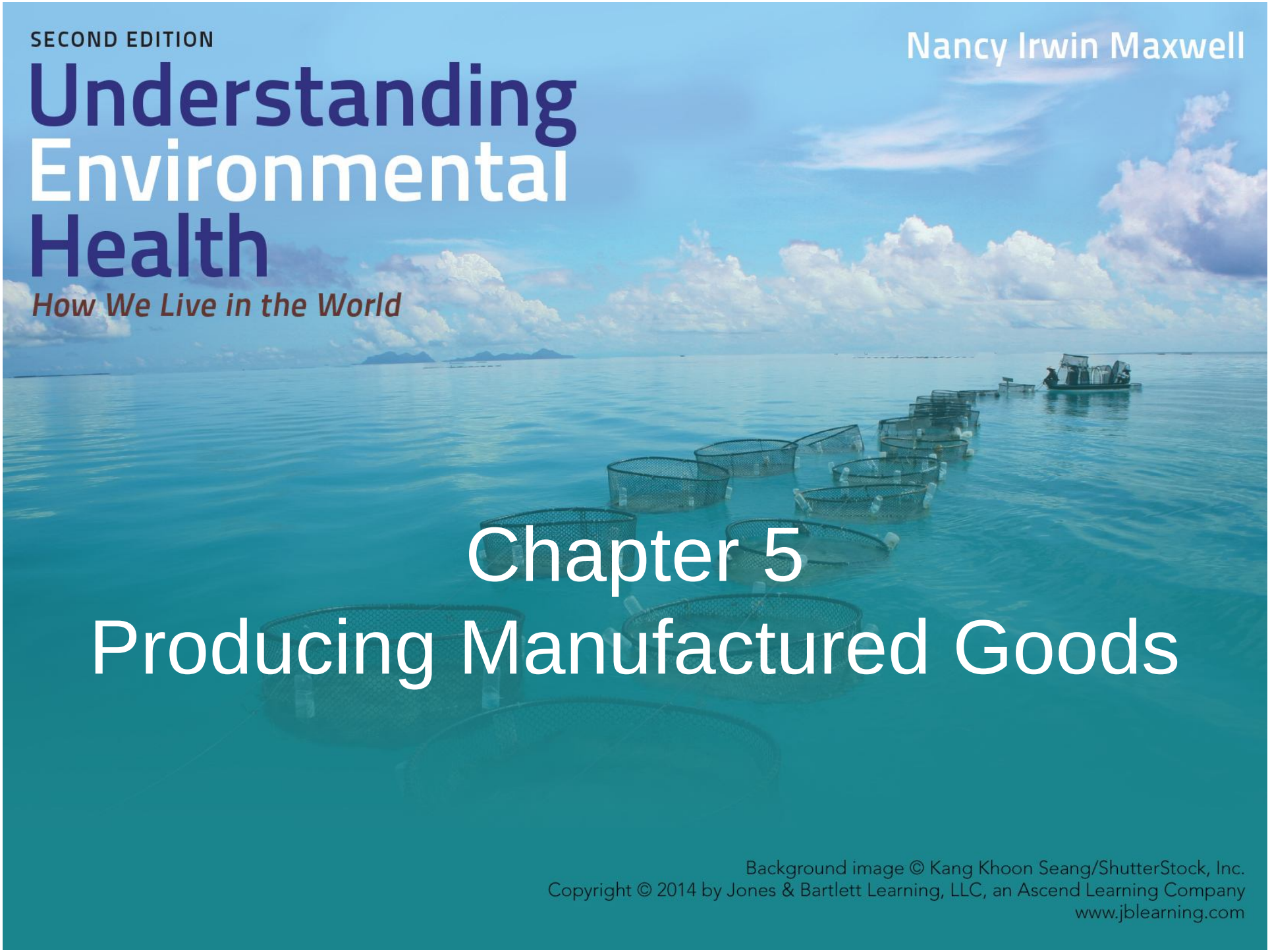

SECOND EDITION

Understanding Environmental Health

How We Live in the World

Nancy Irwin Maxwell

Chapter 5
Producing Manufactured Goods

Introduction

- Social and economic changes in US
  - Expectations and realities
    - "use it up, wear it out, make it do"; thrift as a necessity and a virtue
    - became: "the good life": house, car, washing machine, TV
    - became: "lifestyles": luxuries as necessities
  - Changes in industry and pollution →
    - Visible air pollution → hazardous wastes

FIGURE 5.1 Polluted air blankets a U.S. city in 1946.

