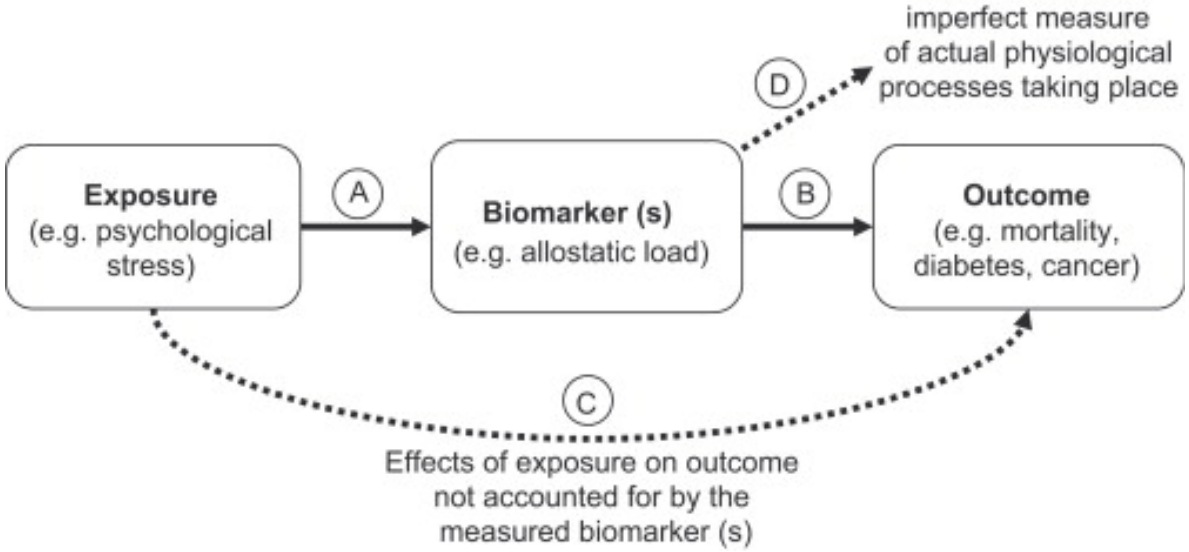
Allostatic Load ("Toxic Stress")

Multi-System Response to Chronic Stress:

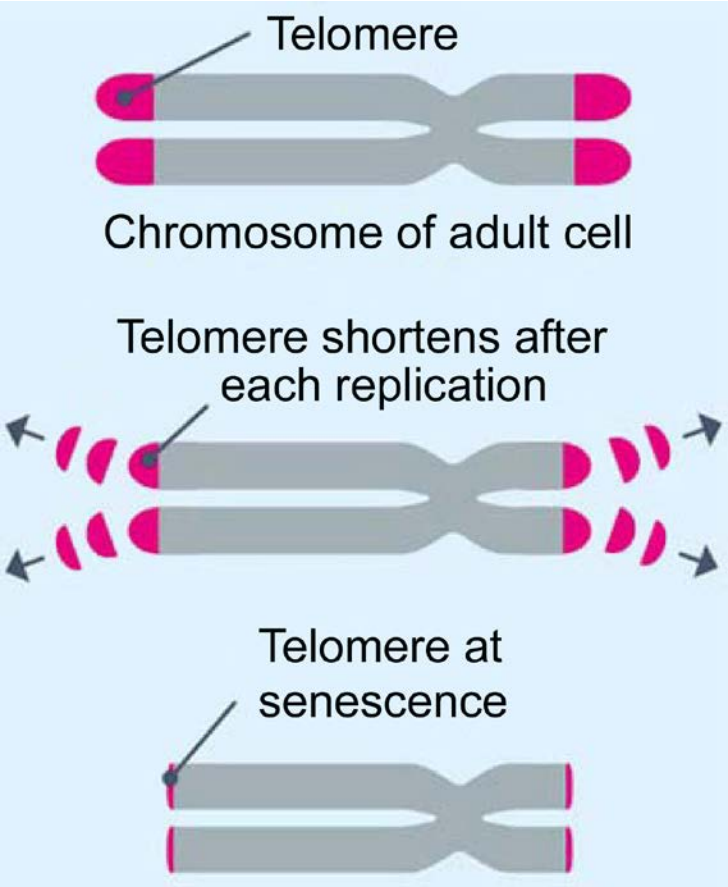
<u>Primary:</u> Stress hormones (cortisol, epinephrine, norepinephrine, DHEA)

