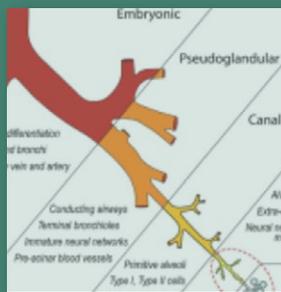
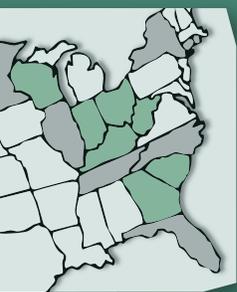


A Story of Health



ACKNOWLEDGEMENTS



Primary Development Organizations

The Agency for Toxic Substances and Disease Registry (ATSDR), the Center for Integrative Research on Childhood Leukemia and the Environment (CIRCLE) at the University of California, Berkeley, Commonweal, the Office of Environmental Health Hazard Assessment, California Environmental Protection Agency (OEHHA), the Science and Environmental Health Network (SEHN), and the Western States Pediatric Environmental Health Specialty Unit (WSPEHSU) teamed up to leverage our combined resources to develop and produce *A Story of Health*.

For more information:

Brian Tencza: bht1@cdc.gov

Maria Valenti: mvalenti@igc.org

Copyright: Portions of this document may be subject to the copyright act. Graphics and illustrations by Stephen Burdick Design may not be reproduced without permission. Before reproducing and or modifying any content or illustration, contact Brian Tencza at ATSDR bht1@cdc.gov. Any permitted reproduction of content or illustrations must be properly acknowledged.

Primary Authors/Development Team

Mark Miller MD MPH, Director, [Western States Pediatric Environmental Health Specialty Unit at UCSF](#)

Director, [Children's Environmental Health Center, Office of Environmental Health Hazard Assessment, California EPA](#)

Director, [Community Outreach Translation Core, CIRCLE, UC Berkeley](#)

Ted Schettler MD MPH, Science Director, [Science and Environmental Health Network](#)

Science Director, [Commonweal](#)

Brian Tencza MEd, Team Lead Education Services, [Agency for Toxic Substances and Disease Registry \(ATSDR\)](#)

Maria Valenti, Director, Health and Environment Literacy Project, Commonweal, www.commonweal.org.

Suggested citation: Miller M, Schettler T, Tencza B, Valenti M. *A Story of Health*. Agency for Toxic Substances and Disease Registry, Commonweal, Science and Environmental Health Network, Western States PESHU. PDF file [online](#).

CONTRIBUTING AUTHORS

Christine Zachek, Victoria Leonard, Marya Zlatnik, Samuel M. Goldman, Sammy Almashat, Karin Russ

ART TEAM

Illustrations, eBook design, production
Stephen Burdick,

[Stephen Burdick Design](#)

Illustrations

Dan Higgins, Visual Information Specialist, Centers for Disease Control and Prevention

REVIEWERS

We gratefully acknowledge the following people who reviewed draft sections of a Story of Health, noting that their review does not constitute an endorsement of the findings or conclusions. Any errors or misrepresentations that remain are entirely the responsibility of the authors.

Introduction and Asthma (Brett's Story): Polly Hoppin; Catherine Karr; Brian Linde; Maria Mirabelli; Madeleine Scammell, Rebecca Wolf

Developmental Disabilities (Amelia's Story): David Bellinger; Lucy Crain; Katherine Herz; Brian Linde; Elise Miller; Leslie Rubin; Madeleine Scammell; Maureen Swanson

Childhood Cancer (Stephen's Story): Myles Abbott; Gary Dahl; Maida Galvez; Catherine Metayer; Elizabeth Raetz; Joshua Schiffman; Oscar Tarrago; Christopher Vlasses; Joe Wiemels

Infertility (Reiko and Toshio's Story): James Donald; Wendy-Heiger Bernays; Ulrike Luderer; Kurt Martinuzzi; Jennifer Schlezinger; Pam Tucker; Veronica Vieira; Blair Wylie

Cognitive Decline (Sam's Story): Deborah Cory-Slechta; Helen Petrovitch; Victoria Tang

OTHER CONTRIBUTORS

Agency for Toxic Substances and Disease Registry:

Online course development and video editing: Amanda Cadore

Copyright and Editing: Diana Cronin

Geographic Information Services Team: Charlton Coles; Stephanie Foster; Melissa M. Smith; Shannon Graham, Julia Bryant

Boston University Superfund Research Project: Ann Aschengrau, Wendy Heiger-Bernays, Jennifer Schlezinger, Veronica Vieira

University of California, Berkeley:

Berkeley/Stanford Children's Environmental Health Center

[Center for Integrative Research on Childhood Leukemia and the Environment](#)

SUPPORTERS

In addition to significant in-kind contributions from all of the primary development organizations, we are grateful to the following supporters who have made this project possible:

The Agency for Toxic Substances and Disease Registry (ATSDR)

The Center for Integrative Research on Childhood Leukemia and the Environment (CIRCLE) at the University of California, Berkeley

The John Merck Fund

DISCLAIMERS:

1. The Western States Pediatric Environmental Health Specialty Unit's preparation of the *Story of Health* was supported by the American College of Medical Toxicology (ACMT) and funded (in part) by the cooperative agreement FAIN: U61TS000238-05 from the Agency for Toxic Substances and Disease Registry (ATSDR). The U.S. Environmental Protection Agency (EPA) supports the PEHSU by providing partial funding to ATSDR under Inter-Agency Agreement number DW-75-95877701.

Educational Technology Services – Jon Schainker and Scott Vento

University of California, Davis: Brenda M. Giddings, California Cancer Registry, Institute for Population Health Improvement, U.C. Davis Health System

University of California, San Francisco: [Program on Reproductive Health and the Environment](#)

Videos – Speakers:

John Balmes; Patricia Buffler; Gary Dahl; Sam Goldman; Linda Guidice; Ulrike Luderer; Mark Miller; Catherine Metayer; Lawrence Rosen; Joseph Wiemels; Thomas Whitehead; Tracey Woodruff; Rosalind Wright; Marya Zlatnik

The Jacob & Valeria Langeloth Foundation

The Office of Environmental Health Hazard Assessment, California Environmental Protection Agency (OEHHA)

Western States PEHSU

The US Environmental Protection Agency

CIRCLE is supported with funds from NIEHS grant P50 ES018172 and US EPA grant RD-83615901, P.I. Catherine Metayer MD PhD.

2. The findings and conclusions in this report are those of the author(s) and do not necessarily represent the official position of the organizations listed (above) as funders.

3. The ATSDR, US EPA, NIEHS, and Cal EPA/OEHHA do not endorse the purchase of any commercial products or services mentioned in this publication.

HELP PAGE How to Navigate Our eBook

THE INDIVIDUAL STORIES OF HEALTH in this eBook are written to address many audiences. For example, some sections are more technical than others – you can skip sections if you wish.

(Note: underlined words or phrases link to online information, prompt down-loads or navigate to a related page.)



Each of the eBook stories is embedded with a wide range of resources. These help further explain possible environmental and/or genetic “risk factors” – (contributors to the development of a disease, or factors that might make a disease worse) – and how these factors interact.

We also provide links for additional resources, including actions you can take to prevent disease, and “tools you can use.”



RESOURCES INCLUDE videos, slides with audio commentary, tables, charts, and graphics. Some ‘pop-up’ in the story, and some connect online. Through these links, you can choose to dig deeper and learn more. Refer to the icons (above) for guidance.

REFERENCES AND CITATIONS: Certain references are cited in the text where we believe they are most warranted. Full references by topic can be found at the end of each story.

Getting Started

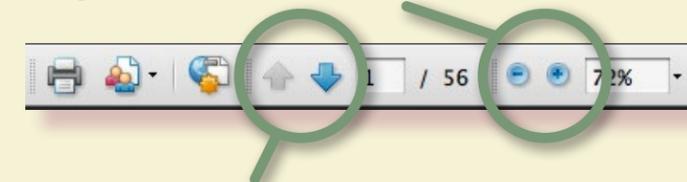
Our eBook Navigation: Click on selections in the bar at the top of each page to move between stories, navigate back to this ‘Help Page’, and to find out more in the References section.

If you lose your place, use the ‘Go Back’ selection in the navigation bar to return to your previous screen.

Adobe Acrobat Tools

This interactive pdf document is best viewed on a laptop or desktop, downloaded and opened in a current version of **Adobe Acrobat Reader**. Refer to the top Adobe menu bar for features including:

Magnify - If you want to enlarge a diagram or some text, click (+) button.



Move through pages - You can use the up and down arrows to move through pages.

You can also move through pages using the scroll up and down feature to the right of your screen.

Note: Navigation features may not work properly using other pdf reader platforms.

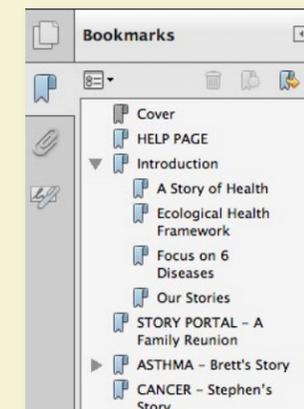


Table of Contents

Use the sidebar **Bookmark Tools** as a table of contents to skip to a section of interest, find your place, or return to this Help page.

Icons

Click on icons that appear throughout the stories for pop-ups, videos, and links to more information as described.



key concept



watch a video



additional resources, tools



technical details for health professionals



skip this section



definition

Skip this section - If you wish to skip a technical section, choose the “Skip this section” arrow and you will jump to the page after the technical sections ends.

You can skip this section and continue to the Story of Health introduction.



INTRODUCTION

This is a story about health.

It is a story of how our own health is intimately connected with the health of our families, friends and communities.

It is a story about how human health is interdependent with our surroundings.

Our overall story is told through the personal stories of a number of fictional people of various ages attending a family reunion.

These individual stories highlight the many ways our health is influenced by the complex environments where we live, eat, work, play, volunteer, gather and socialize.



Our stories explore how many aspects of our lives, and what we are exposed to in our environments, influence health across the lifespan—from the beginning of fetal development to elder years—and how they can promote health and resilience, or disease and disability.

Important determinants of health come from the natural, built, chemical, food, economic, and social environments.

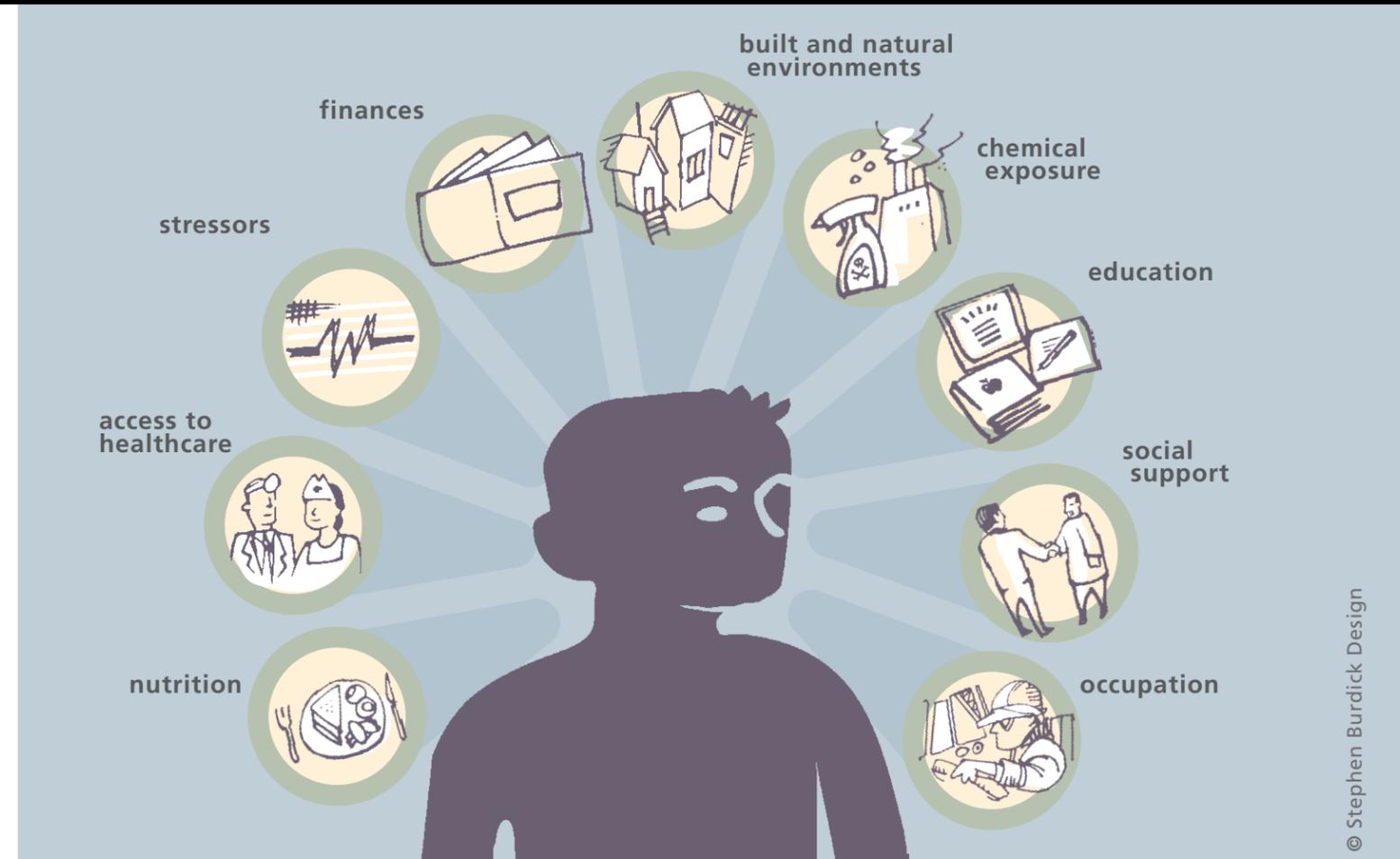
These environments are further expressed through such things as education, housing, nutrition, access to health care, social supports and more.