Source: Reprinted courtesy of CDC Public Health Image Library. ID# 8998. Cont provider CDC/Roy Perry. Available at: http://phil.cdc.gov/phil/home.asp. Accesse October 15, 2012.

FIGURE 5.2 Workers wear protective gear as they handle hazardous wastes.

Source: Reprinted courtesy of CDC Public Health Image Library. ID# 1530. Content provider: CDC. Available at: http://phil.cdc.gov/phil/home.asp. Accessed October 15, 2012.

5.1 Synthetic Organic Chemicals

5.2 Toxic Metals

5.3 Nano-Scale Materials

5.4 Physical Hazards in the Workplace

5.5 Asthma-Causing Agents in the Workplace

5.6 Social Disparities in Exposure to Industrial Pollution

5.7 Regulation of Industrial Pollution

Organic Solvents

Phthalate Plasticizers and Bisphenol A

Persistent Toxic Substances

Ozone-Depleting Chemicals

Toxics Use Reduction

Organic solvents

- Solvents: chemicals that dissolve other substances
  - Cleaning; synthesizing chemicals
    - Petroleum refineries
    - Chemical industry
    - Degreasing metals in electronics industries
    - Dying and dry cleaning textiles
  - Common groundwater contaminants

Organic solvents

- Health effects[1,2]
  - Most affect central nervous system
  - Many damage liver, kidney
  - Cancer
    - Benzene—Group 1 (leukemia)
    - TCE, PCE—Group 2A
- Some widely used solvents →

Table 5.1 Some Widely Used Organic Solvents

Nonchlorinated Solvents	Chlorinated Solvents
Benzene	Trichloroethylene (TCE)
Toluene	Tetrachloroethylene (PCE)
Ethylbenzene	1,1,1-Trichloroethane (TCA)
Xylene	

Organic Solvents

Phthalate Plasticizers and Bisphenol A

Persistent Toxic Substances

Ozone-Depleting Chemicals

Toxics Use Reduction

Phthalate plasticizers and bisphenol A

- Phthalate plasticizers—chemicals used to make plastics *plastic*
- Bisphenol A also used in production
- Both present in some plastic products
  - May move slowly into air or into contents of container

Phthalate plasticizers and bisphenol A

- The phthalate family[3-5]
  - DEHP—polyvinyl chloride (PVC) plastic
  - DINP—plastic toys
  - DBP, DEP, DMP—spreadable / sprayable products
- Common in consumer products[5]
- Indoor sampling and surveillance biomonitoring shows widespread exposure in US population[6, 7-9]

Phthalate plasticizers and bisphenol A

- Health effects of phthalates and bisphenol-A: [3, 10-16]
  - Endocrine disruptors
  - Developmental effects in male lab animals and male infants (hypospadias, reduced anogenital distance)
  - Emerging evidence of link to obesity in lab animals and people

Organic Solvents

Phthalate Plasticizers and Bisphenol A

Persistent Toxic Substances

Ozone-Depleting Chemicals

Toxics Use Reduction

Persistent toxic substances

- All are halogenated (Cl, Fl, Br, I)
- PCBs, dioxins, and furans
  - PCBs: family of hi-MW manmade compounds
  - Chemically stable, nonflammable; used as insulating fluids in electrical equipment
  - Entered environment as industrial wastes
  - Manufacture of PCBs created dioxins, furans as byproducts
  - All are lipophilic and persistent

Persistent toxic substances

- Dioxins also byproducts of other chemical processes
  - Production of herbicide 2,4,5-T
  - Pulp & paper industry (chlorine bleach)
- Acute exposure → chloracne[17-19]
- Dioxins detectable at low levels in everyone[20]
- Wide range of health effects in test animals
- Epidemiologic evidence suggests effects on neurological development,[20] cancer mortality[21]
- Cancer: PCBs Group 2A, dioxin Group 1 [2]

Persistent toxic substances

- Polybrominated diphenyl ethers (PBDEs)
  - Used as flame retardants in many products
    - Penta-BDEs—in fabrics, foams
    - Octa- and deca-BDEs—in plastics
  - Not chemically bound to plastics or textiles[22]
  - Widespread in environment,[23,24] including indoor environment
  - Measured in wildlife and in humans[23-25]
  - Most likely health effect: thyroid disruption[26,27]

Persistent toxic substances

- Perfluorochemicals
  - Process chemicals in production of water- and stain-resistant coatings
  - Released in industrial wastes
    - Widespread in environment and wildlife[28,29]
  - Persist in the body[30]
  - Limited info on human health effects