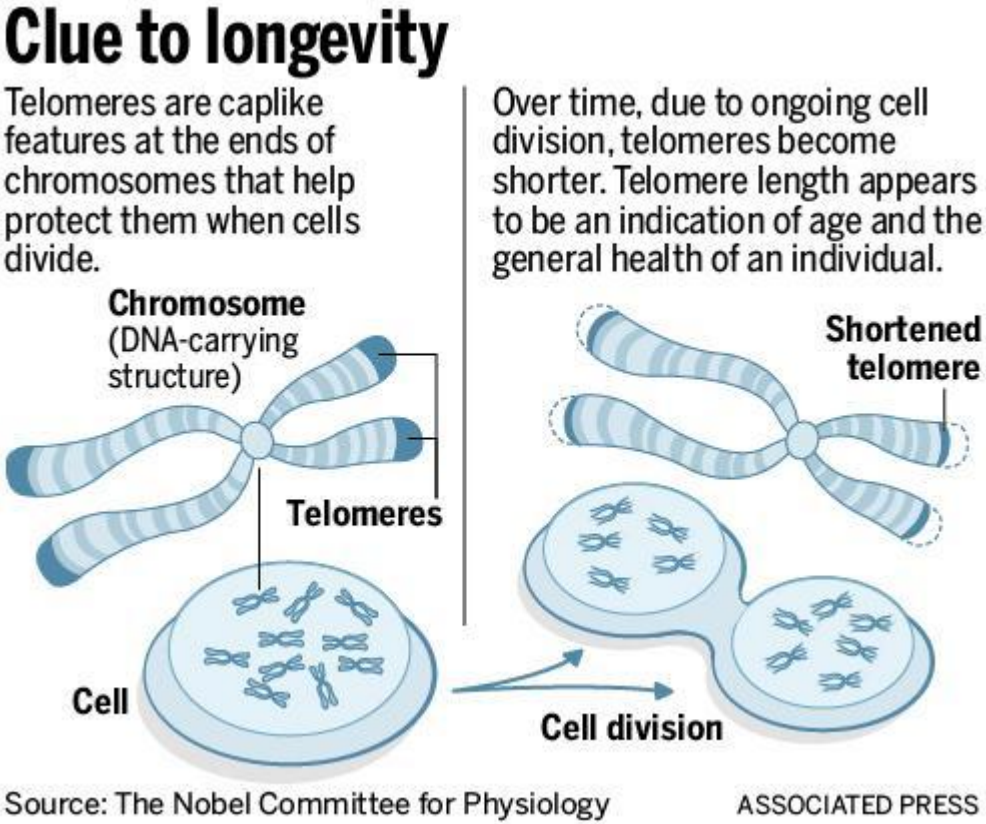
<u>Secondary:</u> Inflammation (C-reactive protein, TNF, IL-6), blood pressure, heart rate variability, insulin/glucose, cholesterol/triglycerides, waist/hip ratio

<u>Tertiary:</u> Cardiovascular disease, neurodegenerative disease, cancer, etc.



