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...sources that are unique to the indoor environment. These sources involve human activities within buildings, such as smoking, burning solid fuels, cooking, and cleaning. Vapors from building and construction materials, equipment, and furniture. Biological contaminants, such as mold, viruses, or allergens. Some contaminants are described below: Allergens are substances that can trigger the immune system, causing an allergic reaction; they can circulate in air and remain on carpets and furniture for months. Asbestos is a fibrous material formerly used for making incombustible or fireproof building materials, such as roof shingles, siding, and insulation. Disturbing asbestos minerals or asbestos-containing materials can release fibers, often too small to see, into the air. Asbestos is known to be a human carcinogen. Carbon monoxide is an odorless and toxic gas. It is found in fumes produced any time you burn fuel in cars or trucks, small engines, stoves, lanterns, grills, fireplaces, gas ranges, or furnaces. Proper venting or exhaust systems prevent build up in the air. Formaldehyde is a strong-smelling chemical found in some pressed wood furniture, wood particle cabinets, flooring, carpets, and fabrics. It can also be a component of some glues, adhesives, paints, and coating products. Formaldehyde is known to be a human carcinogen. Lead is a naturally occurring metal that has been used in a wide variety of products including gasoline, paint, plumbing pipes, ceramics, solders, batteries, and even cosmetics. Mold is a microorganism and type of fungus that thrives in damp places; different molds are found everywhere, indoors and outside. Pesticides are substances used to kill, repel, or control certain forms of plants or bugs that are considered to be pests. Radon is a colorless, odorless, naturally occurring gas that comes from the decay of radioactive elements in soils. It can enter indoor spaces through cracks or gaps in buildings. Most exposures occur inside homes, schools, and workplaces. EPA estimates radon is responsible for about 21,000 U.S. deaths from lung cancer annually. Smoke, a byproduct of combustion processes, such as from cigarettes, cookstoves, and wildfires, contains toxic chemicals like formaldehyde and lead. What is NIEHS Doing? NIEHS supports research on the health effects of indoor air pollutants, such as those listed above, found in homes, schools, and workplaces. Because individuals move between indoor and outdoor environments, researchers are also developing specialized technologies to measure and collect data on personal exposures. Respiratory Disease Actions to reduce mold exposure in early life may have long-term health benefits, potentially decreasing prevalence and severity of asthma. Among inner-city children with asthma who live in homes with high levels of indoor air pollution, those children with sufficient vitamin D levels had fewer symptoms. Household air pollution exposure likely affects lung development prenatally. Indoor air pollution exposure during pregnancy was associated with impaired lung function in infants. This altered infant lung function may then increase risk for pneumonia in the first year of life. Outdoor air quality can affect indoor air. Air pollution levels have been trending downward over several decades in southern California, due to air quality-control policies. These improvements in air quality are associated with improved lung development in children. The school environment contributes to childhood asthma illness. A study found that airborne mouse allergens in inner-city schools are linked to increased symptoms and decreased lung function in asthmatic children. School-based environmental interventions may be beneficial for curbing the public health problem of childhood asthma. Cardiovascular Disease A study partially supported by NIEHS found that markers of cardiovascular disease risk appear when ozone levels are even lower than current EPA air quality standards. In healthy adults, exposure to short-term indoor and outdoor ozone was linked to increased blood platelets, a risk factor for clotting, and increased blood pressure. Cognitive Effects Indoor exposures to air pollutants, including particulate matter, allergens, oxides of nitrogen, endotoxin, and mold, have been associated with impaired health and performance in children and adults. Characterization of indoor air pollution in schools is a public health concern for children, given the large amount of time spent there. Some inner-city schools exceeded WHO guidelines for interior air quality, particularly for nitric oxide, an indoor air pollutant that can affect cognitive outcomes, verbal abilities, and executive functioning. Physical defects and lack of proper ventilation contributed to the poor air quality in schools. The results suggest that improving building conditions and facilities, as well as consideration of the school's outdoor surroundings, could create healthier environments. Office workers scored higher on performance measures when working in "green" environments with low indoor pollutants and low carbon dioxide levels. The air quality within an office can affect employees' cognitive function, including response times and ability to focus, and it may