Organic Solvents

Phthalate Plasticizers and Bisphenol A

Persistent Toxic Substances

Ozone-Depleting Chemicals

Toxics Use Reduction

Ozone-depleting chemicals

- Major cause: chlorofluorocarbons (CFCs)
  - Refrigerants, aerosol propellants, blowing agents
- Seemed ideal: nontoxic, not flammable or corrosive, chemically stable
- But due to stability, reach stratosphere, where complex reactions with O, O_2, and O_3 → net loss of ozone [31]

Ozone-depleting chemicals

- Stratospheric ozone depletion results in
  - More UV exposure at earth's surface, especially UV-A and UV-B
  - Increased risk of skin cancer
- Ozone concentrations hit low in mid-1990s; little change since then[32]
- Recovery anticipated by mid-21st century due to controls of Montreal Protocol

Organic Solvents

Phthalate Plasticizers and Bisphenol A

Persistent Toxic Substances

Ozone-Depleting Chemicals

Toxics Use Reduction

Toxics use reduction

- Preventive approach; objectives:
  - Use less toxic chemicals
  - Use smaller quantity of toxic chemicals
- Achieved through:
  - Green chemistry: the scientific work
  - Alternatives assessment: the practical work
- Benefits workers, communities

5.1 Synthetic Organic Chemicals

5.2 Toxic Metals

5.3 Nano-Scale Materials

5.4 Physical Hazards in the Workplace

5.5 Asthma-Causing Agents in the Workplace

5.6 Social Disparities in Exposure to Industrial Pollution

5.7 Regulation of Industrial Pollution

Overview of toxic metals

- Lead[33,34]
  - In workplace, mostly inorganic lead
  - Smelters, demolition
  - CNS effects: memory, attention
  - Peripheral effects: “wrist drop”
  - Renal toxicity, high blood pressure, miscarriage / stillbirth

FIGURE 5.4 A laborer works with molten metal in a lead smelting plant in Cincinnati, Ohio, at mid-20th century.

Source: Reprinted courtesy of CDC public Health Image Library. ID# 9527. Content providers CDC/Barbara Jenkins. Available at: http://phil.cdc.gov/phil/home.asp. Accessed October 15, 2012.

Overview of toxic metals

- Mercury[35]
  - In manufacturing, mostly elemental or inorganic mercury
  - Effects: excitability, delirium, hallucinations (as displayed by the Mad Hatter)
- Arsenic [36-38]
  - Widespread in earth's crust; groundwater contaminant
  - Copper smelters, tanneries
  - Group 1 carcinogen; neurotoxic effects

Overview of toxic metals

- Cadmium [36-38]
  - Mining and smelting (lead, zinc); metal plating
  - Chronic obstructive pulmonary disease, chronic kidney disease; itai-itai;
  - Group 1 carcinogen: lung cancer
- Chromium-VI [36-38]
  - Chrome plating, leather tanning
  - Group 1 carcinogen: lung cancer

Overview of toxic metals

- Beryllium [36-38]
  - Not a common metal
  - Strong, lightweight; used in high-tech industries (aircraft, space)
  - Chronic beryllium disease: debilitating lung disease; scarring, impaired breathing
  - Group 1 carcinogen: lung

5.1 Synthetic Organic Chemicals
5.2 Toxic Metals
5.3 Nano-Scale Materials
5.4 Physical Hazards in the Workplace
5.5 Asthma-Causing Agents in the Workplace
5.6 Social Disparities in Exposure to Industrial Pollution
5.7 Regulation of Industrial Pollution

Nano-scale Materials

- Nanoparticles: < 100 nm in diameter
  - Same size as ultrafine particulates; materials have different properties on nanoscale
  - Rapidly expanding technology for medicine, industry, consumer products
  - Health effects unclear; concern due to known effects of ultrafine particulates[39,40]
  - Nanotubes, like asbestos fibers, can cause toxicity because of shape[39,40]

5.1 Synthetic Organic Chemicals
5.2 Toxic Metals
5.3 Nano-Scale Materials
5.4 Physical Hazards in the Workplace
5.5 Asthma-Causing Agents in the Workplace
5.6 Social Disparities in Exposure to Industrial Pollution
5.7 Regulation of Industrial Pollution

Fibers and Dusts

Mechanical Hazards

Noise

Light during the "Biological Night"