Telomere Length





Telomere Length & Dementia

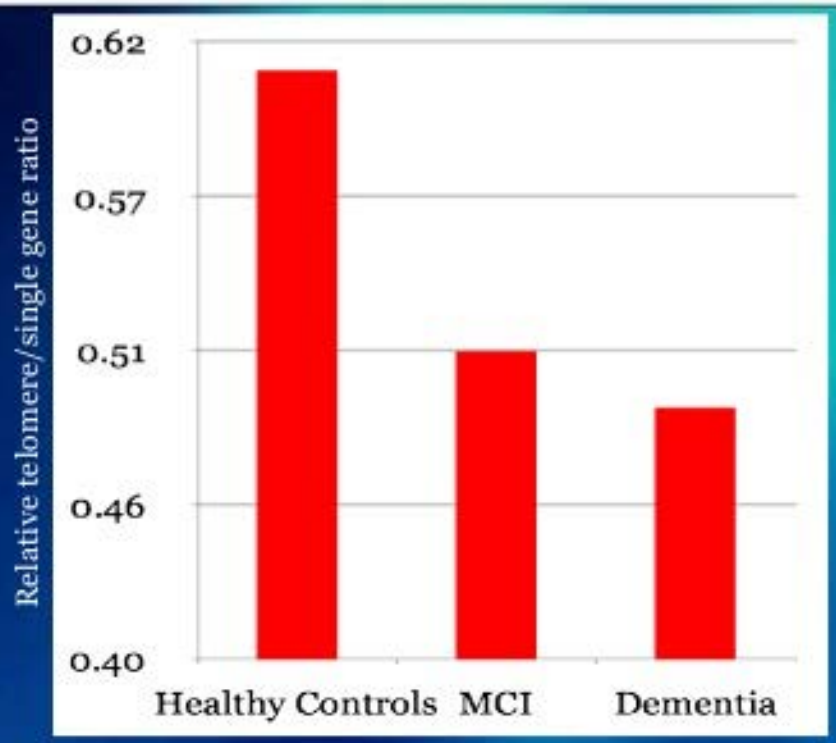
Nurses' Health Study

62 women, ≥ 70 years of age

Controlled for: age, education, smoking history, cardiovascular disease, hypertension, cholesterol levels, and diabetes

telomere length below the median:
12-times greater risk of being diagnosed with dementia

9.6-times greater risk of being diagnosed with mild cognitive impairment.

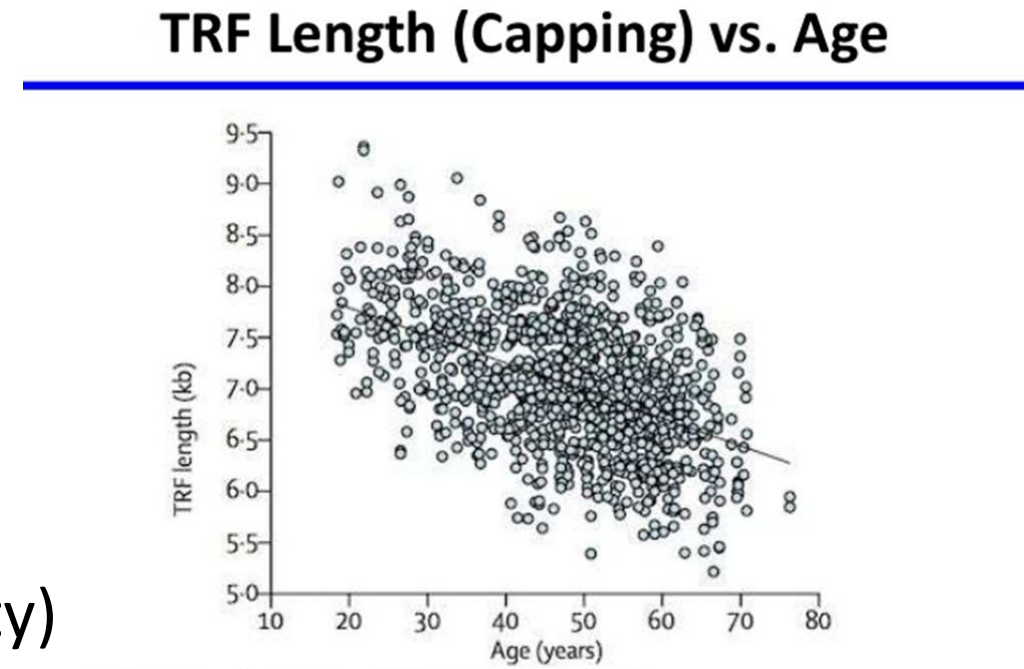


Grodstein F, van Oijen M, Irizarry MC, Rosas HD, Hyman BT, Growdon JH, DeVivo I. Shorter telomeres may mark early risk of dementia: preliminary analysis of 62 participants from the nurses' health study. PLoS One. 2008 Feb 13;3(2):e1590.

Accelerated telomere shortening is associated with early onset of many diseases, including coronary heart disease, heart failure, diabetes, cancer, and osteoporosis.