Many of them interact to create the conditions for health and wellness, or vulnerability to disease.



Watch: Pediatrician Larry Rosen addresses the environment and family health. (2 min.)

Lawrence D. Rosen MD is an integrative pediatrician and founder of the Whole Child Center.



Complex interactions occur among many variables and across individual, community, and societal levels.

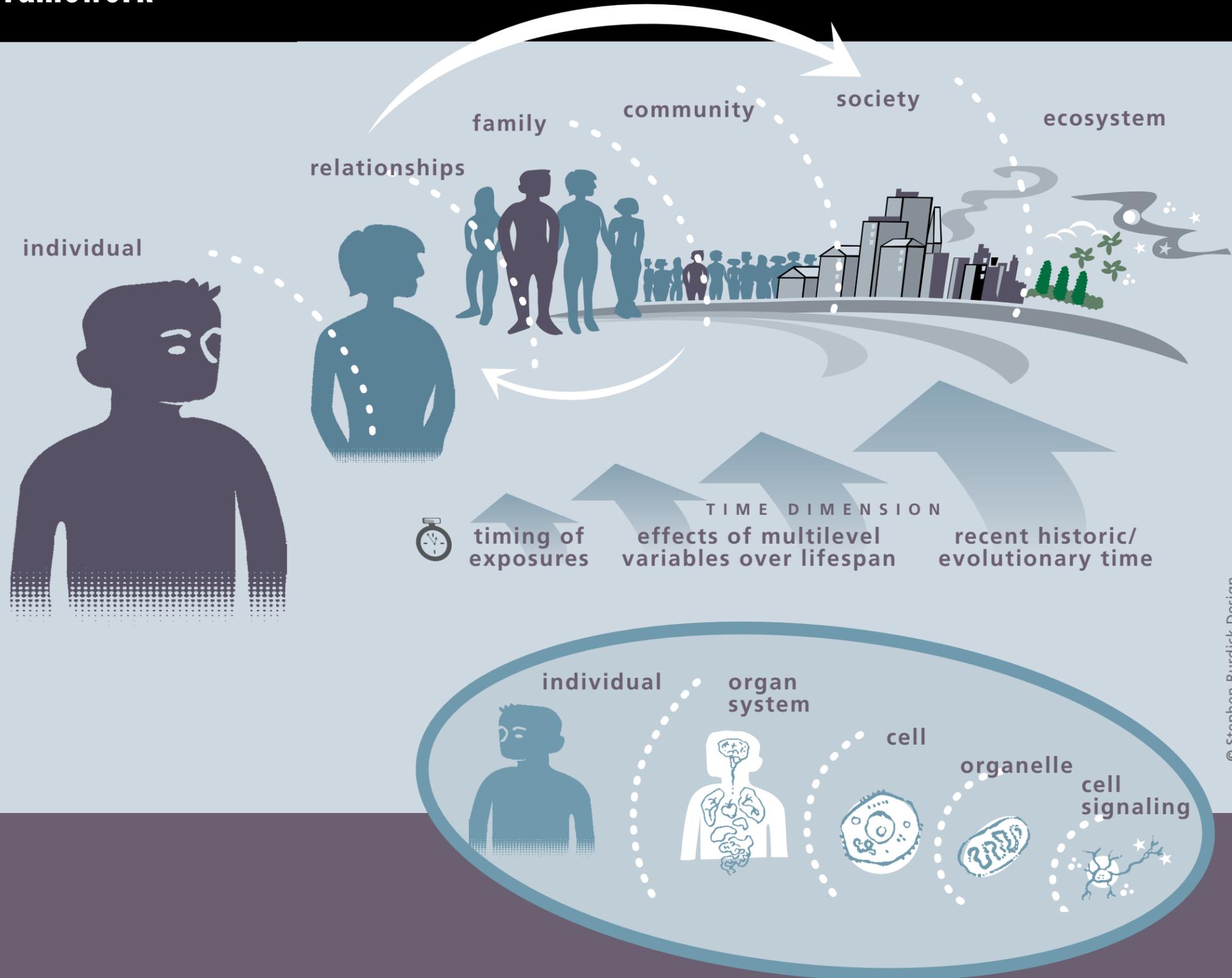
Rarely is one particular thing responsible for health or disease, so we refer to this as a multifactorial (or ecological) approach, the best way to promote health and prevent disease.

INTRODUCTION Ecological Health Framework

The ecological framework can include multiple levels from sub-cellular to societal.

It is not hierarchical in the sense that one level is more important than another, but rather in the sense that individual biology is progressively nested within the person, family, community, society and ecosystem.

The interactions and feedback loops within, across, and among these levels are complex and variable. They exert their influences on health across time.



The ecological health framework also extends to the sub-cellular level.

INTRODUCTION Focus on Six Diseases

Following are stories of people like you and me, our partners, families and friends, our mothers and fathers, sisters and brothers, children, grandparents, cousins, and aunts and uncles.

The personal health stories we will explore include some of the most common and troubling diseases and disorders of our time.

They include:

- Asthma
- Cancer (childhood leukemia)
- Diabetes
- Infertility
- Learning and developmental disabilities
- Cognitive decline



Asthma



Diabetes

Cancer



Cognitive decline



Infertility



Learning and developmental disabilities

INTRODUCTION Our Stories

These stories are not meant to be an exhaustive accounting of every variation of a disease or every possible cause.

Rather, we present current, authoritative scientific evidence to enable you to better understand environmental contributors and make more informed decisions and take action to help improve your health, and the health of your family, friends, community, and patients.



A FAMILY REUNION Six Stories

This page is your portal to six stories of health.

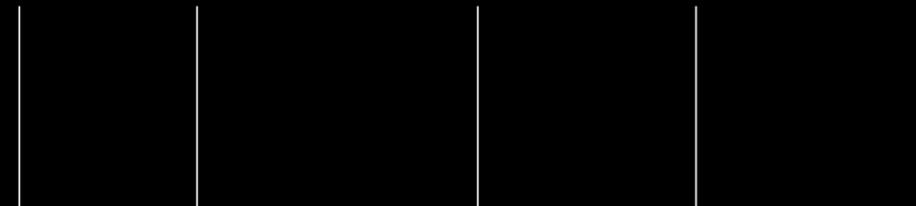
It is recommended that you read through the [introduction](#) first and then choose stories in the order you wish.



Health professionals can receive Continuing Education (CE) for completing *A Story of Health*. [Click here](#) for more details.



Choose stories in the order you wish. Select a disease term to highlight the affected person. Click the arrow button to read his or her fictional story of health.



INTRODUCTION Free Continuing Education

Information on free Continuing Education offered from the Centers for Disease Control and Prevention/Agency for Toxic Substances and Disease Registry

Each of the fictional stories in *A Story of Health* offers free Continuing Education (CE). On the “Final Thoughts” page of the last story of the entire eBook, or of each story (if you download them separately), you will be prompted to [register for CE through a hyperlink](#).

This hyperlink links to the CDC/ATSDR CE page where you can register and take the test for CE for each story. Before you begin each story, please review the learning objectives at right. These will help you focus as you read each story, and prepare you for each CE test.

Review these learning objectives for each story:



FREE CONTINUING EDUCATION Continuing education available by specialty

- Continuing Medical Education (CME) for Physicians
- Continuing Nursing Education (CNE) for Nurses
- Continuing Education Units (CEU) for other professionals
- Continuing Education Contact Hours (CECH) for Certified Health Education Specialists (CHES)

LEARNING/DEVELOPMENTAL DISABILITIES Amelia's Story*

Amelia is a 13-year-old who lives with her parents Darrell and Gloria in a small town in Louisiana.

She enjoys being with her friends, riding her bike, playing soccer, listening to music, and helping out at the restaurant where her mother is the bookkeeper.

Amelia likes school, although she has difficulty learning and is occasionally socially awkward.

Like one in six young people in America, Amelia has a developmental disability.



[More information on learning and developmental disabilities definitions and US trends](#)



[Link: Developmental Disabilities Increasing in US](#)



(*a fictional case)

LEARNING/DEVELOPMENTAL DISABILITIES Amelia's Story

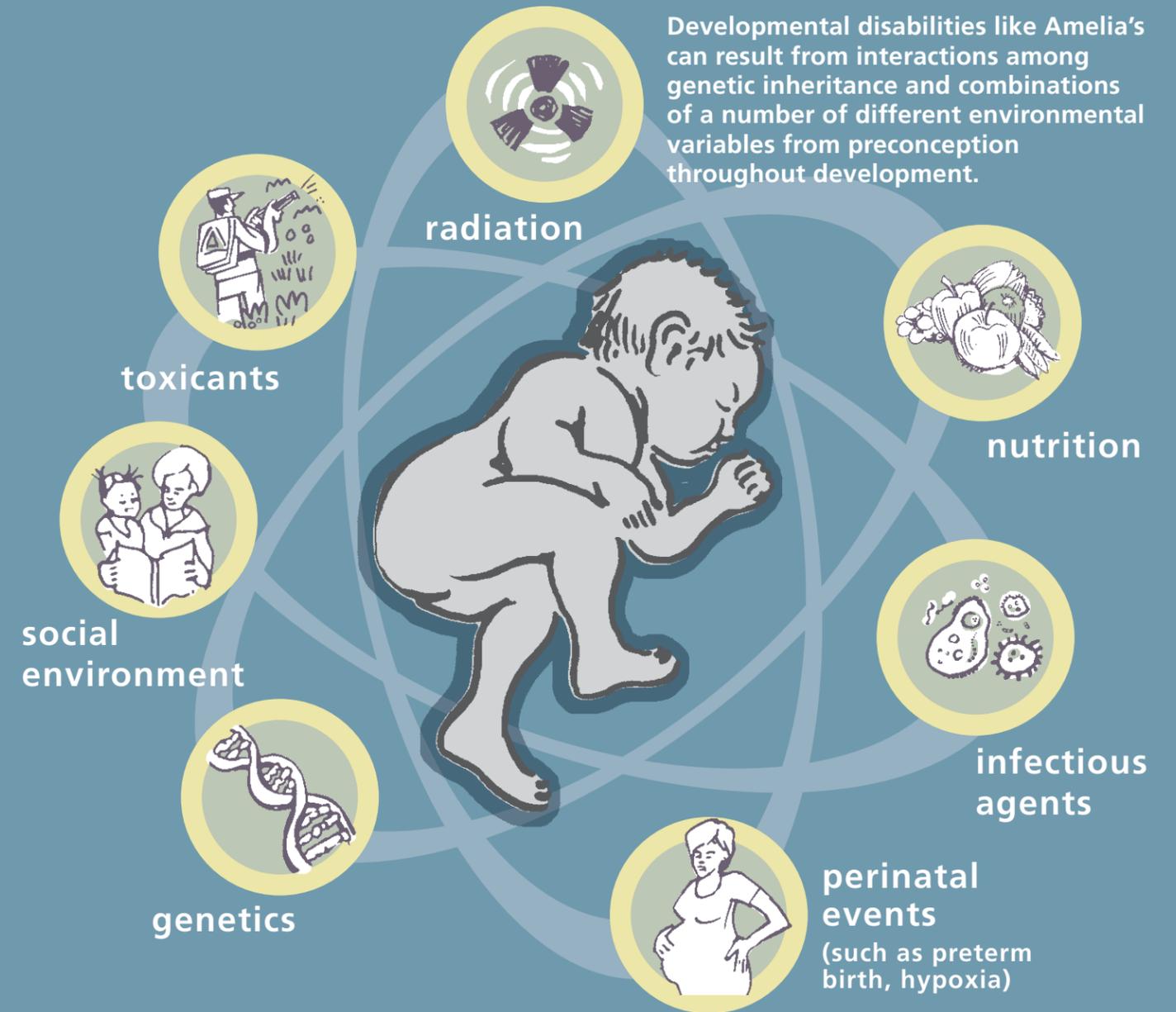
A single variable, such as birth trauma or prenatal exposure to alcohol, may sometimes be the cause of a developmental disability. More commonly, however, multiple risk factors combine to alter brain development and/or function in a variety of ways, resulting in a developmental disability.

Developmental disorders are generally better conceptualized as heterogeneous (different) conditions arising from interactions among genetic and environmental factors. (See “More” below for in-depth information.)

More on environmental and genetic contributors to developmental disabilities

Environmental factors reported to be associated with ADHD*

Multiple Contributors to Developmental Disabilities



*Thapar A, Cooper M, Jeffries R, Stergiakouli E. What causes attention deficit hyperactivity disorder? Arch Dis Child. 2012;97:260-265

LEARNING/DEVELOPMENTAL DISABILITIES Amelia's Story

DEVELOPMENTAL MILESTONES

Amelia's developmental disability was not particularly noticeable at a young age. Her developmental milestones had been only slightly delayed compared to her peers, and she also seemed to be somewhat inattentive, but otherwise progressed reasonably well.

In addition, the subtle expression of her delays and difficulties was missed by her parents, who were distracted after her baby brother David was born.

Checklists for Parents:
[CDC's Developmental Milestones](#) by specific age

Watch: How early recognition of developmental disabilities can assist parents and providers.



LEARNING/DEVELOPMENTAL DISABILITIES Amelia's Story

Amelia's parents, Darrell and Gloria, first became somewhat concerned that she might be having difficulty with school work when she was in the second grade. She seemed to be having trouble paying attention and finishing tasks like her homework.

They decided, though, that she was just going through some normal adjustments at school and at home. Because they were both working long hours at their jobs, taking care of a new baby, and struggling with finances, they did not seek help for Amelia at that time as her difficulties did not seem to be very serious.

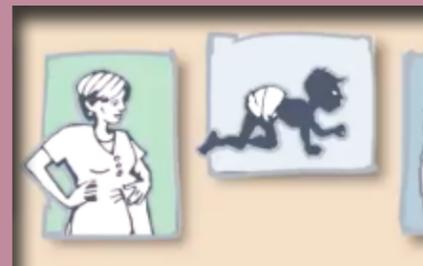
Both parents did make sure they spent time with her to help her read and comfort her when she seemed frustrated.