Fibers and dusts

- Asbestos fibers
  - Mineral fiber; insulating, noncombustible
  - Widespread occupational exposure
    - Mining, manufacturing, construction, shipbuilding, auto repair; workers' families also exposed
  - Asbestosis, lung cancer, mesothelioma (sentinel illness for asbestos exposure)[41-43] →
  - Control lagged behind understanding; high exposures today in less developed countries

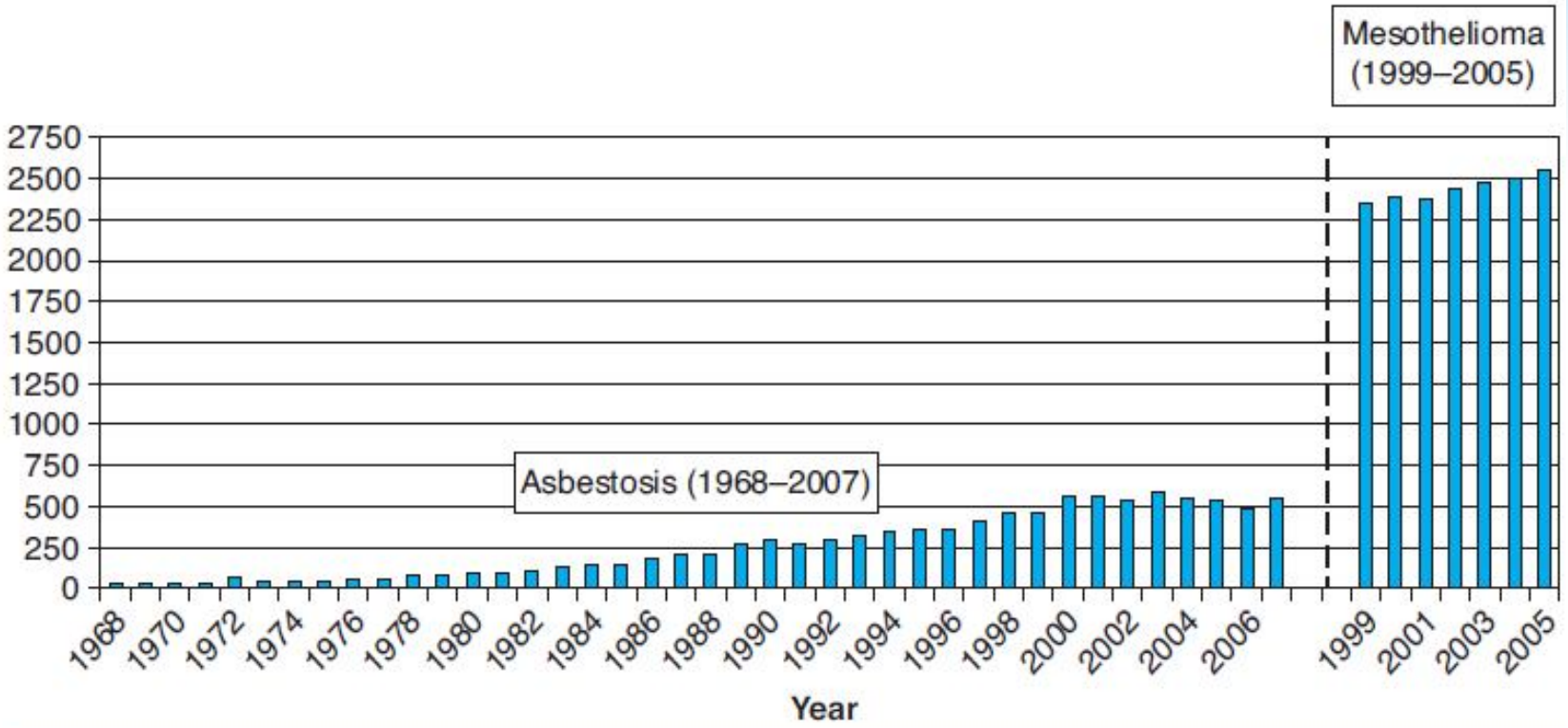

FIGURE 5.5 Deaths with asbestosis or mesothelioma as underlying cause.

Source: Data from Mortality multiple cause-of-death data from National Center for Health Statistics, National Vital Statistics System. Population estimates from U.S. Census Bureau; see Appendix (www2a.cdc.gov/drds/WorldReportData/Appendix.asp) for information about data sources, methods, ICD codes, and limitations for general caution regarding inferences based on small numbers of deaths. Reference Number: 2012F01-01.