Causes of Telomere Shortening

- Age
- Genetic factors
- Socioeconomic status
- Stress
- Exercise
- Smoking
- Diet (quantity and quality)
- Anti-oxidants
- Occupational exposures
- Environmental exposures (especially air pollution)

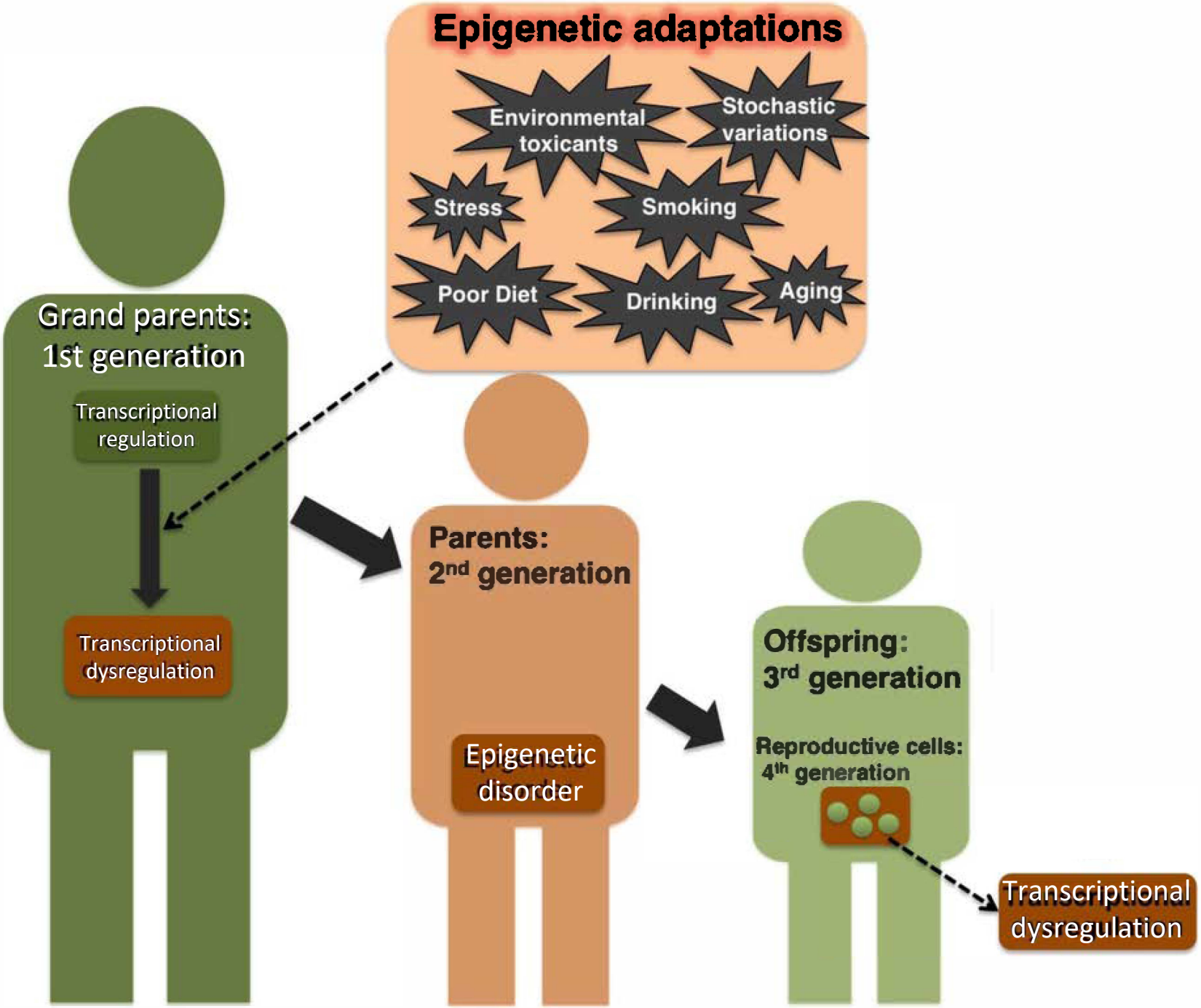


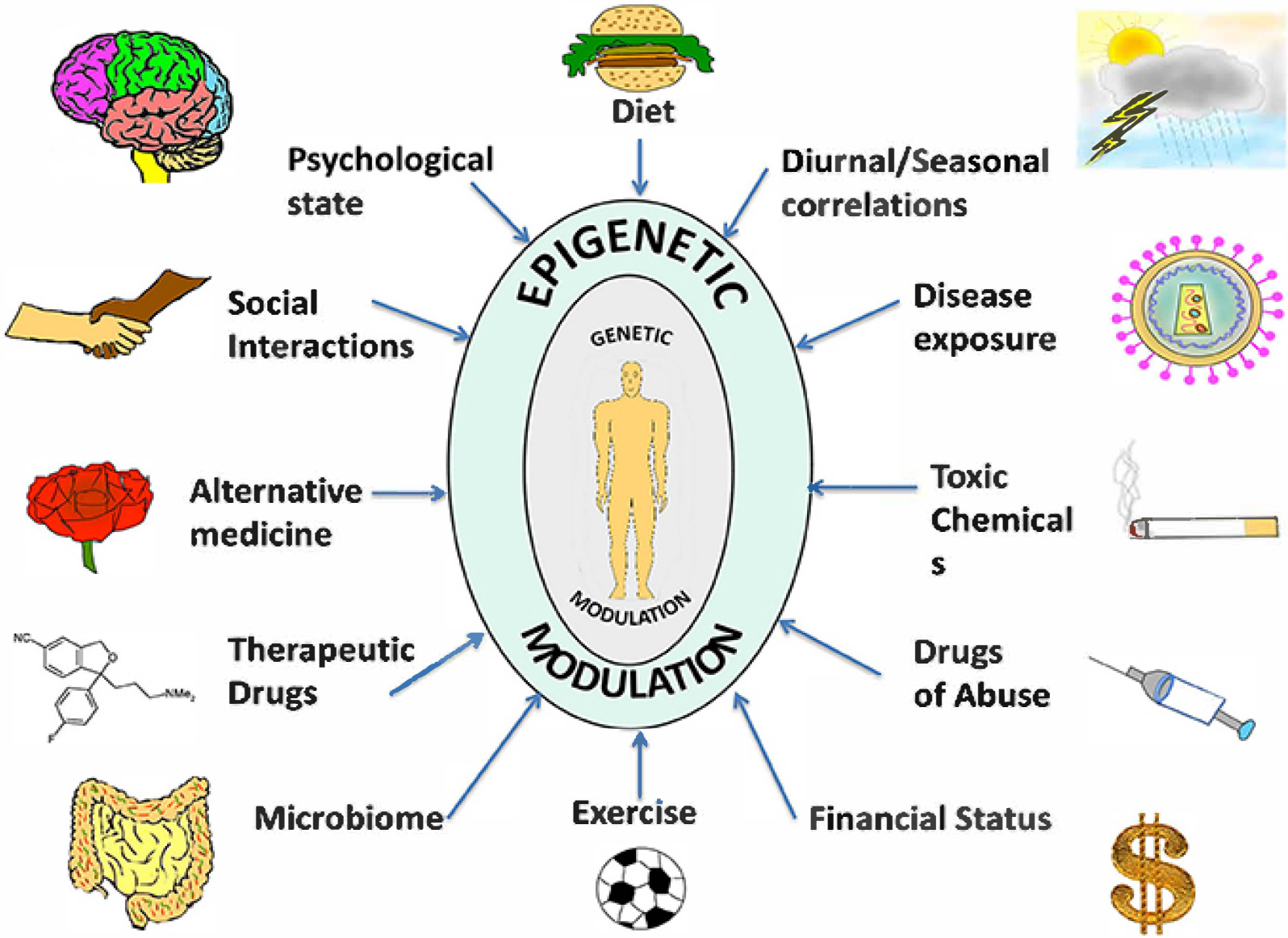
http://www.anti-agingfirewalls.com/2014/02/03/nuclear-aging-the-view-from-the-telomere-end-of-the-chromsome-part-1-context-history-and-about-telomere-lengths-2/