For these and other reasons, her parents put off addressing Amelia's problem until a parent-teacher meeting in the third grade, where they learned more about the difficulty Amelia was having in school. They realized they needed to take action.

Watch: Dr. Mark Miller describes the benefits of an enriched social environment and the way it influences brain structure and function.



Mark Miller MD MPH, Director, Children's Environmental Health Program, Office of Environmental Health Hazard Assessment, California EPA; Director, UCSF Pediatric Environmental Health Specialty Unit



Watch: "Childhood Development, Resilience and the Environment"

LEARNING/DEVELOPMENTAL DISABILITIES Amelia's Story

EVALUATION OF LEARNING DISABILITIES

Amelia's parents met with the school psychologist, Mr. Richards, who did an evaluation to determine Amelia's education needs. He also offered to refer them to a medical setting to see if the family wanted to pursue further diagnosis. When they asked, he referred them to a center in a large city where she could be further evaluated.

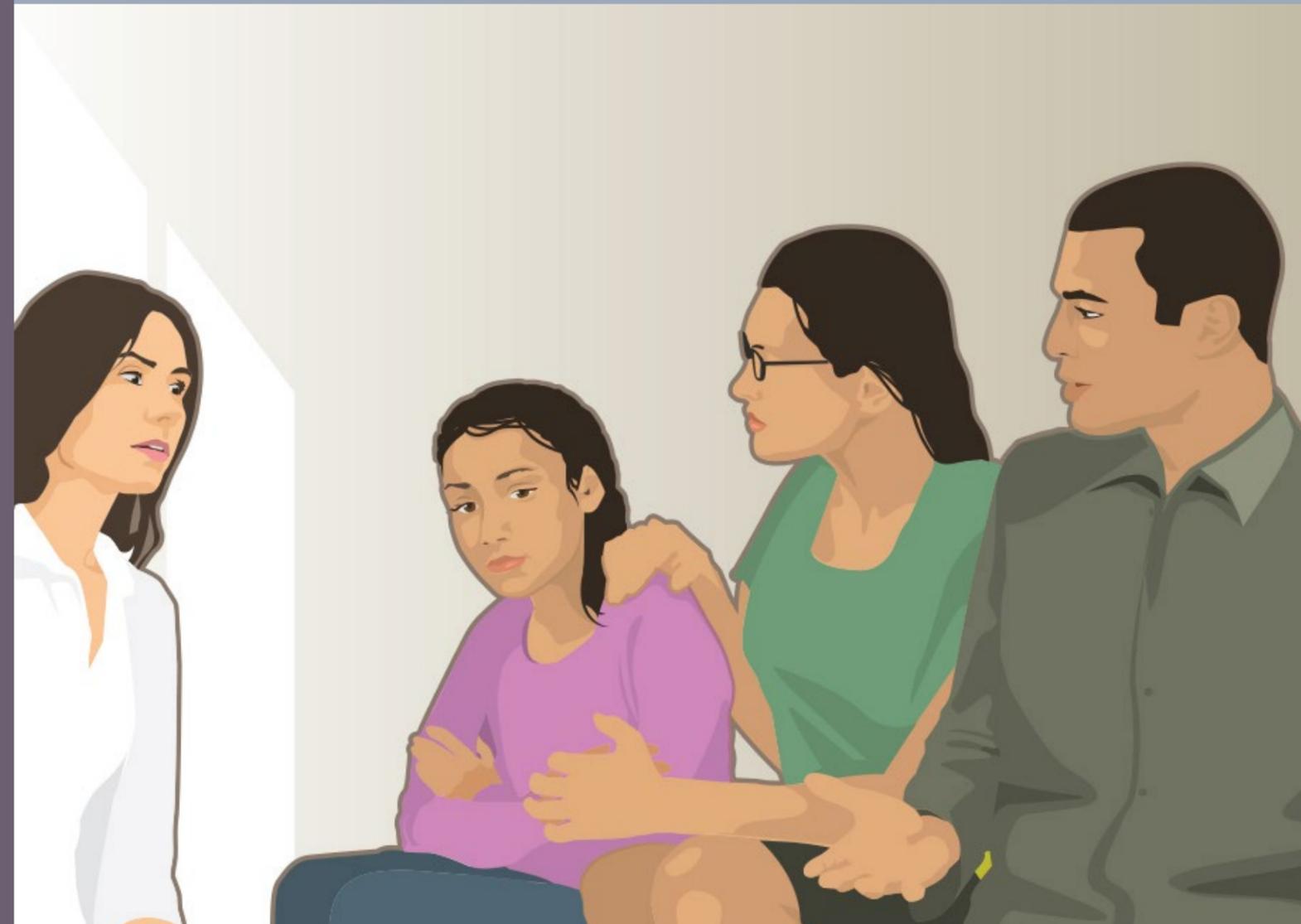
The medical setting was somewhat intimidating at first, but the people at the center made them feel at ease. They were introduced to Dr. Bradley, a developmental pediatrician, who said she would be conducting a number of screening procedures with Amelia.

After the screening, Dr. Bradley met with Amelia and her parents. She explained that Amelia's challenges were somewhat difficult to categorize as she had several that cut across syndromes they might have heard of, such as ADHD.

She explained that Amelia's reading and comprehension difficulties qualified as a learning disability. However, Amelia also exhibited inattention during the testing but not sufficiently for a diagnosis of ADHD.



[Find out more about Evaluations](#)



LEARNING/DEVELOPMENTAL DISABILITIES Amelia's Story



Dr. Bradley said she thought Amelia would do well with some extra help at school along with making other healthy living choices.

- Developmental Screening Tools for Clinicians:
 - Developmental Screening in Early Childhood Systems, American Academy of Pediatrics (AAP)
 - Developmental and Behavioral Screening Initiative, Administration for Children & Families (ACF)

OVERLAPPING SYNDROMES

Learning and behavioral disorders often overlap with other categories. For example:

Among children with ADHD:

- 10-30% also have learning disabilities;
- 30-50% also have language disability;
- 30-80% have other behavior disorders.

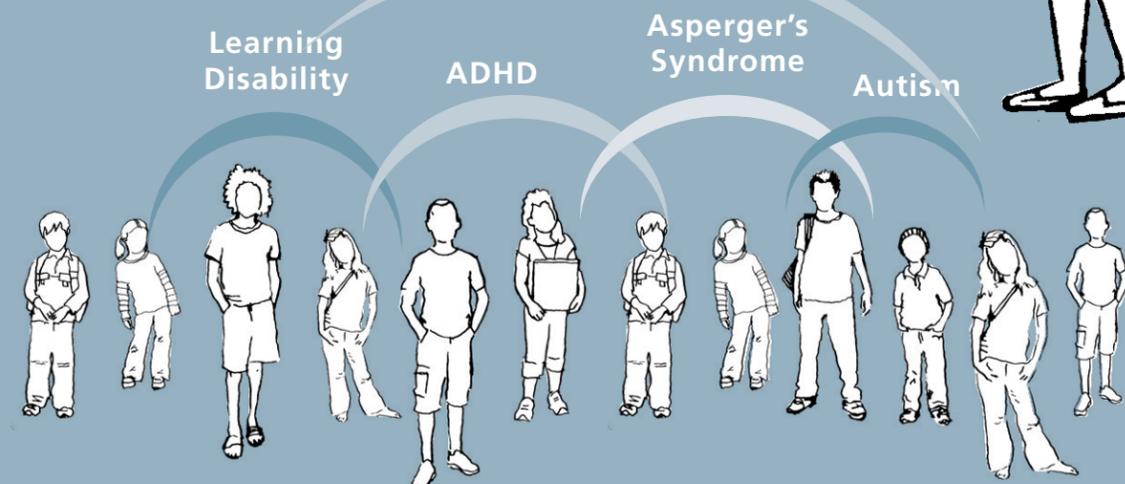
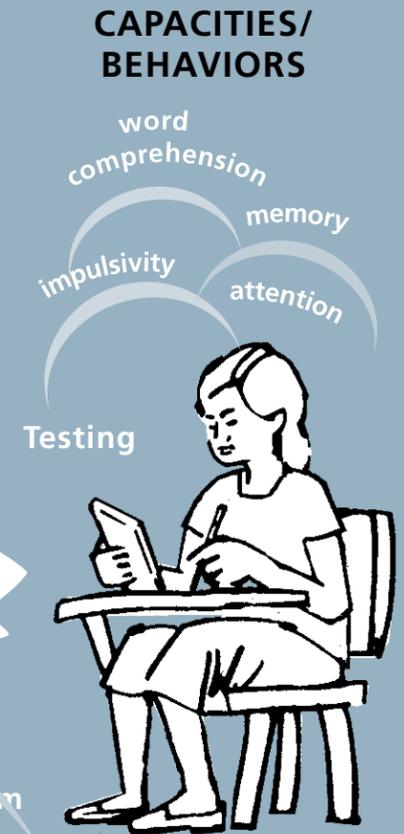
ADHD is also frequently associated with autism spectrum disorder, obsessive compulsive disorder, tic disorders, and intellectual disabilities.

Capacities/Behaviors vs. Syndromes

Cognitive and behavioral capacities and behaviors such as word comprehension, memory, attention, or impulsivity can be evaluated using validated age-appropriate diagnostic tests.

Sometimes multiple capacities and behaviors are bundled together into defined clinical syndromes, such as ADHD or autism spectrum disorders, for purposes of classification and deciding among possible interventions.

But there is often considerable overlap among syndromes. For example, many children with a diagnosis of ADHD also have a learning disability. Variability in the clinical expression of neurodevelopmental disorders creates challenges for diagnostic categorization and demonstrates the complexity of their origins.



DEVELOPMENTAL SYNDROMES



Learning Disability



ADHD



Autism spectrum disorder



LEARNING/DEVELOPMENTAL DISABILITIES Amelia's Story

Amelia's parents, Darrell and Gloria, asked Dr. Bradley what could have caused Amelia's learning disability, and Dr. Bradley was interested in exploring that as well.

Dr. Bradley suggested that there is often a genetic predisposition and added that if Amelia had been born prematurely, or had a low birth weight, either could be a risk factor for her developmental disability.

Gloria told her that Amelia was a little underweight when she was born, but no one seemed very concerned about it at the time. Dr. Bradley also mentioned that smoking or drinking during pregnancy could increase the risk. Gloria told her that her husband had smoked during her pregnancy, although when Amelia was born he had quit with help from their local medical clinic.

Finally, Dr. Bradley told them about the risk to brain development from exposures early in life to other toxic chemicals and substances, such as lead, mercury, and diesel fumes from trucks and cars.

Preconception and Healthy Child Development

+ [More information: CDC's Preconception care for women and men](#)

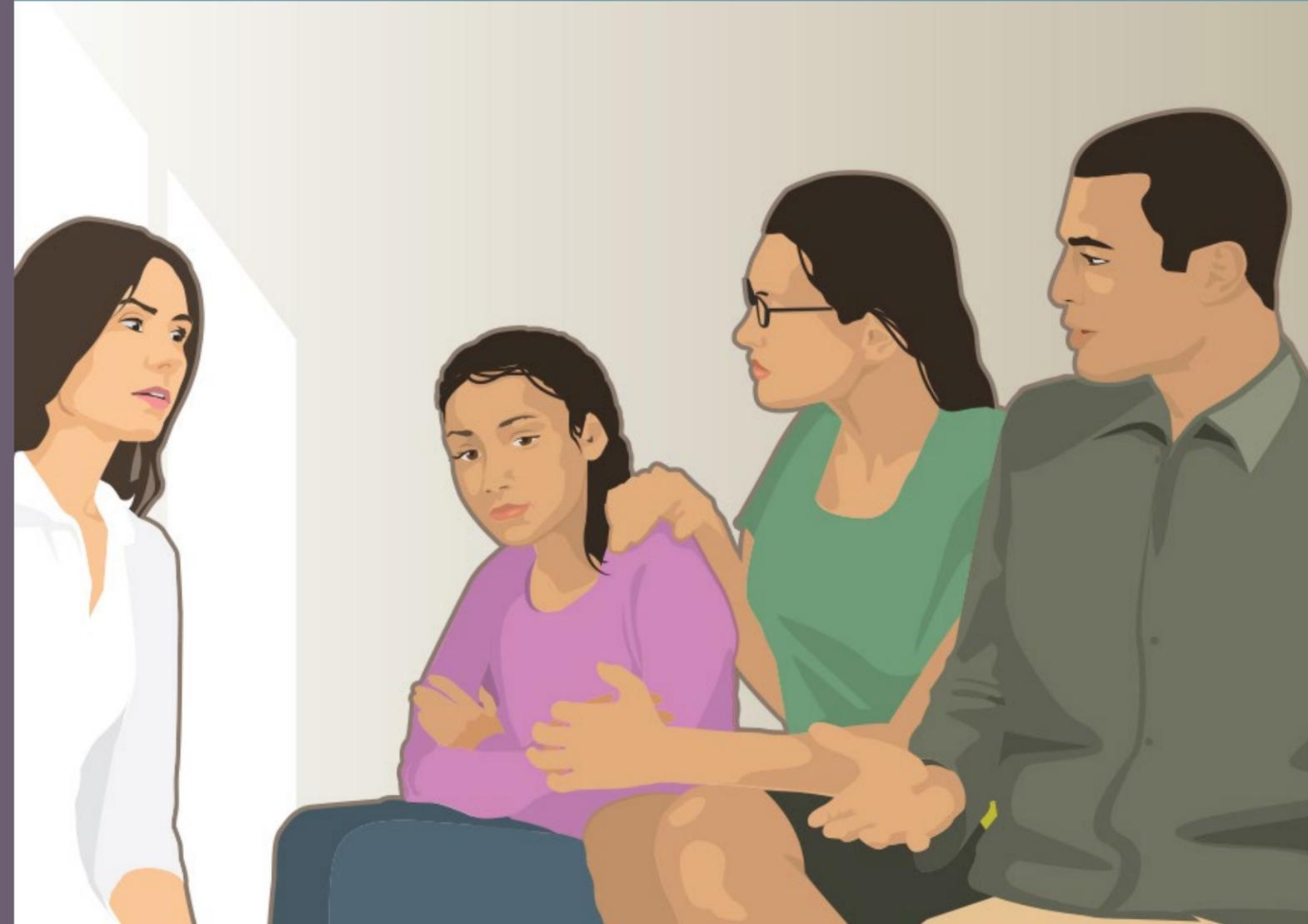
Prenatal Care and Healthy Child Development