Fibers and dusts

- Cotton dust
  - Cotton mill workers
  - Fibrotic lung disease: byssinosis ("brown lung")
  - Disabling but not highly fatal[44,45]
  - Common today in less developed but rapidly industrializing countries[46,47]

Fibers and Dusts

Mechanical Hazards

Noise

Light during the "Biological Night"

Mechanical hazards

- Occupational fatalities
  - Overall 3.5 fatalities per 100,000 FTE workers in US (2010)[48]
  - Highest-fatality occupations: fishing (116.0), logging (91.9) [49]
- About 250 nonfatal injuries for each death[48]
  - Chronic effects of vibration, repetitive work[50,51]

Fibers and Dusts

Mechanical Hazards

Noise

Light during the "Biological Night"

Noise

- Noise: sound that can damage hearing or otherwise harm health
- Effects on hearing
  - Threshold shift—upward shift in threshold at which sound at certain frequency can be perceived
  - Tinnitus (ringing or other sound in the ears) after exposure to loud noise

Noise

- Annual incidence noise-induced hearing loss: 15 per 10,000 full-time manufacturing workers[52]
- Highest–hearing-loss industries: iron foundries, animal slaughterhouses[52]
- Military service linked to hearing loss[53,54]
- Other workplace noise effects: "cognitive failures,"[55] cardiovascular risks[56]

Fibers and Dusts

Mechanical Hazards

Noise

Light during the "Biological Night"

Light during the "biological night"

- Shift work can disrupt circadian rhythms: basic physiological day/night cycle
  - Common in varied sectors: manufacturing, finance, real estate, food services [57]
- IARC classifies "shift work that involves circadian disruption" as Group 2A carcinogen[58]
- In rodents, light-at-night linked to increase in body mass index[59]

5.1 Synthetic Organic Chemicals
5.2 Toxic Metals
5.3 Nanotechnology
5.4 Physical Hazards in the Workplace
5.5 Asthma-Causing Agents in the Workplace
5.6 Social Disparities in Exposure to Industrial Pollution
5.7 Regulation of Industrial Pollution

Exposures and Occupations

- Isocyanates[60-62]
  - Paint-hardening chemicals; exposures to paint sprayers in various settings
- Metals [61, 62]
  - Aluminum (soldering)
  - Chromium and nickel (electroplating)
- Various dusts, fumes, organic compounds

5.1 Synthetic Organic Chemicals
5.2 Toxic Metals
5.3 Nanotechnology
5.4 Physical Hazards in the Workplace
5.5 Asthma-Causing Agents in the Workplace
5.6 Patterns in Exposure to the Products and Byproducts of Manufacturing
5.7 Regulation of Industrial Pollution

Industrial Pollution and Workplace Exposures in the United States

Chemical Burdens in People and Micro-environments

The Global Disparity in Protections for Workers

Industrial pollution / workplace exposures

- Social disparities (race, poverty) in
  - Industrial pollution and occupational hazards
  - Particulate air pollution
  - Disposal of hazardous wastes
- Regional disparities in burden of coal mining, uranium mining

Industrial Pollution and Workplace Exposures in the United States

Chemical Burdens in People and Micro-environments

The Global Disparity in Protections for Workers

Burdens of chemical exposure

- Differences in blood serum levels of BPA and PFCs by income and/or ethnicity[8]
- Differences in measures of PBDE exposure by geographic location, socioeconomic status, and race/ethnicity[63-66]

Industrial Pollution and Workplace Exposures in the United States

Chemical Burdens in People and Micro-environments

The Global Disparity in Protections for Workers

Global Disparity in Protections for Workers

- More developed countries export hazards to avoid costs of managing them
- Workers in less developed countries bear heavy burden of illness & injury
  - Shipbreaking →
    - In India and Bangladesh, to extract scrap metal
  - Recycling of used computers
    - In China and India, to extract salable components
- Basel Convention

FIGURE 5.7 Manual laborers break down beached ships on the shore of Bangladesh.
Source: © 2008 Pierre Claquin. Used with permission.