Epigenetics

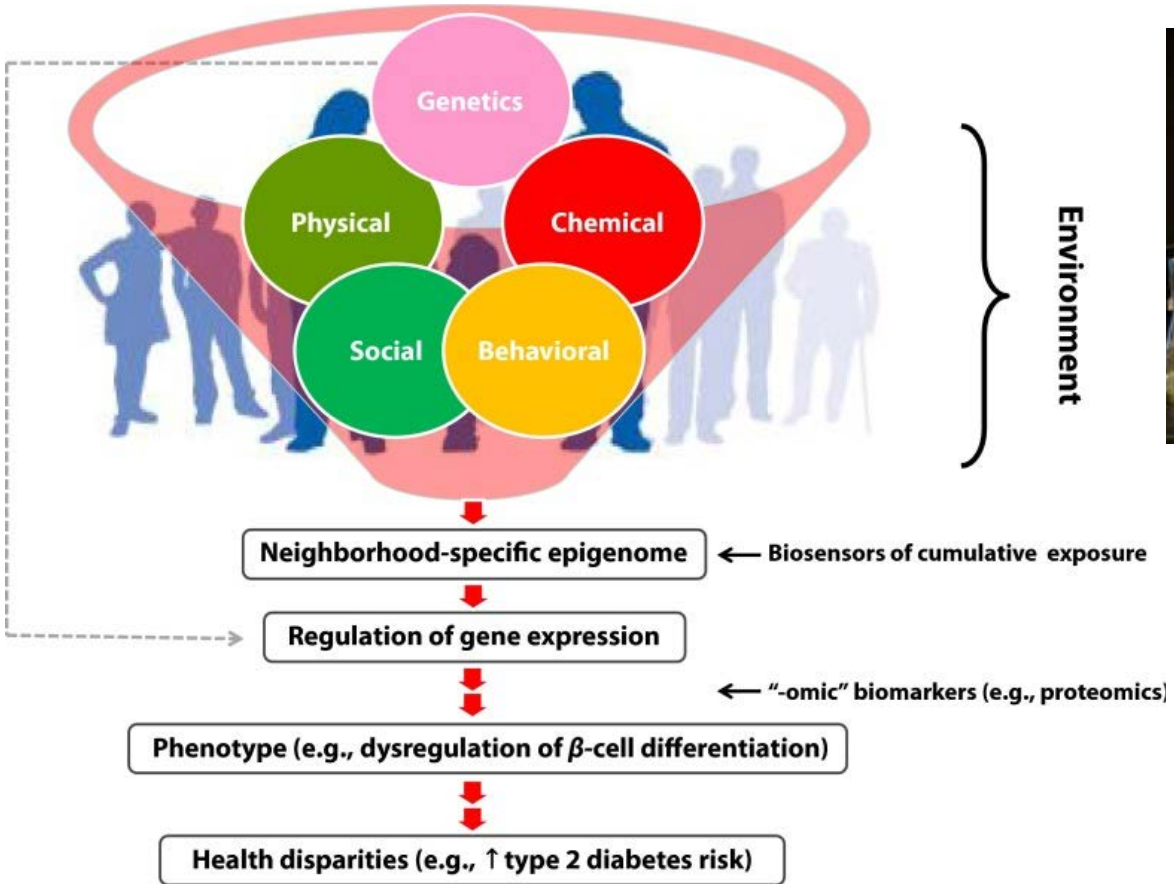
- Changes in organisms caused by modification of gene expression rather than alteration of the genetic code itself.