Folate supplementation recommendations for women

A Rationale for Thyroid Screening

Thyroid disruption technical diagram

[For Clinicians: Environmental health history form](#)



MORE INFORMATION:

- [CDC on pregnancy](#)
- [American Congress of Obstetrics and Gynecology \(ACOG\):](#)
 - [Good Health Before Pregnancy \(pdf\)](#)
 - [Prenatal Nutrition](#)
 - [Environmental Chemicals](#)
- [Royal College of OB/GYN: - Chemical Exposures During Pregnancy](#)
- [UCSF: Program on Reproductive Health and the Environment](#)
- [American Thyroid Association Guidelines](#)

LEARNING/DEVELOPMENTAL DISABILITIES Amelia's Story

BRAIN DEVELOPMENT

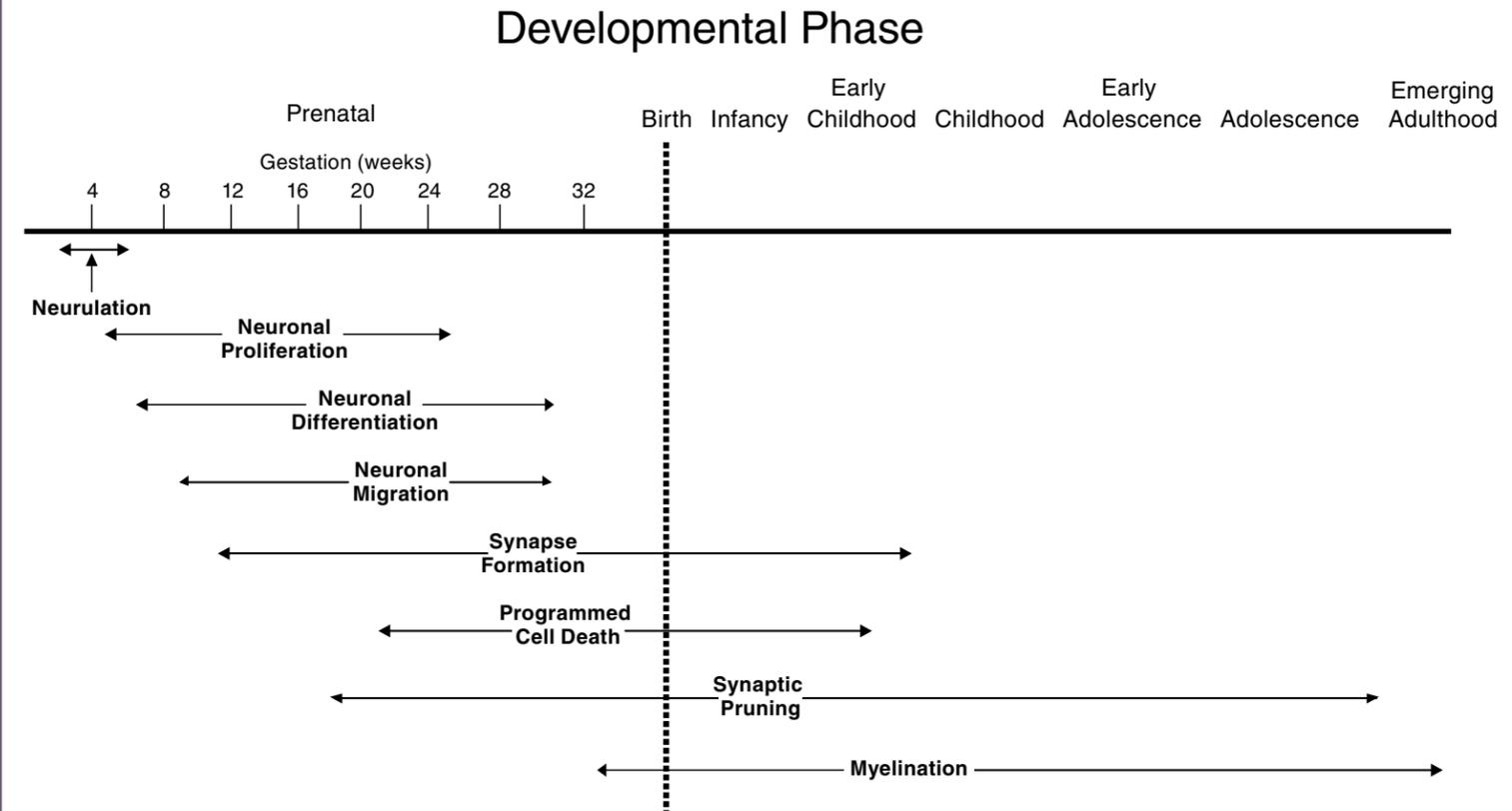
Brain development begins soon after conception and continues throughout adolescence into adulthood. It is characterized by a critical sequence of events that helps to determine brain structure and function. Each of these processes is subject to disruption by exposure to various environmental agents. Inadequate nutrition and adverse social circumstances can also impair these developmental processes.

Even brief disruptions during critical periods of early brain development can have significant downstream effects with long-lasting consequences.

The clinical manifestation of disruption from neurodevelopmental toxicants or other stressors depends on the nature of the agent as well as the size, timing, and duration of exposure.

Find out more:
[Cellular events in neurodevelopment](#)

Timeline of major events in brain development



Source: [Preventing Mental, Emotional and Behavioral Disorders Among Young People: Progress and Possibilities](#). Mary Ellen O'Connell, Thomas Boat, and Kenneth E. Warner, Eds. Natl Academies Press, Washington, DC. 2009. Graphic used with permission.

LEARNING/DEVELOPMENTAL DISABILITIES Amelia's Story

BRAIN DEVELOPMENT

The pattern of formation of nerve connections (synapses) in the cerebral cortex is characterized by rapid proliferation and over-production of synapses, followed by a phase of synapse elimination (pruning) that reduces the number of synapses to more adult-like levels.

This process is prominent in the first years of life, although it extends to some degree into adolescence. However, different brain regions with different functions develop on different time courses.



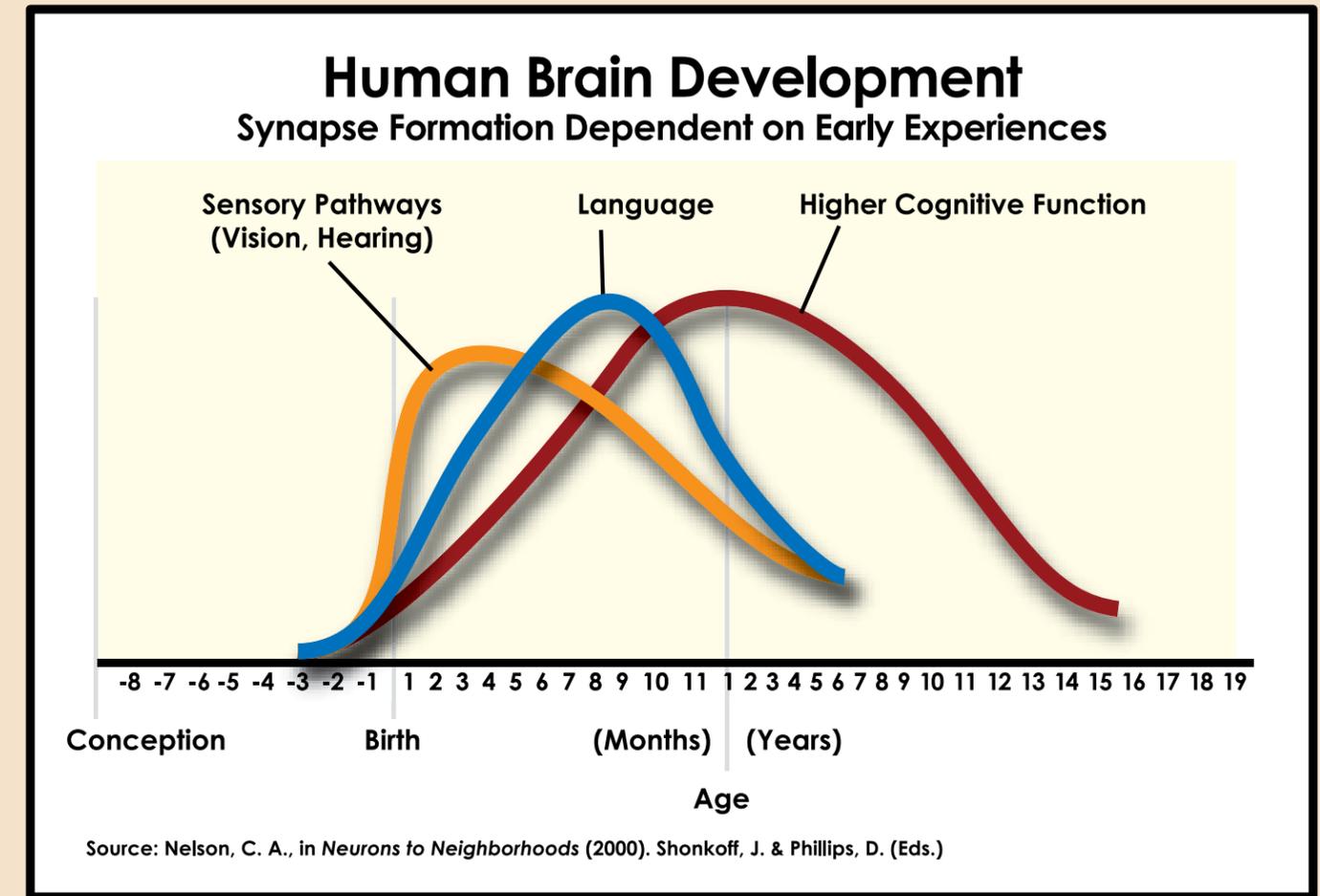
"Core Concepts in the Science of Early Childhood Development" Harvard Univ. Center for the Developing Child

Watch: Little Things Matter: The Impact of Toxins on the Developing Brain

Dr. Bruce P. Lanphear, MD MPH
Professor, Simon Fraser University



Experience-dependent synapse formation



Graphic: "A Science-Based Framework for Early Childhood Policy" Center on the Developing Child, Harvard University
Reproduced with permission.

LEARNING/DEVELOPMENTAL DISABILITIES Amelia's Story

Dr. Bradley discussed some of the ways that Gloria and Darrell could help Amelia with her learning problems and discussed eligibility that would allow support for Amelia to attend special programs.

She encouraged them by saying that it was never too late to focus on habits to promote health for the whole family, like healthy eating, exercise, avoiding toxic chemicals, and trying to deal positively with stress.

She referred them back to Mr. Richards at the school to discuss developing a school program tailored to Amelia's needs.

She gave them some booklets and brochures. Amelia's parents thought Dr. Bradley was helpful but left feeling a little overwhelmed.

Amelia was worried because she figured there was extra school work in her future.



Effect modifiers:
iron deficiency, poverty,
lead exposure.



Resources to help parents:
[Learning Disabilities Association](#)

Watch: Dr. Mark Miller describes how lead and stress affect brain functioning, and the benefits of an enriched environment. (4 min.)



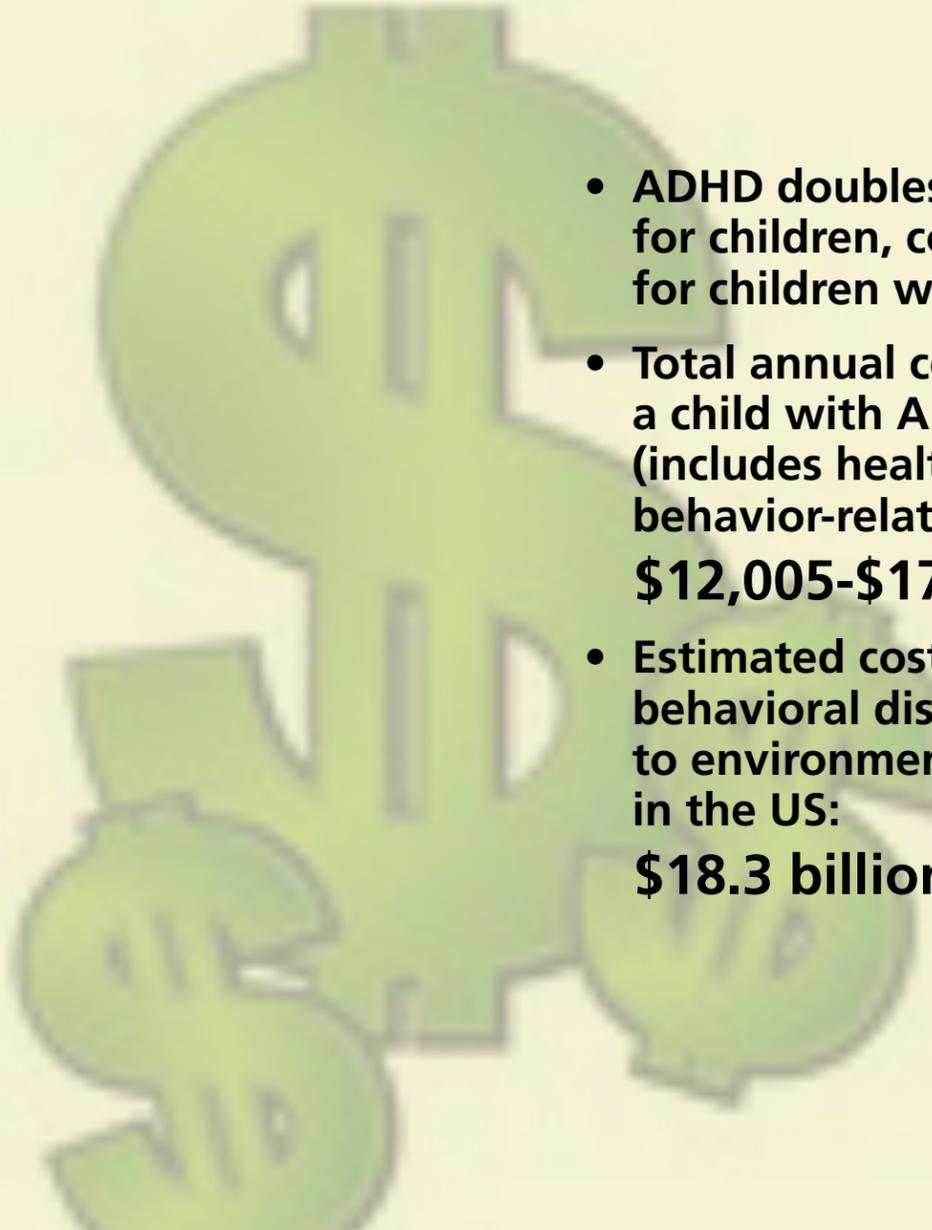
LEARNING/DEVELOPMENTAL DISABILITIES Amelia's Story

ECONOMIC COSTS

Developmental disabilities affect individuals, families, and communities and have staggering economic costs.