5.1 Synthetic Organic Chemicals
5.2 Toxic Metals
5.3 Nanotechnology
5.4 Physical Hazards in the Workplace
5.5 Asthma-Causing Agents in the Workplace
5.6 Social Disparities in Exposure to Industrial Pollution
5.7 Regulation of Industrial Pollution

Moving upstream: Cleanup of abandoned hazardous waste sites

- Superfund (CERCLA) passed 1980 and amended as SARA in 1986
- EPA identifies abandoned hazardous waste sites →
  - Placed on National Priorities List
  - Site assessment, including risk assessment
  - If possible, *polluter pays* for assessment and cleanup; if not, the Superfund pays
  - Work complete at >1000 sites; in process at >1000 sites

Cleanup of abandoned hazardous waste sites

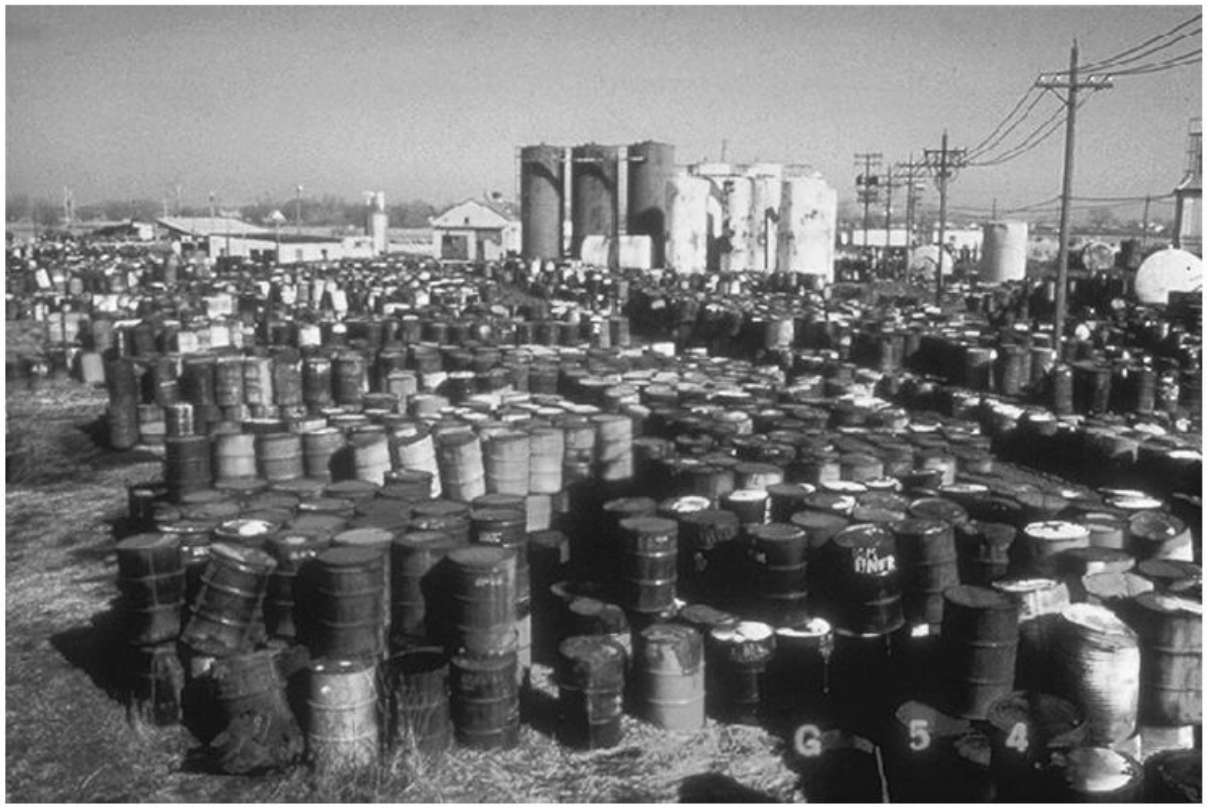

FIGURE 5.8 Drums of toxic wastes litter a Superfund site in this undated photo.

Source: Reprinted courtesy of CDC Public Health Image Library. ID# 1193. Content provider: CDC. Available at: http://phil.cdc.gov/phil/home.asp. Accessed October 15, 2012.

Controls on current discharges of manufacturing wastes

- Discharges to air: Clean Air Act
  - Criteria Air Pollutants, Hazardous Air Pollutants
- Discharges to water: Clean Water Act
  - Federal standards for ambient water quality (Ambient Water Quality Criteria; AWQC)
  - Requirement to use “best available technology” to meet standard
  - States set permit requirements for discharges, to meet AWQC and technology requirement
  - Law distinguishes point, nonpoint sources

Controls on current discharges of manufacturing wastes

- Land disposal of hazardous wastes: Resource Conservation and Recovery Act
  - Applies to specific wastes listed by EPA
  - And to any waste that is ignitable, corrosive, reactive, or toxic (according to criteria)
  - Requires: "cradle-to-grave" tracking of hazardous wastes; performance requirements for landfills