also affect their productivity, according to NIEHS-funded research led by Harvard T.H. Chan School of Public Health. Cancer/Community Involvement NIEHS grant recipients work directly with communities affected by indoor air pollution to help reduce exposures and improve quality of life. Examples follow. Citizen Science Together with researchers at two NIEHS-funded core centers — the University of Kentucky Center for Appalachian Research in Environmental Sciences and the University of Cincinnati Center for Environmental Genetics — high school students developed and pilot-tested a family-centered home radon testing toolkit with the ultimate goal of preventing lung cancer. To enable community-based research, NIEHS-funded researchers invented a low-cost, portable sensor for detecting indoor pollutants. The development of such high quality and affordable real-time sensors provides new opportunities to conduct research and inform individuals or communities on daily health risks. Engaging youth as partners in environmental health research can motivate them to pursue careers in science, build self-esteem and leadership skills, and educate their communities. At the University of California, Berkeley, the Lifting Up Communities by Intervening with Research (LUCIR) study involved high school students in characterizing chemicals in household cleaning products and estimating exposures to those chemicals. They repeated the process with "green" cleaning products, and noted reductions in harmful chemicals. Then to educate their target audience of Latina household cleaning staff, they developed engaging videos about choosing safer cleaning products. Learn more from a podcast linked below. Tribal Nations Hopi tribe members in the American Southwest identified indoor air quality, as well as arsenic in drinking water, as environmental exposures of concern. These perceptions derive from actual experiences with health problems such as cancer and asthma. Study authors emphasize including traditional values and practices in future interventions to reduce environmental health risks. Patricia Nez Henderson, M.D., vice president of the Black Hills Center for American Indian Health and a NIEHS-funded researcher, is working to create culturally-relevant smoking cessation and secondhand smoke reduction interventions in Lakota communities. Learn more from a podcast listed below. Residential burning of biomass for heat leads to elevated indoor levels of fine particulate matter (PM2.5) that often exceed health-based air quality standards. NIEHS-funded grant recipients are developing and testing low-cost, educational, and sustainable interventions for improving residential heating to reduce young children's risk of respiratory diseases in Native American communities. Low- and Middle-income Countries (LMICs) NIEHS participates in the Household Air Pollution Intervention Network trial, a randomized controlled study of liquefied petroleum gas stove and fuel distribution to 3.200 households in four countries. The largest global source of indoor pollution, particularly in LMICs, comes from cooking and heating with solid fuels, including dung, wood, agricultural residues, and coal. Data from studies, such as this one, are needed to inform policies on interventions to reduce household air pollution among vulnerable populations. In LMICs, about 3 million infants and children younger than 5 years die every year from pneumonia, according to WHO. Exposure to household air pollution from burning biomass fuels was implicated in about a third of these cases. NIEHS has funded research related to cookstoves, which contributes to understanding health effects of this form of household air pollution. NIEHS also partnered with the American Thoracic Society, the European Respiratory Society, and the Global Alliance for Clean Cookstoves on an international workshop on respiratory health effects of household air pollution. The workshop task force concluded, in 2018, scientific evidence supports the potential to develop scalable solutions that can reduce these exposures and improve lives.

Respiratory diseases from household air pollution are preventable for 2.8 billion people. Research, co-funded by NIEHS, shows that prenatal household air pollution exposure increased the chance of developing pneumonia in the first year of life. The authors concluded that cleaning interventions, such as cookstoves, may be most effective when begun before children are born. Further Reading: Stories from the Environmental Factor (NIEHS Newsletter) Press Releases Podcasts Engaging Youth in Research (2021) The NIEHS-funded Center for the Health Assessment of Mothers and Children of Salinas (CHAMCAOS) shares experiences with youth-led research, what they have learned, and how the program prepares the next generation of environmental health leaders. Using Culturally Appropriate Messages to Promote Smoke-free Homes (2021) - NIEHS-funded researchers work with tribal communities to encourage smoke-free homes and improve health. Additional Resources Addressing Air Pollution and Asthma (IMB) - NIEHS supported a translational research study that may lead to improved health for children suffering from asthma. The researchers found that certain agricultural practices contribute to poor air quality and asthma among