Effects can include:

- academic difficulties,
- employment problems,
- financial stress,
- emotional stress,
- substance abuse,
- lawbreaking , *and even*
- suicide.

- 
- ADHD doubles health care costs for children, comparable to costs for children with asthma.
 - Total annual cost-of-illness for a child with ADHD in the US (includes health-, education-, behavior-related costs):
\$12,005-\$17,458/yr.
 - Estimated costs of neuro-behavioral disorders attributable to environmental pollutants in the US:
\$18.3 billion/yr.

(CDC, National Center on Birth Defects and Developmental Disabilities – ADHD Data and Statistics; Trasande & Liu, 2011)

LEARNING/DEVELOPMENTAL DISABILITIES Amelia's Story

TOXICANTS AND HEALTH

Gloria decided to look online to learn more about environmental chemicals that can contribute to learning and developmental disabilities.

She began to think of the many ways that her family might have been exposed to lead, mercury, pesticides, endocrine disruptors, solvents, air pollution and other substances that she read about.

+ Chemicals and neurodevelopmental health effects – an overview.

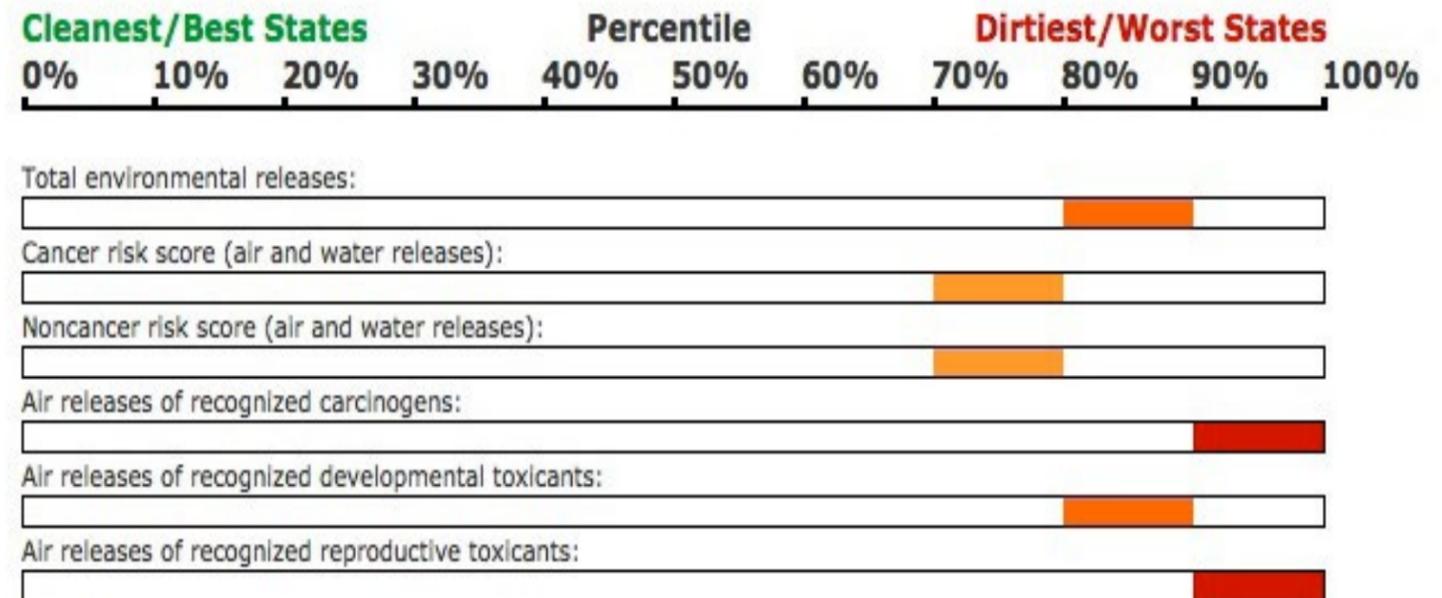
It was not difficult. Before Amelia was born her parents lived in Baton Rouge, Louisiana where Gloria worked at a petrochemical factory. At the factory she had noticed the smell of solvents nearly every day. The smells from the factory were more bothersome when Gloria was dealing with morning sickness.

Gloria and Darrell moved to their current home just as Gloria was beginning her second trimester of pregnancy.

+ [Link: Scorecard: Get an in-depth pollution report for your county, covering air, water, chemicals, and more.](#)

+ [Link: California Proposition 65 - chemicals known to cause cancer or reproductive toxicity](#)

2002 Rankings: Major Chemical Releases or Waste Generation in LOUISIANA*



See how this state ranks on other chemical release and waste management attributes tracked by Scorecard
Graphic used with permission.

Grandjean P, Landrigan P. Neurobehavioural effects of developmental toxicity [Lancet Neurol.](#) 2014 March;(13):330-338.

LEARNING/DEVELOPMENTAL DISABILITIES Amelia's Story

TOXICANTS AND HEALTH - AIR POLLUTION

When Darrell and Gloria moved from Baton Rouge to a smaller town in Louisiana, they chose their new home because of its affordability. The house was a nice size for the growing family, but it was on a busy street, where many trucks passed on their way to factories in surrounding towns.

Soon after the family moved to their new home, Gloria and Darrell undertook some remodeling. Darrell was very busy with his new job, and Gloria (who was pregnant with Amelia) did most of the painting and had new carpet installed.

It was not until many years after moving that Gloria learned that air pollution from traffic emissions can have adverse effects on child development. She also learned that remodeling projects can involve exposures to chemicals that can harm a developing child's brain.

Air pollution, family stress and nutrition - synergistic effects on brain development.

Link: TENDR (Targeting Environmental Neuro-Development Risks)



LEARNING/DEVELOPMENTAL DISABILITIES Amelia's Story

TOXICANTS AND HEALTH - PESTICIDES

Gloria recalled that they had the new house sprayed for pests after receiving promotional materials in the mail soon after Amelia was born. Although they do not use pesticides in their home or outside any longer, their neighbors regularly spray their lawns with pesticides. She later learned that pesticides, some of which are neurotoxic and can impair brain development, are widely used.

Gloria also thought about Darrell's job as a carpenter and how he works with a lot of chemicals.

She was amazed at how many exposures to toxic chemicals her family had experienced that she had never thought about before!

**Prevention Strategies:
Integrated Pest
Management**

**Link: Organophosphate
exposures during
pregnancy and child
neurodevelopment:
Recommendations for
essential policy reforms**



More Resources:

Pesticides: [EPA - Integrated
Pest Management](#)

Bio-Integral Resource
Center ([BIRC](#))

Pesticide Action
Network ([PAN](#))



Drawing courtesy of the Bio-Integral
Resource Center, artist Diane Kuhn.
Reproduced with permission.

LEARNING/DEVELOPMENTAL DISABILITIES Amelia's Story

TOXICANTS AND HEALTH - MERCURY

Amelia liked to go fishing with her father, who was an avid fisherman. For several years they had enjoyed catching and eating a variety of fish from the local lake.

Gloria remembered Darrell coming home from fishing one day and telling her about a posted fish advisory, warning fisherman not to eat the fish due to contamination from mercury.

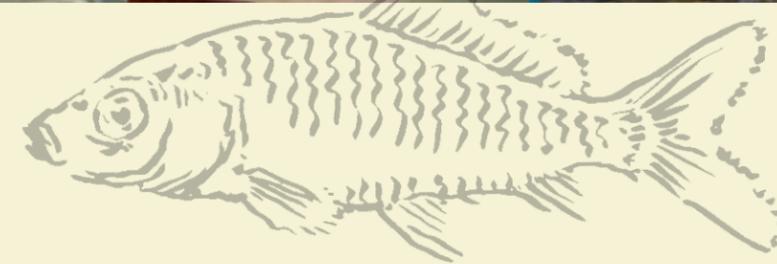
The advisory included a state web site where Gloria was able to learn more. She read that mercury, like lead, is a heavy metal that disrupts brain development. She also read about the health benefits of eating uncontaminated fish and about nutritious fish with low contaminant levels available in local supermarkets.

Gloria searched for an alternative place where Darrell and Amelia could continue to enjoy fishing and from which the family could also eat the fish they caught. She found a nearby river where the fish were not contaminated. Amelia was happy that she and her dad could still fish together.

[Link: EPA fish advisories](#)



[Link: Pediatric Environmental Health Toolkit animation on mercury in fish and children's health](#)



Photos from EPA: <http://water.epa.gov/scitech/swguidance/fishshellfish/fishadvisories/index.cfm>, used with permission.

LEARNING/DEVELOPMENTAL DISABILITIES Amelia's Story

TOXICANTS AND HEALTH - LEAD

Finally, Gloria thought about the older houses they had lived in and the lead paint problems. They had been careful to remove the paint properly, but maybe they had not removed it all.

Lead removal from gasoline and other products – a public health success story

Luckily, she didn't have to worry about lead in gasoline anymore. She read about how that was a public health success story and how it had reduced blood lead levels in children.

Lead - developmental effects

[PEHSU](#) animation on lead exposure and children's health



Link: [CDC: Primary prevention of lead exposure](#)

Where is the Lead?

- Formerly used in house paint, gasoline, water pipes, solder in food cans;
- Currently found in imported pottery, some cosmetics, some traditional (indigenous or folk) medicine, older water pipes, older house paint, some types of industrial paint, aviation fuel, car batteries, and bullets;
- Most common sources of exposures: older paint, dust, and water pipes.



LEARNING/DEVELOPMENTAL DISABILITIES Amelia's Story

TOXICANTS AND HEALTH

Gloria also wondered about other chemicals that she was exposed to when she was pregnant with Amelia, including second-hand tobacco smoke and solvents at the factory where she worked before they moved.

Amelia had thrived in her daycare. She seemed happy there and learned some of the basic skills she needed for kindergarten. Amelia's daycare was a good choice, but Gloria thought about hazardous chemicals Amelia might have been exposed to when she was there.

These include formaldehyde emitted from certain furnishings and building materials like cabinets, hazardous chemicals in carpeting, phthalates in flexible plastic toys and vinyl flooring, bleach and other cleaning solutions, and air pollutants from indoor natural gas combustion.



More information:

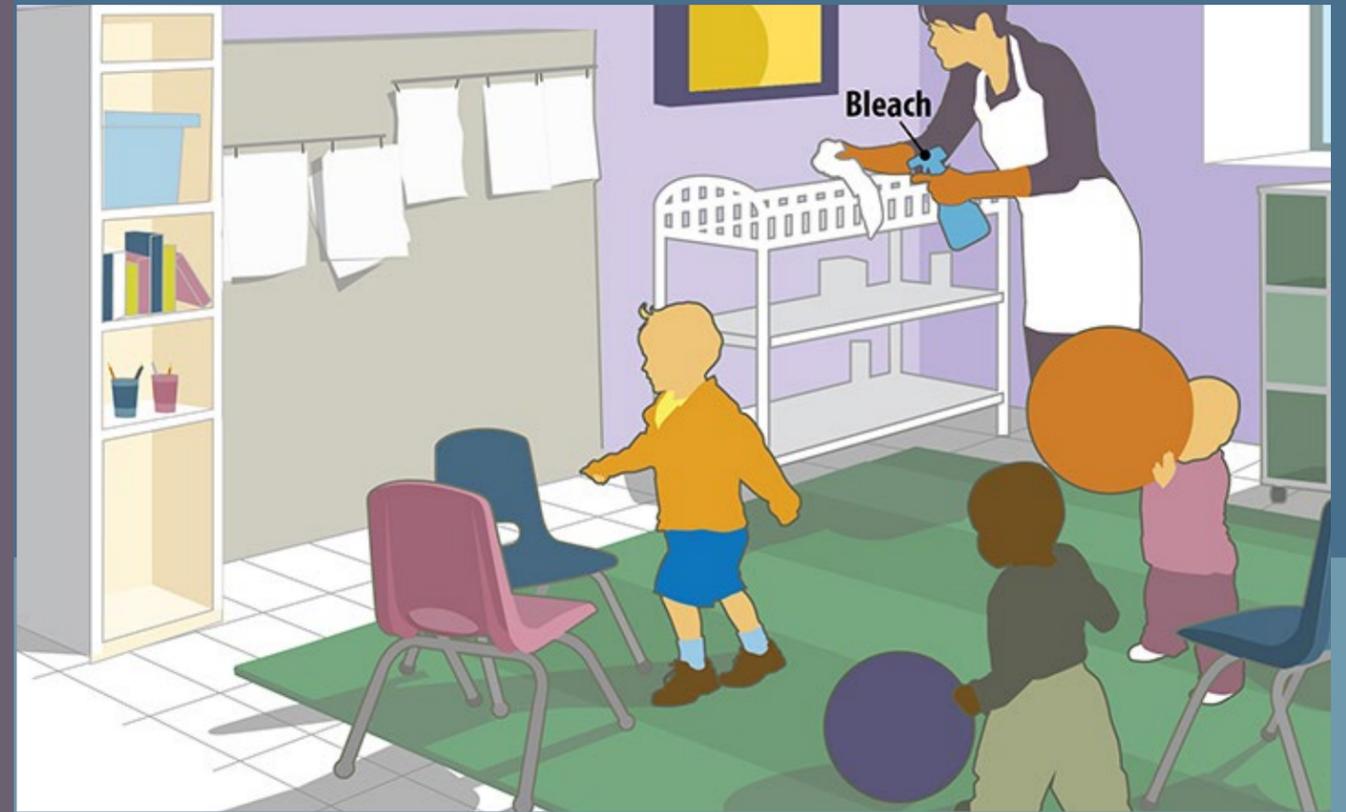
Benefits of early childhood education and policies:

- [Harvard University Center on the Developing Child: Resource Library](#)

Preventing/reducing toxic chemical exposures in child care settings:

- [Eco-Healthy Child Care](#)
- [Integrated pest management curriculum and Green cleaning toolkit](#)

Watch: Watch Dr. Mark Miller describes the benefits of early childhood education (1.42 min.)