Controls on workplace hazards

- OSHAct (1970)—requires most employers to provide workplace “free of recognized hazards”
- Focus on mechanical hazards, chemical inhalation hazards
- OSHA sets Permissible Exposure Limits (PELs)
  - Time-weighted average, short-term exposure limit, ceiling

Controls on workplace hazards

- NIOSH produces Recommended Exposure Limits (RELs), intended as basis for OSHA's PELs
- ACGIH produces Threshold Limit Values (TLVs, also time-weighted average)
- Process of deriving PELs from RELs (or TLVs) has foundered

Controls on workplace hazards

- OSHAct gives modifications to work environment priority over personal protective equipment
- Employers must provide workers training and information on chemical hazards
  - Materials Safety Data Sheet (MSDS)

Regulation of the manufacture and use of chemicals

- Toxic Substances Control Act
  - Precautionary: before manufacturing new chemical, company must notify EPA
  - EPA can restrict manufacture, distribution, use of chemical
  - In practice, EPA has restricted only 5 chemicals (or sets of chemicals)
  - Issues: corporate confidentiality as barrier; EPA's lack of resources

Regulation of the manufacture and use of chemicals

- Consumer Product Safety Improvement Act of 2008
  - Ban on sale of toys and children's products containing phthalates
- Montreal Protocol on Substances that Deplete the Ozone Layer
  - In force 1989; 197 nations, including US, have signed
  - Country-specific limits on production and consumption of specific chemicals

Securing the public's right to information about chemical wastes

- Emergency Planning and Community Right-to-Know Act (part of SARA)
  - Requires industry to publish quantities (in pounds) of specific chemicals released each year at specific sites
    - Data in Toxics Release Inventory, publicly available electronic database
  - Created state and local emergency response commissions
  - Companies must submit relevant MSDSs to local commission

Pollution prevention and the precautionary principle

- Pollution Prevention Act (1990)
  - Named source reduction (waste prevention) as preferred option over treatment / disposal
  - Created Office of Pollution Prevention in EPA
  - Had little effect
- In 2009, EPA announced new principles for managing toxic chemicals
  - More precautionary, more transparent
  - Future impact uncertain

References

1. Levin SM, Lilis R. Organic compounds. In: Wallace RB, Doebbeling BN, eds. *Maxcy- Rosenau-Last Public Health and Preventive Medicine.* Stamford, CT: Appleton & Lange; 1998:509–542.
2. International Agency for Research on Cancer. Agents Classified by the IARC Monographs, Volumes 1–104. 2012. Available at: http://monographs.iarc.fr/ENG/Classification /ClassificationsAlphaOrder.pdf. Accessed April 7, 2012.
3. Shea KM. Pediatric exposure and potential toxicity of phthalate plasticizers. *Pediatrics*. 2003;111:1467–1474.
4. Toxics Use Reduction Institute. DEHP Facts/Use Nationally and in Massachusetts. Available at: www.turi.org/About/Library/TURI_Publications/Massachusetts_Chemical_ Fact_Sheets/DEHP_Fact_Sheet/DEHP-Facts/Use_Nationally_and_in_Massachusetts. Accessed April 12, 2012.
5. Dodson RE, Mishioka M, Standley LJ, Perovich LJ, Brody JG, Rudel RA. Endocrine disruptors and asthma-associated chemicals in consumer products. *Environ Health Persp.* 2012; 120(7):935–943.
6. Rudel RA, Camann DE, Spengler JD, Korn LR, Brody JG. Phthalates, alkylphenols, pesticides, polybrominated diphenyl ethers, and other endocrine-disrupting compounds in indoor air and dust. *Environ Sci Technol*. 2003;37:4543.
7. U.S. Centers for Disease Control and Prevention. Fourth National Report on Human Exposure to Environmental Chemicals, updated tables, February 2012 [data]. Available at: www.cdc.gov/exposurereport/. Accessed April 12, 2012.