children. The team combined high-efficiency particulate air (HEPA) cleaners and a home-based education program to reduce children's exposure to pollutants in the home. Fungal Diseases webpage from the National Institute of Allergy and Infectious Diseases covers fungal diseases caused by a variety of fungi commonly found in the environment. You can inhale fungi spores, or they can land on you. As a result, fungal infections tend to start in the lungs or on the skin. Indoor Air in Homes and Coronavirus (COVID-19) is a how-to guide by the EPA on improving ventilation to preserve indoor air quality and halt the spread of COVID-19. Prescription for Prevention: Indoor Air is a resource for healthcare professionals developed by the Icahn School of Medicine at Mount Sinai through an NIEHS grant. The Inside Story: A Guide to Indoor Air Quality is a safety guide prepared by EPA and the Consumer Product Safety Commission with steps for reducing indoor air pollution in your home. Related Health Topics Endocrine disruptors are natural or man-made chemicals that may mimic or interfere with the body's hormones, known as the endocrine system. These chemicals are linked with many health problems in both wildlife and people. Table of Contents What is NIEHS Doing? Further Reading Endocrine-disrupting chemicals (EDCs) are natural or human-made chemicals that may mimic, block, or interfere with the body's hormones, which are part of the endocrine system. These chemicals are associated with a wide array of health issues. The Endocrine System Endocrine glands, distributed throughout the body, produce the hormones that act as signaling molecules after release into the circulatory system. The human body is dependent on hormones for a healthy endocrine system, which controls many biological processes like normal growth, fertility, and reproduction. Hormones act in extremely small amounts, and minor disruptions in those levels may cause significant developmental and biological effects. How Do We Encounter These Chemicals? Endocrine disruptors are found in many everyday products, including some cosmetics, food and beverage packaging, toys, carpet, and pesticides. Some chemicals that act as flame retardants may also be endocrine disruptors. Contact with these chemicals may occur through air, diet, skin, and water. EDCs cannot be completely avoided or removed; however, you can make informed choices to reduce exposure and risk of any potential health effects. Chemicals That May Disrupt Your Endocrine System According to the Endocrine Society, there are nearly 85,000 human-made chemicals in the world, and 1,000 or more of those could be endocrine disruptors, based on their unique properties. The following are among the most common and well-studied. Atrazine is one of the most commonly applied herbicides in the world, often used to control weeds in corn, sorghum, and sugarcane crops. Bisphenol A (BPA) is used to make polycarbonate plastics and epoxy resins. It is used in manufacturing, food packaging, toys, and other applications. BPA resins may be found in the lining of some canned foods and beverages. Dioxins are a byproduct of certain manufacturing processes, such as herbicide production and paper bleaching. They can be released into the air from waste burning and wildfires. Perchlorate is a colorless salt manufactured and used as an industrial chemical to make rockets, explosives, and fireworks, which can be found in some groundwater. Per- and polyfluoroalkyl substances (PFAS) are a large group of chemicals used widely in industrial applications, such as firefighting foam, nonstick pans, paper, and textile coatings. Phthalates are a large group of compounds used as liquid plasticizers. They are found in hundreds of products including some food packaging, cosmetics, fragrances, children's toys, and medical device tubing. Cosmetics that may contain phthalates include nail polish, hair spray, aftershave lotion, cleanser, and shampoo. Phytoestrogens are naturally occurring substances with hormone-like activity found in some plants; they may have a similar effect to estrogen produced by the body. Soy foods, for example, contain phytoestrogens. Polybrominated diphenyl ethers (PBDE) are used to make flame retardants for products such as furniture foam and carpet. Polychlorinated biphenyls (PCBs) were used to make electrical equipment, such as transformers, and are in hydraulic fluids, heat transfer fluids, lubricants, and plasticizers. PCBs were mass-produced globally until they were banned in 1979. Triclosan is an ingredient that was previously added to some antimicrobial and personal care products, like liquid body wash and soaps. How do people encounter endocrine-disrupting chemicals? People may be exposed to endocrine disruptors through food and beverages consumed, pesticides applied, and cosmetics used. In essence, your contact with these chemicals may occur through diet, air, skin, and water. Even low doses of endocrine-disrupting chemicals may be unsafe. The body's normal endocrine functioning involves very small changes in hormone levels, yet we know even these small changes can cause significant developmental and biological effects. This observation leads scientists to think that endocrine-disrupting chemical exposures, even at low amounts, can alter the