LEARNING/DEVELOPMENTAL DISABILITIES Amelia's Story

TOXICANTS AND COMMUNITY HEALTH

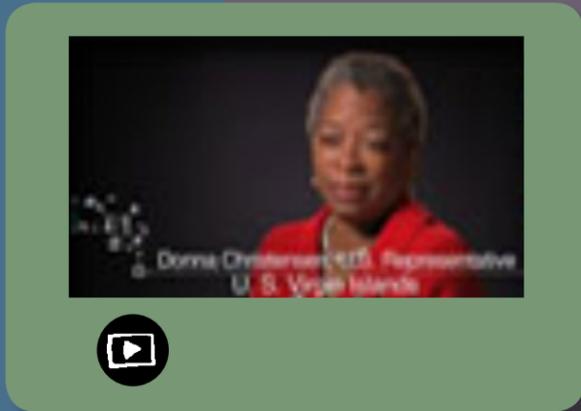
Gloria and Darrell became worried that there might not be much they could do about reducing the family's ongoing exposures to hazardous chemicals.

Gloria decided to call up a friend who was involved in the community to see if she knew more about community exposures to toxic chemicals.

Her friend told her there was a local group called "Clean and Green" that was working on reducing the use of chemicals in their town and other issues relating to the environment. She said they had received information from other communities facing similar issues.

Gloria heard the term "environmental justice" for the first time.

Key Concept:
Environmental Justice



Watch: Representative Donna Christensen from the U.S. Virgin Islands speak about EJ from a physician's perspective. (2.47 min.)



Watch: Peggy Shepard of WE ACT for Environmental Justice addresses "sacrifice zones" at TEDxHarlem (8 min.)



Watch presentations:
[WSPEHSU/OEHHA symposium Environmental Justice and Children](#)

Find out more: [Toxic Wastes and Race at Twenty: 1987-2007 \(pdf\)](#)
[Read the latest goals EJ 2020 Action Agenda: EPA's Environmental Justice Strategy](#)
Browse maps: [Interactive Global Atlas of Environmental Justice](#)

LEARNING/DEVELOPMENTAL DISABILITIES Amelia's Story

TOXICANTS AND COMMUNITY HEALTH



Gloria started attending meetings of Clean and Green.

She learned a lot about the many sources of pollution in the community, in the air, in the water, and on land.

The group had information about environmental contamination and community health studies. They were working with scientists from a nearby university who were considering doing a health study, as there seemed to be higher than expected levels locally of several diseases, including cancer, and concerns that there were excessive numbers of children being born with birth defects.

Chemical regulations

Links for more info:

[Safer Chemicals Healthy Families](#)

EPA: [Laws and Executive Orders](#)

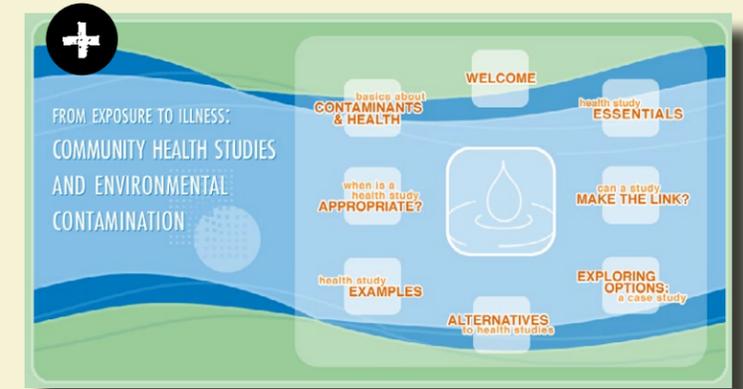
Community Health Studies and the Environment

Citizens concerned about pollution in their community, or about apparent high levels of diseases like cancer, sometimes turn to scientists and health experts to ask them to study their town to see if there are connections between pollution and their health. These studies are difficult and expensive, and citizens are often disappointed in the results.

Find out why with these two resources.

HEALTH STUDIES GUIDE: Boston University Superfund Research Project

A guide for making informed decisions, written to assist community groups and individuals who think that some form of environmental health investigation or health study may be useful or necessary in their community.



FROM EXPOSURE TO ILLNESS: Community Health Studies and Environmental Contamination

The Environmental Health Investigations Branch, California Department of Public Health

Created as a means to share the experience and perspective of public health staff dedicated to studying links between environmental exposure to chemicals and health effects in California communities.



Graphics used with permission.

LEARNING/DEVELOPMENTAL DISABILITIES Amelia's Story

The next time Amelia went to her new family practice for a checkup, Gloria told them about Amelia's diagnosis of a learning disability.

Her nurse practitioner, Robert, suggested some things to do that could help Amelia.

They included making sure she got enough exercise, adequate sleep, healthy and nutritious foods, and encouragement to spend time outdoors in green space or natural surroundings, such as in the park, because that could help her with her attention and focus.



[Link: Animation on "Healthy Food and Exercise" – UCSF Pediatric Environmental Health Specialty Unit.](#)



LEARNING/DEVELOPMENTAL DISABILITIES Amelia's Story

Amelia's parents both became involved in the community group. Over the years they had some major successes, including getting the truck route that used to go by their house changed to a less residential area. They knew that would promote the health of their entire family and community.

The education plan that the school, the developmental pediatrician, and Amelia's parents put together included learning strategies for reading and math that Amelia found helpful.

Amelia still struggles to some extent with particular tasks in school and can sometimes become frustrated in social situations, but she knows she has the support of her family and friends and that means a lot.

Her parents know they are doing everything they can to improve the health of their family.



LEARNING/DEVELOPMENTAL DISABILITIES Amelia's Story

Throughout the pages of Amelia's story we've seen a wide range of interacting factors across her lifespan that may have increased her risk for developmental disabilities.

These include exposure to toxic chemicals and community stressors, diet, socioeconomics, genetics, and gene-environment interactions.

We have also seen factors that can increase resilience and enhance healthy development, such as parental love and attention, childhood enrichment activities, and early childhood education.

Although Amelia's story is fictional, children throughout our country face a similar range of issues and circumstances. Developmental disabilities are widespread. It is critical that we consider the multiple environmental influences associated with increased risks of developmental disabilities, and their long term consequences for children like Amelia, when we design prevention strategies and treatments to address them.

Continue to [Final Thoughts](#) >



Children throughout our country face a similar range of exposures and consequences.



A wide range of interacting factors across Amelia's lifespan may increase the risk for developmental disabilities



It is critical that we consider the multiple environmental influences associated with increased risks of developmental disabilities, and their long term consequences for children like Amelia, when we design prevention strategies and treatments.

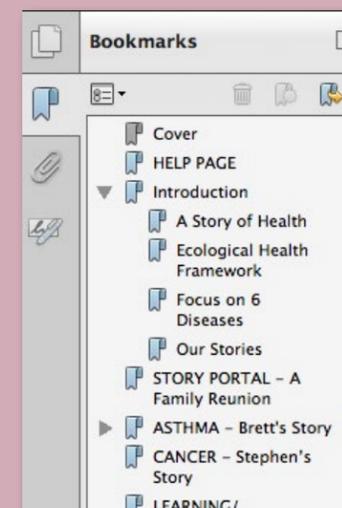
COMMON THEMES

Although the fictional narratives in *A Story of Health* describe the lives of children and adults with different conditions and diseases – infertility, asthma, developmental disabilities, childhood leukemia and cognitive decline - common themes resonate. They include:

- Important environmental influences come from the natural, chemical, food, built, and social environments.
- Although there are exceptions, most diseases as well as good health are the result of complex interactions among multiple environmental influences and genetics.
- Early-life experiences, particularly during critical windows of development, can have profound beneficial or detrimental lifelong effects, even into elder years.
- Healthy people and healthy communities are interdependent. All people do not have equal access to nutritious food, clean air and water, safe workplaces, healthy housing, green spaces, peaceful neighborhoods or quality health care.
- Preventing disease and promoting health require actions and commitments from the individual, family, community and society. Health promoting public policies are necessary to make healthy living available to all people.

Resources

We have linked to many useful resources in each story relevant to a wide range of audiences, including clinicians. To quickly access resources on specific topics in each story, use the **Bookmarks** toolbar on the left (which you can open or close), or return to the [Help page](#) for more details on other eBook features.



Additional resources to help prevent disease and promote health:

[Portal to Toxicant and Disease Database:](#)

A searchable database that summarizes links between chemical contaminants and approximately 180 human diseases or conditions.

Portal to Science Resources: Hundreds of additional resources on environmental health including organizations, publications, videos and more.

Pediatric Environmental Health Toolkit application for mobile devices

Approaches to Healthy Living: A 4-page guide on how to avoid toxicants, eat healthier, reduce stress.

[Healthy Aging: The Way Forward:](#)

An ecological approach to policy level interventions for healthy aging across the lifespan.

Continuing Education

Register for Continuing Education (CE) for *A Story of Health* for a variety of health professions. Free credits are offered by the Centers for Disease Control and Prevention/Agency for Toxic Substances and Disease Registry [at this link](#).



Another free CE course on environmental health offered by the CDC/ATSDR is the **Pediatric Environmental Health Toolkit** online course.

Asthma

Childhood
LeukemiaLearning/
Developmental
Disabilities

Diabetes

Infertility

Cognitive Decline

Developmental and Learning Disabilities Case References and Resources by Topic

Note: there are many topic overlaps

ADHD

Nussbaum N. ADHD and female-specific concerns: a review of the literature and clinical implications. *Journal of Attention Disorders*. 2012 Feb; vol. 16 no. 2 87-100

Pastor PN, Reuben CA. Diagnosed attention deficit hyperactivity disorder and learning disability: United States, 2004-2006. *Vital Health Stat* 2008. 10(237)

Semrud-Clikeman M, Bledsoe J. Updates on attention-deficit/hyperactivity disorder and learning disorders. *Curr Psychiatry Rep*. 2011 Oct;13(5):364-73. doi: 10.1007/s11920-011-0211-5. Review

Sexton CC, Gelhorn HL, Bell JA, Classi PM. The co-occurrence of reading disorder and ADHD: epidemiology, treatment, psychosocial impact, and economic burden. *J Learn Disabil*. 2012 Nov-Dec;45(6):538-64. doi: 10.1177/0022219411407772. Epub 2011 Jul 14

Skogli EW, Teicher MH, Andersen PN, Hovik KT, Oie M. ADHD in girls and boys - gender differences in co-existing symptoms and executive function measures. *BMC Psychiatry*. 2013 Nov 9;13:298

Thapar A, Langley K, Muñoz-Solomando A. The ADHD debate: being mindful of complexity and wary of reductionist explanations and polarization: Commentary on 'A social relational critique of the biomedical definition and treatment of ADHD; ethical, practical and political implications'. *J Fam Ther*. 2013 May;35(2):219-223

Thapar A, Cooper M, Jeffries R, Stergiakouli E. What causes attention deficit hyperactivity disorder? *Arch Dis Child*. 2012;97:260-265

United States Environmental Protection Agency. America's children and the environment - third edition. Report number EPA 240 R-13-001, 2013



Autism

Goodrich AJ, et al. Joint effects of prenatal air pollutant exposure and maternal folic acid supplementation on risk of autism spectrum disorder. *Autism Res*. 2018 Jan;11(1):69-80.

Hallmayer J, Cleveland S, Torres A, Phillips J, et al. Genetic heritability and shared environmental factors among twin pairs with autism. *Arch Gen Psychiatry*. 2011;68(11):1095-1102

Sandin S, Lichtenstein P, Kuja-Halkola R, Larsson H, et al. The familial risk of autism. *JAMA*. 2014;311(17):177-1777

Schmidt RJ, Iosif AM, Guerrero Angel E, Ozonoff S. Association of maternal prenatal vitamin use with risk for autism spectrum disorder recurrence in young siblings. *JAMA Psychiatry*. 2019 Feb 27.

Schmidt RJ, Tancredi DJ, Ozonoff S, et al. Maternal periconceptional folic acid intake and risk of autism spectrum disorders and developmental delay in the CHARGE (Childhood Autism Risks from Genetics and Environment) case-control study. *Am J Clin Nutr*. 2012;96:80-9.