Genetically Identical Mice

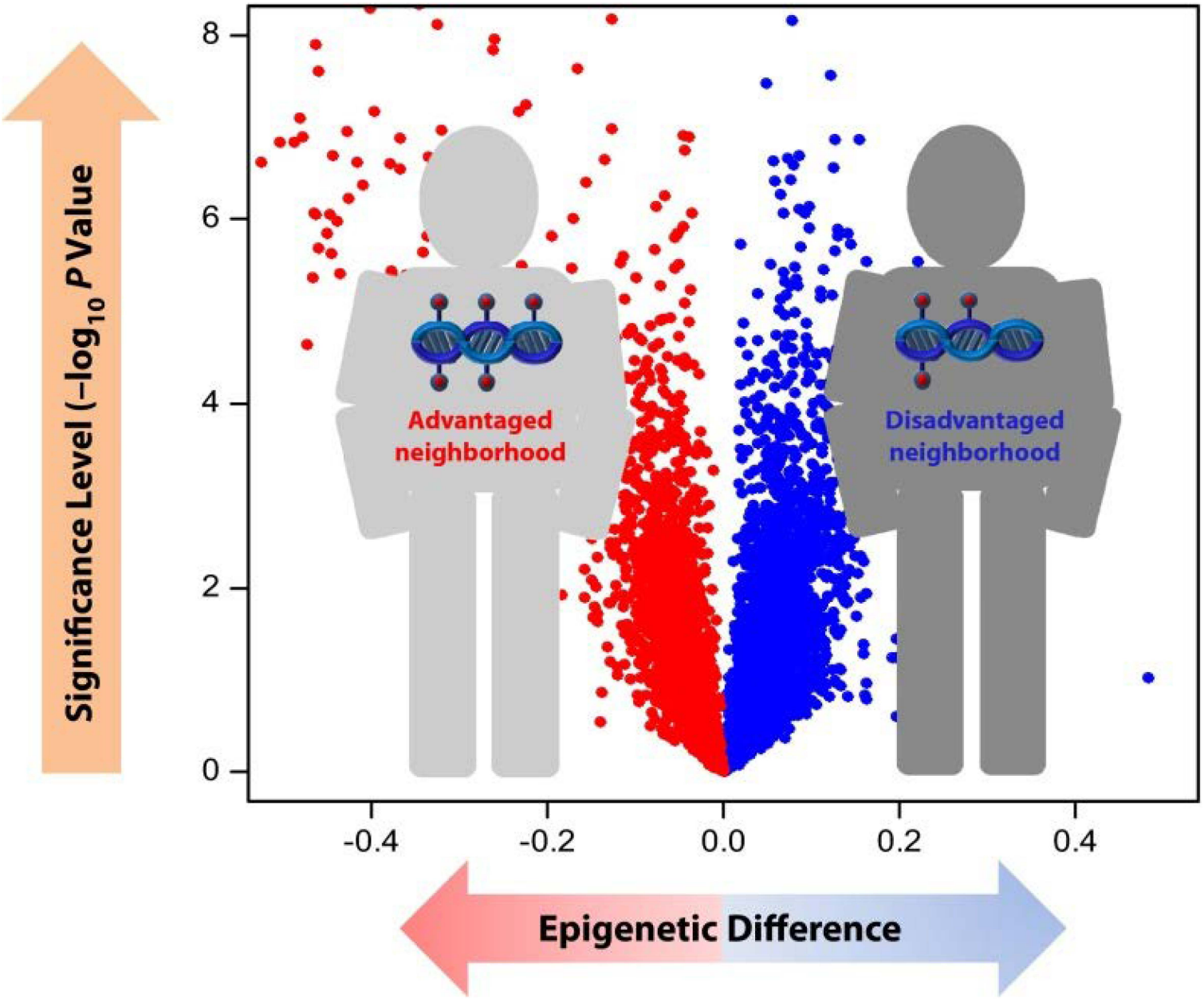

Epigenetic adaptations
Environmental toxicants
Stochastic variations
Stress
Smoking
Poor Diet
Drinking
Aging
Grand parents: 1st generation
Transcriptional regulation
Transcriptional dysregulation
Parents: 2nd generation
Epigenetic disorder
Offspring: 3rd generation
Reproductive cells: 4th generation
Transcriptional dysregulation


Diet
Psychological state
Diurnal/Seasonal correlations
EPIGENETIC
GENETIC
MODULATION
MODULATION
Social Interactions
Disease exposure
Alternative medicine
Toxic Chemicals
Therapeutic Drugs
Drugs of Abuse
Microbiome
Exercise
Financial Status

Future:
Neighborhood-Specific Epigenome



Olden K, et al. Am J Public Health. 2014 October; 104(10): 1816–1821.


Significance Level (−log10 P Value
8
6
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Advantaged neighborhood
Disadvantaged neighborhood
Epigenetic Difference

Conclusion

- Existing approaches to cumulative impacts all have limitations
  - Don’t include all exposures, intrinsic, and extrinsic stressors
  - Not very quantitative
  - Technical and hard for communities to engage
- Newer approaches are emerging
  - Better exposure measurement
  - Better markers of toxic stress (allostatic load)
  - Better markers of overall health (telomere length)
  - Neighborhood markers? (epigenome)
- Need to make decisions now and be nimble as new tools emerge

Questions?