body's sensitive systems and lead to health problems. When absorbed in the body, an endocrine disruptor can decrease or increase normal hormone levels (left), mimic the body's natural hormones (middle), or alter the natural production of hormones (right). For more than three decades, NIEHS has been a pioneer in conducting research on the health effects of endocrine disruptors. NIEHS-supported research leads to a greater understanding of how endocrine-disrupting chemicals may harm our health and cause disease. This work began with studies on the endocrine-disrupting effects of the drug diethylstilbestrol (DES). From 1940s through 1970s, DES was used to treat women with high-risk pregnancies, with the mistaken belief that it prevented miscarriage. In 1972, prenatal exposure to DES was linked to the development of a rare form of vaginal cancer in daughters whose mothers took DES, and with numerous noncancerous changes in both sons and daughters. NIEHS experiments on DES successfully replicated and predicted health problems, which was useful in discovering how DES may harm wellbeing. NIEHS was involved in developing a consensus statement in 2019 on the key characteristics of endocrine-disrupting chemicals, which provides a framework to help scientists evaluate potential endocrine disruptors. NIEHS leads cutting-edge research projects on endocrine disrupting chemicals to understand how they work and define their role in health and disease. Research areas in progress include: Developing new models and tools to better understand how endocrine disruptors work Developing and applying high throughput assays to identify substances with endocrine disrupting activity Conducting animal and human health research to define linkages between exposure to endocrine disruptors and health effects Developing new assessments and biomarkers of exposure and toxicity Identifying and developing new intervention and prevention strategies Related work of the National Toxicology Program In 2000, an independent panel of experts convened by NIEHS and the National Toxicology Program (NTP), which is housed at NIEHS, concluded there was credible evidence that very low doses of some hormone-like chemicals can adversely affect bodily functions in test animals. NTP is evaluating endocrine disruptors including pesticides, perfluorinated chemicals, compounds that may replace BPA in the marketplace, and components of flame-retardants for how they may affect body tissues such as breast, uterus, fat cells, male reproductive tract, and liver. In addition, they conduct laboratory studies that help them prioritize endocrine disrupting chemicals for further toxicity testing. NTP scientists collaborate with researchers from the U.S. Environmental Protection Agency (EPA) to develop and validate integrated, high throughput testing strategies to detect substances that could disrupt endocrine functions by interacting with the hormones estrogen and androgen. In addition, they created a comprehensive database from thousands of scientific studies on how different substances interact with hormones. The multi-agency Tox 21 program, in which NIEHS participates, is developing and applying new models and tools using robotics to predict endocrine disrupting activity for environmental substances. What has NIEHS discovered? NIEHS-supported research has discovered links between endocrine-disrupting chemicals and the ways in which wellbeing may be harmed, as shown by the following examples: Attention. Attention-deficit/hyperactivity disorder (ADHD) is one of the most common childhood disorders, which can continue through adolescence and into adulthood. ADHD symptoms include difficulty staying focused, paying attention, and controlling behavior. Researchers reported in JAMA that ordinary exposure to certain phthalates, as found in urine samples, was associated with ADHD-related behaviors in adolescence. The drug DES may be linked to an increased chance of developing ADHD in the grandchildren of women who used it during pregnancy. Immunity. Children exposed to high levels of PFAS had a diminished immune response to vaccines. Metabolism. Long-term exposure to arsenic can disrupt metabolism, increasing the risk of diabetes and other metabolic disorders. Preterm birth. Researchers analyzing a large, diverse data sample of births in the U.S., found that exposure to certain phthalates was associated with decreased gestational age and increased risk of preterm birth. Puberty. Chemicals in lavender oil and tea tree oil are potential endocrine disruptors. Researchers found that persistent exposure to lavender oil products is associated with premature breast development in girls, and abnormal breast development in boys. Reproduction. DES can cause epigenetic changes, altering the way genes are turned on and off, in reproductive organs of mice. The findings provide a possible explanation for how endocrine disruptors affect fertility and reproduction. Further Reading: Stories from the Environmental Factor (NIEHS Newsletter) Press Releases Preterm Birth More Likely With Exposure to Phthalates (July 11, 2022) Podcasts Additional Resources Related Health Topics Bisphenol A (BPA) is a chemical produced in large quantities for use primarily in the production of polycarbonate plastics. It is found in various