Surén P, Roth C, Bresnahan M, et al. Association between maternal use of folic acid supplements and risk of autism spectrum disorders in children. *JAMA*. 2013 Feb 13;309(6):570-7.

Chemical exposures and neurodevelopment - general

Braun JM, Kahn RS, Froehlich T, Auinger P, Lanphear BP. Exposures to environmental toxicants and attention deficit hyperactivity disorder in U.S. children. *Environ Health Perspect*. 2006 Dec;114(12):1904-9

Ekanayake R, Miller M, Marty, M. Office of Environmental Health Hazard Assessment, California Environmental Protection Agency. Report to the Legislature. *Children's Environmental Health Program*. February 2014

Grandjean P. Only one chance: How environmental pollution impairs brain development—and how to protect the brains of the next generation. Oxford Univ Press; New York, 2013

Grandjean P, Landrigan P. Neurobehavioural effects of developmental toxicity *Lancet Neurol*. 2014 March;(13):330-338

Hubbs-Tait L, Nation J, Krebs, N, Bellinger D. Neurotoxicants, micronutrients, and social environments: Individual and combined effects on children's development. *Psychological Sci in the Public Interest*. 2005; 6(3): 57-121

Julvez J, Grandjean P. Neurodevelopmental toxicity risks due to occupational exposure to industrial chemicals during pregnancy. *Ind Health*. 2009 Oct;47(5):459-68

Koger SM, Schettler T, Weiss B. Environmental toxicants and developmental disabilities: a challenge for psychologists. *Amer Psychol*. 2005 April; 60 (3). 243-255

Schettler T. Toxic threats to neurologic development of children. *Environ Health Perspect*. Dec 2001; 109(Suppl 6): 813-816

Schettler T, Stein J, Valenti M, Wallinga D. In Harm's Way: Toxic Threats to Child Development. January 2001. Greater Boston Physicians for Social Responsibility and Clean Water Fund

Stein J, Schettler T, Wallinga D, Valenti M. In harm's way: toxic threats to child development. *J Dev Behav Pediatr*. 2002 Feb;23(1 Suppl):S13-22



Chemical exposures and neurodevelopment - Specific Pollutants

Air pollution, air pollution and stress

Anthopolos R, Edwards S, Mikranda M. Effects of maternal prenatal smoking and birth outcomes extending into the normal range on academic performance in fourth grade in North Carolina, USA. *Paediatr Perinat Epidemiol*. 2013 Nov;27(6):564-74. doi: 10.1111/ppe.12081. Epub 2013 Aug 25

Becerra T, Wilhelm M, Olsen J, Cockburn M, Ritz B. Ambient air pollution and autism in Los Angeles county, California. *Environ Health Perspect*. 2013; 121(3):380-386

Bolton JL, Huff NC, Smith SH, Mason SN, Foster WM, Auten RL, Bilbo SD. Maternal stress and effects of prenatal air pollution on offspring mental health outcomes in mice. *Environmental Health Perspectives*. 2103 Sept; Volume 121:9

Bradman A. Air pollution and contaminants at child-care and preschool facilities in California. *California Environmental Protection Agency Air Resources Board. Fact Sheet*. April 2012

Chen R, Clifford A, Lang L, Anstey KJ. Is exposure to secondhand smoke associated with cognitive parameters of children and adolescents?-a systematic literature review. *Ann Epidemiol*. 2013 Oct;23(10):652-61

Freire C, Ramos R, Puertas R, Lopez-Espinosa MJ, Julvez J, Aguilera I, Cruz F, Fernandez MF, Sunyer J, Olea N. Association of traffic-related air pollution with cognitive development in children. *J Epidemiol Community Health*. 2010 Mar;64(3):223-8

Guxens M, Aguilera I, Ballester F, Estarlich M, Fernández-Somoano A, Lertxundi A, Lertxundi N, Mendez MA, Tardón A, Vrijheid M, Sunyer J, INMA (Infancia y Medio Ambiente) Project. Prenatal exposure to residential air pollution and infant mental development: modulation by antioxidants and detoxification factors. *Environ Health Perspect*. 2012 Jan;120(1):144-9

Herrmann M, King K, Weitzman M. Prenatal tobacco smoke and postnatal secondhand smoke exposure and child neurodevelopment. *Curr Opin Pediatr*. 2008 Apr;20(2):184-90

Payne-Sturges DC et al. Healthy Air, Healthy Brains: Advancing Air Pollution Policy to Protect Children's Health. *Am J Public Health*. 2019 Apr;109(4):550-554.

Perera FP, Rauh V, Whyatt RM, Tsai WY, Tang D, Diaz D, Hoepner L, Barr D, Tu YH, Camann D, Kinney P. Effect of prenatal exposure to airborne polycyclic aromatic hydrocarbons on neurodevelopment in the first 3 years of life among inner-city children. *Environ Health Perspect*. 2006 Aug;114(8):1287-92

Rauh VA, Whyatt RM, Garfinkel R, Andrews H, Hoepner L, Reyes A, Diaz D, Camann D, Perera FP. Developmental effects of exposure to environmental tobacco smoke and material hardship among inner-city children. *Neurotoxicol Teratol*. 2004 May-June;26(3):373-85

Roberts A, Lyall K, Hart J, Laden F, et al. Perinatal air pollutant exposures and autism spectrum disorder in the children of Nurses' Health Study II participants. *Environ Health Perspect*. 2013; 121(8): 978-984

Volk H, Kerin T, Lurmann F, Hertz-Picciotto I, McConnell R, Campbell D. Autism spectrum disorder: interaction of air pollution with the MET receptor tyrosine kinase gene. *Epidemiology*. 2014; 25(1):44-47

Volk H, Lurmann F, Penfold B, Hertz-Picciotto I, McConnell R. Traffic-related air pollution, particulate matter, and autism. *JAMA Psychiatry*. 2013; 70(1):71-77

Alcohol

O'Leary C, Taylor C, Zubrick S, et al. Prenatal alcohol exposure and educational achievement in children aged 8-9 years. *Pediatrics*. 2013 Aug;132(2):e468-75

Lead

Fergusson DM and Horwood. The effects of lead levels on the growth of word recognition in middle childhood. *Intern J Epidemiol*. 1993 Oct;22:891-897

Munoz H, Romiew I, Palazuelos E, et al. Blood lead levels and neurobehavioral development among children living in Mexico City. *Arch Environ Health*. 1993 May-June;48(3):132-139.



Needleman HL, Reiss JA, Tobin MJ, et al. Bone lead levels and delinquent behavior. *JAMA*. 1996 Feb 7; 275:363-369

Rice DC. Developmental lead exposure: neurobehavioral consequences. In Slikker W. and Chang LW (ed): Handbook of developmental neurotoxicology. San Diego, CA: Academic Press, 1998, p 544

Silva PA, Hughes P, Williams S, et al. Blood lead, intelligence, reading attainment and behaviour in eleven year old children in Dunedin, New Zealand. *J Child Psychol Psychiatry*. 1988 Jan;29(1):43-52

Thomson GO, Raab GM, Hepburn WS, et al. Blood-lead levels and children's behaviour - results from the Edinburgh lead study. *J Child Psychol Psychiatry*. 1989 July;30(4):515-528. 1989

Tuthill RW. Hair lead levels related to children's classroom attention-deficit disorder. *Arch Environ Health*. 1996 May-June;51:214-220

Winneke G, Kramer U, Brockhaus A, et al. Neuropsychological studies in children with elevated tooth-lead concentrations. II. Extended study. *Int Arch Occup Environ Health*. 1983; 51(3):231-252

Winneke G, Kramer U. Neuropsychological effects of lead in children: interactions with social background variables. *Neuropsychobiology* 1984; 11(3):195-202

Yule W, Urbanowicz MA, et al. Teachers' ratings of children's behavior in relation to blood lead levels. *Br J Dev Psych*. 1984;2(295)

Yule W. The relationship between blood lead concentration, intelligence, and attainment. *Dev Med Child Neurol*. 1981; 23:567-576

[continued >](#)

Asthma

Childhood
LeukemiaLearning/
Developmental
Disabilities

Diabetes

Infertility

Cognitive Decline

Mercury

National Research Council. [Toxicological effects of methylmercury](#). Washington, DC: The National Academies Press, 2000

Pesticides

Eskenazi B, Huen K, Marks A, et al. PON1 and neurodevelopment in children from the CHAMACOS study exposed to organophosphate pesticides in utero. [Environ Health Perspect](#). 2011;118(12):1775-1781

Horton MK, Rundle A, Camann DE, Boyd Barr D, Rauh VA, Whyatt RM. Impact of prenatal exposure to piperonyl butoxide and permethrin on 36-month neurodevelopment. [Pediatrics](#). 2011 Mar;127(3):e699-706

Levin E, Slotkin T. Research brief 230: [Combined exposure to glucocorticoids and chlorpyrifos influences neurobehavioral development](#). NIEHS Superfund Research Program. Jan 2014

Muñoz-Quezada MT, Lucero BA, Barr DB, Steenland K, et al. Neurodevelopmental effects in children associated with exposure to organophosphate pesticides: A systematic review. [Neurotoxicology](#). 2013 Dec;39:158-68

Potera C. Newly discovered mechanism for chlorpyrifos effects on neurodevelopment. [Environ Health Perspect](#). 2012 Jul;120(7):a270-1

Rauh V, Perera F, Horton M, et al. Brain abnormalities in children exposed prenatally to a common organophosphate pesticide. [Proc Natl Acad Sci USA](#). 2102; 109(20):7871-7876

Rauh V, Arunajadai S, Horton M, et al. Seven-year neurodevelopmental scores and prenatal exposure to chlorpyrifos, a common agricultural pesticide. [Environ Health Perspect](#). 2011;119(8):1196-1201

Roberts JR, Karr CJ; Council On Environmental Health. Pesticide exposure in children. [Pediatrics](#). 2012 Dec;130(6):e1765-88

Phthalates

Ejareadar M, Nyanza EC, Ten Eycke K, Dewey D. Phthalate exposure and children's neurodevelopment: A systematic review. [Environ Res](#). 2015 Oct;142:51-60.



Lee DW, Kim MS, Lim YH, Lee N, Hong YC. Prenatal and postnatal exposure to di-(2-ethylhexyl) phthalate and neurodevelopmental outcomes: A systematic review and meta-analysis. [Environ Res](#). 2018 Nov;167:558-566.

Miodovnik A, Edwards A, Bellinger DC, Hauser R. Developmental neurotoxicity of ortho-phthalate diesters: review of human and experimental evidence. [Neurotoxicology](#). 2014 Mar;41:112-22.

Solvents

Eskenazi B, Gaylord L, Bracken MB, Brown D. In utero exposure to organic solvents and human neurodevelopment. [Dev Med Child Neurol](#). 1988 Aug;30(4):492-501

Laslo-Baker D, Barrera M, Knittel-Keren D, Kozar E, et al. Child neurodevelopmental outcome and maternal occupational exposure to solvents. [Arch Pediatr Adolesc Med](#). 2004 Oct;158(10):956-61

Effects of enriched social environment and early childhood education on neurodevelopment

Arling GL, Harlow HF. Effects of social deprivation on maternal behavior of rhesus monkeys. [J Comp Physiol Psychol](#). 1967 Dec;64(3):371-7

Carlson M, Earls F. Psychological and neuroendocrinological sequelae of early social deprivation in institutionalized children in Romania. 1997. [Annals of the New York Academy of Sciences](#), 807: 419-428

Caldji C, Tannenbaum B, Sharma S, Francis D, Plotsky PM, Meaney MJ. Maternal care during infancy regulates the development of neural systems mediating the expression of fearfulness in the rat. [Proc Natl Acad Sci USA](#). 1998 Apr 28;95(9):5335-40

Harlow HF, Dodsworth RO, Harlow MK. Total social isolation in monkeys. [Proc Natl Acad Sci U S A](#). Jul 1965; 54(1): 90-97

High PC; American Academy of Pediatrics Committee on Early Childhood, Adoption, and Dependent Care and Council on School Health. School readiness. [Pediatrics](#). 2008 Apr;121(4):e1008-15

Hubbs-Tait L, Nation JR, Krebs NF, and Bellinger DC. Neurotoxins, micronutrients, and social environments individual and combined effects on children's development. [Psychological Science in the Public Interest](#). 2005 Dec;vol. 6 no. 357-121

Liu D, Caldji C, Sharma S, Plotsky PM, Meaney MJ. Influence of neonatal rearing conditions on stress-induced adrenocorticotropin responses and norepinephrine release in the hypothalamic paraventricular nucleus. [J Neuroendocrinol](#). 2000 Jan;12(1):5-12

Liu D, Diorio J, Tannenbaum B, Caldji C, Francis D, Freedman A, Sharma S, Pearson D, Plotsky PM, Meaney MJ. Maternal care, hippocampal glucocorticoid receptors, and hypothalamic-pituitary-adrenal responses to stress. [Science](#). 1997 Sep 12;277(5332):1659-62

Palfrey JS, Hauser-Cram P, Bronson MB, Warfield ME, Sirin S, Chan E. The Brookline Early Education Project: a 25-year follow-up study of a family-centered early health and development intervention. [Pediatrics](#). 2005 Jul;116(1):144-52

Shonkoff JP. Leveraging the biology of adversity to address the roots of disparities in health and development. [PNAS](#) 2012 October vol. 109 no. Supplement 2 17302-17307 Center on the Developing Child at Harvard University, Cambridge, MA 02138



Walker SP, Chang SM, Powell CA, Grantham-McGregor SM. Effects of early childhood psychosocial stimulation and nutritional supplementation on cognition and education in growth-stunted Jamaican children: prospective cohort study. [Lancet](#). 2005 Nov 19;366(9499):1804-7

Weiss B, Bellinger DC. Social Ecology of Children's Vulnerability to Environmental Pollutants. [Environ Health Perspect](#). 2006 October; 114(10):1479-1485