products including shatterproof windows, eyewear, water bottles, and epoxy resins that coat some metal food cans, bottle tops, and water supply pipes. How does BPA get into the body? The primary source of exposure to BPA for most people is through the diet. While air, dust, and water are other possible sources of exposure, BPA in food and beverages accounts for the majority of daily human exposure. Bisphenol A can leach into food from the protective internal epoxy resin coatings of canned foods and from consumer products such as polycarbonate tableware, food storage containers, water bottles, and baby bottles. The degree to which BPA leaches from polycarbonate bottles into liquid may depend more on the temperature of the liquid or bottle, than the age of the container. BPA can also be found in breast milk. Why are people concerned about BPA? One reason people may be concerned about BPA is because human exposure to BPA is widespread. The 2003-2004 National Health and Nutrition Examination Survey (NHANES III) conducted by the Centers for Disease Control and Prevention (CDC) found detectable levels of BPA in 93% of 2517 urine samples from people six years and older. The CDC NHANES data are considered representative of exposures in the United States. Another reason for concern, especially for parents, may be because some animal studies report effects in fetuses and newborns exposed to BPA. If I am concerned, what can I do to prevent exposure to BPA? Some animal studies suggest that infants and children may be the most vulnerable to the effects of BPA. Parents and caregivers can make the personal choice to reduce exposures of their infants and children to BPA: Don't microwave polycarbonate plastic food containers. Polycarbonate is strong and durable, but over time it may break down from over use at high temperatures. Plastic containers have recycle codes on the bottom. Some, but not all, plastics that are marked with recycle codes 3 or 7 may be made with BPA. Reduce your use of canned foods. When possible, opt for glass, porcelain or stainless steel containers, particularly for hot food or liquids. Use baby bottles that are BPA free. Cosmetics and personal care products contain a mix of chemicals. Researchers are working to better understand if any affect human health. Some of the chemicals are classified as endocrine disrupting, which means they may interfere with the body's hormones and cause adverse health effects. Table of Contents What is NIEHS Doing? Further Reading Women and men around the world use cosmetics to enhance or change their appearance. The Federal Food, Drug, and Cosmetic Act (FD&C) defines cosmetics by their intended use, as products "intended to be rubbed, poured, sprinkled, or sprayed on, introduced into, or otherwise applied to the human body...for cleansing, beautifying, promoting attractiveness, or altering the appearance." The common term makeup refers to cosmetics such as foundation, eye shadow, mascara, and lipstick. Products for hair coloring, straightening, cleansing, or styling are considered cosmetics. Other cosmetics may include nail polish, body wash, moisturizers, and perfumes. Under the FD&C Act, cosmetic products and ingredients, with the exception of color additives, do not require Food and Drug Administration (FDA) approval before they go on the market. However, the law requires manufacturers to report on the safety of cosmetic products to the FDA. Drugs are regulated by the FDA and require premarket approval. Drugs are also defined, in part, by their intended use "in the diagnosis, cure, mitigation, treatment, or prevention of disease." Some products may meet the definitions of both cosmetics and drugs. For example, foundation makeup products with sunscreen have two intended uses. The foundation helps alter the skin's appearance, and the sunscreen component is intended to help protect skin from damage. The sunscreen component puts the makeup product in both categories. What is NIEHS Doing? Testing chemicals in cosmetics and personal care products - Staff in the Division of Translational Toxicology at NIEHS conduct research on chemicals used in cosmetics and personal care products, such as the following: Antimicrobials, such as triclosan, are used in some body washes and other products to kill or stop the growth of microorganisms, such as bacteria. Engineered nanomaterials, like zinc oxide and titanium dioxide, are commonly used in cosmetics and sunscreens to protect skin from harmful ultraviolet rays. Engineered nanomaterials are measured in nanometers. A nanometer is one millionth of a millimeter, or approximately 100,000 times smaller than the diameter of a human hair. Parabens are used to preserve the shelf life of many cosmetic and personal care products. Phthalates are found in cosmetics, such as nail polish and hair spray, and plastic packaging. Sun protection cosmetics include sunscreen lotions, creams, and sprays that help prevent sunburn and resulting skin damage. Specific chemicals in these products, known as ultraviolet (UV) filters, absorb or block UV radiation from the sun. These chemicals may be added to some makeup products. Toxicologists at NIEHS are assessing the safety of UV filters. While these studies are ongoing, findings to date do not suggest endocrine-disrupting effects from those chemicals. The NIEHS Sister Study - In an analysis of hair products usage, researchers found that frequent use of permanent hair dyes was associated with an increased risk of developing cancer, especially among black women. Frequent use of chemical hair straighteners was also associated with increased breast cancer risk regardless of race. 1 To be clear, NIEHS research does not show that certain hair products cause cancer. Many factors affect whether cancer develops or not. Women who used chemical hair-straightening products were at higher risk for uterine cancer compared to women who did not report using these products, according to research from The Sister Study that included more than 33,000 women. But it is the most common cancer of the female reproductive system. In a separate study, researchers analyzed data on the use of genital powder and ovarian cancer from the Sister Study and three other prospective cohort studies. There was no statistically significant association between genital powder use and ovarian cancer, but they found a small increased risk of ovarian cancer for women with intact reproductive tracts (no hysterectomy or tubal ligation). 2 Salon workers and pregnancy - NIEHS-funded research found women working as cosmetologists and manicurists had an increased risk for gestational diabetes, or diabetes during pregnancy. They also found a higher risk for placenta previa, a condition where the placenta partially or totally covers the cervix — the opening to the uterus — which can cause severe bleeding during pregnancy and delivery. 3 Adolescents and endocrine disruptors - NIEHS-supported research found that Latina adolescent girls, who reported daily use of personal care products, had higher levels of endocrine-disrupting chemicals in their urine, which may impact reproductive development. 4 Further Reading: Stories from the Environmental Factor (NIEHS Newsletter) Press Releases Additional Resources Related Health Topics Toxicology is the study of the harmful effects of chemicals, substances, or environmental agents on living systems. Table of Contents What is NIEHS Doing? Further Reading Once a field that focused on studying poisons, toxicology has evolved into a broader discipline dedicated to evaluating potential risks of various exposures and promoting the safety of humans, animals, and the environment. These exposures include many chemicals, of which two examples are bisphenol A (BPA), and perfluorinated chemicals known as PFAS. Potentially harmful chemicals and metals, such as lead and arsenic, can be found in environmental agents, such as traffic-related air pollution. In consumer products, chemicals such as phthalates are found in many items, including some food packaging, toys, and medical device tubing. By discovering the ways in which environmental exposures can affect our health, toxicology research can point to strategies for preventing disease, birth defects, and other adverse conditions, and for improving the wellbeing of people. What factors play a role in toxicology studies? Dose-response relationship: Toxicologists study the relationship between the amount of a substance and its effects on an organism. This analysis helps determine the level of exposure (dose) at which a substance may become harmful and pose a health risk to humans. All substances have the potential to be toxic under certain conditions or at certain doses. Exposure pathways: Understanding how chemicals enter the body is crucial for assessing risk and developing safety measures. Routes of exposure include inhalation, ingestion, or direct skin contact. Susceptibility factors: Individual differences, such as age, sex, genetics, and health status, influence how a person responds to an environmental exposure. Just because someone is exposed to a harmful substance does not mean they will get sick from it. Critical windows of exposure: During certain life stages, like pregnancy, early childhood, and adolescence, people are generally more sensitive to chemical exposures. Toxicologists tend to focus on these critical periods for studies. Even low-dose exposures that may seem insignificant could have biological effects or lead to an adverse health effect if the exposure happens during a critical window of development, such as when the brain and reproductive tract are forming. How does the science of toxicology improve people's lives? Toxicology provides critical information that regulatory agencies, decision makers, and others can use to develop programs and policies that limit our exposures to toxic substances. These advances are intended to help prevent or reduce the likelihood of diseases or other adverse health outcomes. For example, the California state government used federal research findings to establish a drinking water standard for hexavalent chromium. Data from NIEHS studies was also been used by the Environmental Protection Agency to set drinking water limits for some PFAS. These standards will help reduce people's exposure to these persistent toxicants. Other benefits of toxicology include: Government agencies have a sound scientific basis for establishing regulations and policies aimed at protecting and preserving human health and the environment from toxic pollution. Companies, such as those in the pharmaceutical