Zuckerman B, Halfon N. School readiness: an idea whose time has arrived. [Pediatrics](#). 2003 Jun;111(6 Pt 1):1433-6

Financial Costs of Developmental Disabilities

Centers for Disease Control and Prevention, National Center on Birth Defects and Developmental Disabilities- [ADHD Data and Statistics - Accessed Jan 16, 2014](#)

Trasnade L, Liu Y. Reducing the staggering costs of environmental disease in children, estimated at \$76.6 billion in 2008. [Health Aff \(Millwood\)](#). 2011 May;30(5):863-70. doi: 10.1377/hlthaff.2010.1239

Gene-environment interactions

Bergdahl IA, Grubb A, Schutz A, et al. Lead binding to delta-aminolevulinic acid dehydratase in human erythrocytes. [Pharmacology and Toxicology](#). 1997 Oct;81(4):153-158

Claudio L, Lee T, Wolff MS, et al. A murine model of genetic susceptibility to lead bioaccumulation. [Fundam Appl Toxicol](#). 1997 Jan;35(1):84-90

Costa LG, Li WF, Richter RJ, et al. The role of paraoxonase (PON1) in the detoxification of organophosphates and its human polymorphism. [Chemico-Biological Interactions](#). May 14 1999;119-120:429-38

Genc S, Gurdol F, Guvene S, et al. Variations in serum cholinesterase activity in different age and sex groups. [European Journal of Clinical Chemistry and Clinical Biochemistry](#). 1997;35(3):239-240

Mutch E, Blain PG, Williams FM. Interindividual variations in enzymes controlling organophosphate toxicity in man. [Human and Experimental Toxicology](#). 1992 March;11(2):109-116

Pilkington A, Buchanan D, Jamal GA, Gillham R, Hansen S, Kidd M, Hurley JF, Soutar CA. An epidemiological study of the relations between exposure to organophosphate pesticides and indices of chronic peripheral neuropathy and neuropsychological abnormalities in sheep farmers and dippers. [Occup Environ Med](#). 2001 Nov;58(11):702-10

Schwartz BS, Lee BK, Stewart W, et al. Delta-aminolevulinic acid dehydratase genotype modifiers four hour urinary lead excretion after oral administration of dimercaptosuccinic acid. [Occupational and Environmental Medicine](#). 1997;54(4):241-246

Sithisarankul P, Cadorette M, Davoli CT, et al. Plasma 5-aminolevulinic acid concentration and lead exposed children. [Environmental Research](#). 1999 Jan;80(1):41-49

Sithisarankul P, Schwartz BS, Lee BK, et al. Aminolevulinic acid dehydratase genotype mediates plasma levels of the neurotoxin, 5-aminolevulinic acid, in lead-exposed workers. [Amer J Industrial Med](#). 1997 July;32(1):15-20

Smith CM, Wang X, Hu H, et al. A polymorphism in the delta-aminolevulinic acid dehydratase gene may modify the pharmacokinetics and toxicity of lead. [Environ Health Perspect](#). 1995 Mar;103(3):248-253

Tomokuni K, Ichiba M, Fujisiro K. Interrelation between urinary delta-aminolevulinic acid, serum ALA, and blood lead in workers exposed to lead. [Industrial Health](#). 1993; 31(2):51-57

Wetmur JG. Influence of the common human delta-aminolevulinic acid dehydratase polymorphism on lead body burden. [Environ Health Perspect](#). 1994 Sept;102 suppl 3:215-219

Wetmur JG, Lehnert G, Desnick RJ. The delta-aminolevulinic acid dehydratase polymorphism higher blood lead levels in lead workers and environmentally exposed children with the 1-2 and 2-2 isozymes. [Environmental Research](#). 1991;56(2):109-119

Willcutt E, Pennington B, Duncan L, Smith S, et al. Understanding the complex etiologies of developmental disorders: behavioral and molecular genetic approaches. [J Dev Behav Pediatr](#). 2010 Sept; 31(7):533-544

Health Disparities

Rubin LI, et al. Break the cycle of environmental health disparities in vulnerable children. [Int Journal of Disability and Human Develop](#). 2012;11:301-305

Learning Disabilities

Alexander D. Learning disabilities as a public health concern. In Cramer SC, Ellis E (eds). [Learning disabilities: Lifelong issues](#). Paul H. Brookes Publishing Company, Inc., Baltimore, MD 1996, pp 249-253

American Psychiatric Association. [Diagnostic and statistical manual of mental disorders](#), Fourth edition. Washington, DC 1994

Butterworth B, Kovas Y. Understanding neurocognitive developmental disorders can improve education for all. [Science](#). 2013; 340: 300-305

Cramer SC, Ellis E. [Learning disabilities: Lifelong issues](#). Paul H. Brookes Publishing Company, Inc., Baltimore, MD 1996

Dickman GE. The link between learning disabilities and behavior. In Cramer SC, Ellis E (eds). [Learning disabilities: Lifelong issues](#). Paul H. Brookes Publishing Company, Inc., Baltimore, MD 1996, pp 215-228

[continued >](#)

Asthma

Childhood
LeukemiaLearning/
Developmental
Disabilities

Diabetes

Infertility

Cognitive Decline



Dyson LL. The experience of families of children with learning disabilities: Parental stress, family functioning and sibling concept. *Journal of Learning Disabilities*. 1996;29(3):280-286

McBride HEA, Siegel LS. Learning disabilities and adolescent suicide. *Journal of Learning Disabilities*. 1997 Nov-Dec;30(6):652-659

Wagner M, Newman L, et al. In Cramer SC, Ellis E (eds). *Learning disabilities: Lifelong issues*. Paul H. Brookes Publishing Company, Inc., Baltimore, MD 1996 (introduction)

Nature – Health Benefits

Frumkin H, Louv R. The powerful link between conserving land and preserving health. *Land Trust Alliance Special Anniversary Report* 2007

Grassman V, et al. Possible Cognitive Benefits of Acute Physical Exercise in Children With ADHD: A Systematic Review. *J Atten Disord*. 2014 Mar. (epub)

Maller C, Townsend M, Pryor A, St. Leger L. Healthy nature, healthy people: contact with nature as an upstream health promotion intervention for populations. *Health Promotion International* 2006; 21(1):45-54

Mitchell R, & Popham F. Effect of exposure to natural environment on health inequalities: an observational population study. *Lancet*. 2008;372(9650):1655-60

St. Leger L. Health and nature – new challenges for health promotion. *Health Promotion International*. 2003;18:173-175

Taylor, AF & Kuo, FE Children with attention deficits concentrate better after walk in the park. *J. of Att. Dis*. 2009; 20(10) 1-20

Ulrich RS. Effects of health care environmental design on medical outcomes. In: Dilani A, editor. *Design and health: Proceedings of the 2nd international conference on health and design*. Stockholm, Sweden: Svensj Byggtjanst; 2001:49-59

Neurodevelopment

Gerson M, Van den Eeden SK, Gahagan P. Take-home lead poisoning in a child from his father's occupational exposure. *Am J Ind Med*. 1996 May;29(5):507-8

Fenske RA, Lu C, Negrete M, Galvin K. Breaking the take home pesticide exposure pathway for agricultural families: workplace predictors of residential contamination. *Am J Ind Med*. 2013 Sep;56(9):1063-71

Lambrot R, Xu C, Saint-Phar S, Chountalos G, Cohen T, Paquet M, Suderman M, Hallett M, and Kimmins S. Low paternal dietary folate alters the mouse sperm epigenome and is associated with negative pregnancy outcomes. *Nature Communications* 4. 2013;Article number:2889

Rice D, Barone S. Critical periods of vulnerability for the developing nervous system: evidence from human and animal models. *Environ Health Perspect*. 108 (Suppl 3):511-533, 2000

Shonkoff P Phillips D. Eds. *From neurons to neighborhoods: the science of early childhood development*. National Academy Press, Washington DC. 2000

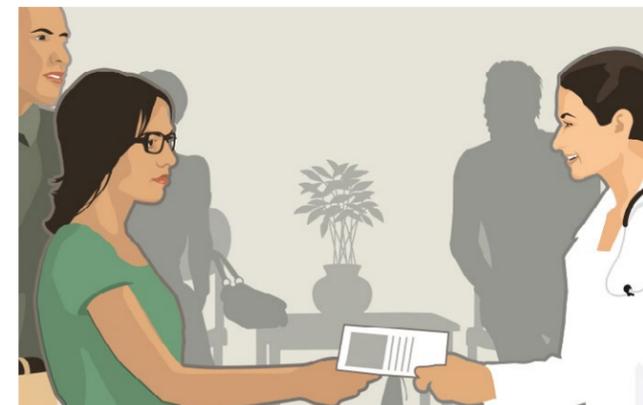
Nutrition and Neurodevelopment

Carter et al. Iron deficiency anemia and cognitive function in infancy. *Pediatrics*. 2010 Aug;126(2):e427-34

Jacka FN1, Ystrom E, Brantsaeter AL, Karevold E, Roth C, Haugen M, Meltzer HM, Schjolberg S, Berk M. Maternal and early postnatal nutrition and mental health of offspring by age 5 years: a prospective cohort study. *J Am Acad Child Adolesc Psychiatry*. 2013 Oct;52(10):1038-47

Lyall K, Schmidt R, Hertz-Picciotto I. Maternal lifestyle and environmental risk factors for autism spectrum disorders. *Int J Epidemiol* 2014;43(2):443-464

Lozoff B, Castillo M, Clark K, Smith J. Iron-fortified vs low-iron infant formula: developmental outcome at 10 years. *Arch Pediatr Adolesc Med*. 2012 Mar;166(3):208-215



Miilichap JG, Yee MM. The diet factor in attention-deficit/hyperactivity disorder. *Pediatrics*. Published online January 9, 2012 .doi: 10.1542/peds.2011-2199

Suglia SF, Solnick S, PhD, Hemenway D. Soft drinks consumption is associated with behavior problems in 5-year-olds. *J Pediatr* 2013 Nov;163(5):1323-8

Poverty - brain development

Hanson JL, Hair N, Shen DG, Shi F et al. Family poverty affects the rate of human infant brain growth. *PLoS One*. 2013 Dec 11;8(12):e80954

Hubbs-Tait L, Nation J, Krebs N, Bellinger D. Neurotoxicants, micronutrients, and social environments. Individual and combined effects on children's development. *Psychological Science in the Public Interest*; 2005;6(3):57-121

Luby J, Belden A, Botteron K, Marrus N, et al. The effects of poverty on childhood brain development: the mediating effect of caregiving and stressful life events. *JAMA Pediatr*. 2013 Dec 1;167(12):1135-42

Weiss B, Bellinger D. Social ecology of children's vulnerability to environmental pollutants. *Environ Health Perspect* 2006;114(10):1479-1485

Preterm birth, low birth weight and mental health

Singh G, Kenney M, Ghandour R, et al. Mental health outcomes in US children and adolescents born prematurely or with low birth weight. *Depress Res Treat*. 2013; 2013:570743

Thyroid

Cooper DC, Biondi B. Subclinical thyroid disease. *Lancet*. 2012 Mar 24;379(9821):1142-54

Garber JR, Cobin RH, Gharib H, Hennessey JV, Klein I, Mechanick JJ, Pessah-Pollack R, Singer PA, Woeber KA; American Association of Clinical Endocrinologists and American Thyroid Association Taskforce on Hypothyroidism in Adults. Clinical practice guidelines for hypothyroidism in adults: cosponsored by the American Association of Clinical Endocrinologists and the American Thyroid Association. *Endocr Pract*. 2012 Nov-Dec;18(6):988-1028

Haddow JE, Palomaki GE, Allan WC, Williams JR, et al. Maternal thyroid deficiency during pregnancy and subsequent neuropsychological development of the child. *N Engl J Med*. 1999 Aug 19;341(8):549-55

Hynes KL, Otahal P, Hay I, Burgess JR. Mild iodine deficiency during pregnancy is associated with reduced educational outcomes in the offspring: 9-year follow-up of the gestational iodine cohort. *J Clin Endocrinol Metab*. 2013 98(5):1954-62

LaFranchi SH, Haddow JE, Hollowell JG. Is thyroid inadequacy during gestation a risk factor for adverse pregnancy and developmental outcomes? *Thyroid*. 2005 Jan;15(1):60-71

Miller MD, Crofton KM, Rice DC, Zoeller RT. Thyroid-disrupting chemicals: interpreting upstream biomarkers of adverse outcomes. *Environ Health Perspect*. 2009 Jul;117(7):1033-41.

Mitka M. Even mild iodine deficiency during gestation may impair brain function in children. *JAMA* 2013 Jun 19;309(23):2428

Pearce EN, Braverman LE. Environmental pollutants and the thyroid. *Best Pract Res Clin Endocrinol Metab*. 2009 Dec;23(6):801-13

Pop VJ, Brouwers EP, Vader HL, Vulsma T, van Baar AL, de Vijlder JJ. 2003. Maternal hypothyroxinaemia during early pregnancy and subsequent child development: a 3-year follow-up study. *Clin Endocrinol (Oxf)* 59(3):282-288

Pop VJ, Kuijpers JL, van Baar AL, Verkerk G, van Son MM, de Vijlder JJ, et al. 1999. Low maternal free thyroxine concentrations during early pregnancy are associated with impaired psychomotor development in infancy. *Clin Endocrinol (Oxf)* 50(2):149-155

Pop VJ, Vulsma T. 2005. Maternal hypothyroxinaemia during (early) gestation. *Lancet* 365(9471):1604-1606

Stagnaro-Green A, Pearce E. Thyroid disorders in pregnancy. *Nat Rev Endocrinol*. 2012 Nov;8(11):650-8

Trends

Boyle, C, Boulet S, Schieve LA, Cohen RA, Blumberg SJ, Yeargin-Allsop M, Visser S, Kogan MD. Trends in the prevalence of developmental disabilities in US children, 1997-2008 *Pediatrics Volume 127, Number 6, June 2011*

Centers for Disease Control: *Developmental disabilities increasing in US*