and chemical industries, are able to develop safer products, drugs, and workplaces. Consumers have access to information that helps them make decisions about their own health and prevent diseases. How is federal toxicology research coordinated? NIEHS is headquarters for the National Toxicology Program (NTP), an interagency partnership that includes the National Center for Toxicological Research of the U.S. Food and Drug Administration (FDA) and the National Institute for Occupational Safety and Health of the Centers for Disease Control and Prevention (CDC). Researchers at NIEHS support NTP through toxicology testing, laboratory research, and literature-based assessments. They also oversee NTP databases, advisory groups, and peer review of draft reports. NIEHS extramural research. NIEHS funds grants in toxicology and environmental health sciences, which primarily go to research universities or non-profit research institutions. For example, NIEHS-funded researchers are working to develop new and improved models of toxicity that can help predict cancer and other adverse health outcomes that may result from fetal or early life exposures. NIEHS intramural research. In-house, or intramural research, is performed by scientists who are employed by the federal government and work onsite at NIEHS, particularly the Division of Translational Toxicology. That division's mission is to improve public health through toxicological data and knowledge development that are translatable, predictive, and timely. NTP Interagency Center for the Evaluation of Alternative Toxicological Methods (NICEATM). NIEHS, a key player in toxicology, is leading national efforts to reduce the use of animals in chemical safety testing, to keep pace both with emerging substances and the technology used to study them, and to communicate findings with stakeholders and the public. NICEATM works to find and evaluate test methods that replace, reduce, and refine the use of animals in testing, particularly mammals. These methods might include computer models, cell-based systems, and non-mammalian model organisms. For example, NICEATM created the Systematic Evaluation of the Application of Zebrafish in Toxicology (SEAZIT) program to promote the broader adoption of zebrafish models for toxicological screening. Integrated Chemical Environment (ICE). ICE is a resource developed by NICEATM. It includes curated toxicology data on thousands of chemicals and a collection of tools to assist in the prediction of the effects of exposures. Recent research shows that ICE data generated in the laboratory can be highly predictive of the effects of exposures seen in people in the real world. Chemical Effects in Biological Systems (CEBS). CEBS is a comprehensive toxicology database that compiles individual and summary animal data from the NTP testing program and other depositors into a single electronic repository. The resource currently contains over 11,000 exposure agents and over 8,000 studies, including all available NTP carcinogenicity, short-term toxicity, and genetic toxicity studies. Toxicology in the 21st Century. Tox21 is a unique collaboration among four federal agencies, including NIEHS. This program, formed in 2008 and is ongoing, develops innovative non-animal test methods to rapidly evaluate whether substances adversely affect human health. For example, Tox21 uses robotics in high-throughput screening, which is important for increasing the volume and speed of toxicity testing. Public Health Impact NIEHS and NTP toxicology research have significantly influenced public health policies. For example, NTP evaluates substances to determine if they should be labeled as human carcinogens, which are substances that could cause cancer in humans. This evaluation is included in the Report on Carcinogens, a congressionally mandated report that lists agents posing cancer hazards to many people in the U.S. Several states and federal agencies use this report as an authoritative source for decision-making and hazard communication. An interactive tool, available to the public, highlights the important role that cancer hazard identification can play in preventing cancer. Challenges and Future Directions The field of toxicology faces several challenges, including the complexity of chemical mixtures, the need for better predictive models, and the ethical considerations of testing potentially harmful substances on animals. Future directions in toxicology research include the development of more sophisticated biomarkers, the use of big data and computational models, and a greater focus on personalized medicine to tailor interventions based on individual susceptibility. Further Reading: Stories from the Environmental Factor (NIEHS Newsletter) Additional Resources ToxLearn. A toxicology tutorial provided by the National Library of Medicine, covering key principles of toxicology. What is Toxicology? A website designed by the Toxicology Education Foundation to enhance public understanding of toxicology through access to objective, science-based information on the safety of chemicals and other agents. Becoming a Toxicologist. This webpage by the Society of Toxicology provides those considering a career in toxicology with information on the profession, schooling needed, and more. Related Health Topics