References

8. Nelson JW, Scammel MK, Hatch EE, Webster TF. Social disparities in exposures to bisphenol A and polyfluoralkyl chemicals: A cross-sectional study within NHANES 2003– 2006. *Environ Health*. 2012;11.
9. Rudel RA, Gray JM, Engel CL, et al. Food packaging and bisphenol A and bis(2-ethyhexyl) phthalate exposure: findings from a dietary intervention. *Environ Health Persp*. 2011;119:914.
10. Martino-Andrade AJ, Chahoud I. Reproductive toxicity of phthalate esters. *Mol Nutr Food Res*. 2010;54:148.
11. Saillenfait AM, Sabate JP, Gallissot F. Effects of in utero exposure to di-n-hexyl phthalate on the reproductive development of the male rat. *Reprod Toxicol*. 2009;28:468.
12. Ormond G, Nieuwenhuijsen MJ, Nelson P, et al. Endocrine disruptors in the workplace, hairspray, folate supplementation, and risk of hypospadias: case-control study. *Environ Health Persp*. 2009;117:303.
13. Swan S, Main K, Liu F, et al. Decrease in anogenital distance among male infants with prenatal phthalate exposure. *Environ Health Persp*. 2005;113:1056–1061.
14. vom Saal F, Hughes C. An extensive new literature concerning low-dose effects of bisphenol A shows the need for a new risk assessment. *Environ Health Persp*. 2005;113:926–933.
15. Grun F, Watanabe H, Zamanian Z, et al. Endocrine-disrupting organotin compounds are potent inducers of adipogenesis in vertebrates. *Mol Endocrinol*. 2006;20:2141–2155.
16. Stahlhut S, van Wijngaarden E, Dye T, Cook S, Swan S. Concentrations of urinary phthalate metabolites are associated with increased waist circumferences and insulin resistance in adult U.S. males. *Environ Health Persp*. 2007;115:876–882.
17. Baccarelli A, Pesatori AC, Consonni D, et al. Health status and plasma dioxin levels in chloracne cases 20 years after the Seveso, Italy accident. *Brit J Dermatol*. 2005;152:459–465.

References

18. Yoshimura T. Yusho in Japan. *Ind Health*. 2003;41:139–148.
19. BBC News. Deadly dioxin used on Yushchenko. December 17, 2004. Available at: http://news.bbc.co.uk/2/hi/europe/4105035.stm. Accessed February 5, 2007.
20. Webster TF, Commoner B. Overview: The dioxin debate. In: Schecter A, Gasiewicz T, eds. *Dioxins and Health, 2nd ed.* New York: John Wiley & Sons, Inc.; 2003:1–53.
21. Clapp RW. Polychlorinated biphenyls. In: Wallace RB, Kohatsu N, eds. *Maxcy- Rosenau-Last Public Health and Preventive Medicine.* 15th ed. New York: McGraw-Hill; 2008.
22. de Wit CA. An overview of brominated flame retardants in the environment. *Chemosphere*. 2002;46:583–624.
23. Alcaee M, Wenning RJ. The significance of brominated flame retardants in the environment: current understanding, issues and challenges. *Chemosphere*. 2002;46:579–582.
24. McDonald TA. A perspective on the potential health risks of PBDEs. *Chemosphere*. 2002;46:745–755.
25. Meironyte D, Noren K, Bergman A. Analysis of polybrominated diphenyl ethers in Swedish human milk. A time-related trend study, 1972–1997. *J Toxicol Environ Health*. 1999;Part A: 329–341.
26. Fonnum F, Mariussen E. Mechanisms involved in the neurotoxic effects of environmental toxicants such as polychlorinated biphenyls and brominated flame retardants. *J Neurochem*. 2009;111:1327.
27. Messer A. Mini-review: polybrominated diphenyl ether (PBDE) flame retardants as potential autism risk factors. *Physiol Behav*. 2010;100:245.
28. Giesy JP, Kannan K. Global distribution of perfluorooctane sulfonate in wildlife. *Environ Sci Technol*. 2001;35:1339–1342.
29. Kannan K, Koistinen J, Beckmen K, et al. Accumulation of perfluorooctane sulfonate in marine mammals. *Environ Sci Technol*. 2001;35:1593–1598.

References

30. Organisation for Economic Co-operation and Development. Co-operation on existing chemicals: Hazard assessment of perfluorooctane sulfonate (PFOS) and its salts. Joint meeting of the chemicals committee and the working party on chemicals, pesticides and biotechnology; 2002;88:2. Available at: www.oecd.org/dataoecd/23/18/2382880.pdf. Accessed February 7, 2008.
31. World Meterological Organization. Scientific Assessment of Ozone Depletion: 2006. 2006;Report No. 50. Available at: www.wmo.int/pages/prog/arep/gaw/ozone_2006/ozone_ asst_report.html. Accessed October 15, 2012.
32. World Meteorological Organization. Scientific Assessment of Ozone Depletion: 2010 (Global Ozone Research and Monitoring Project Report No. 52). 2010. Available at: http://ozone.unep.org/Assessment_Panels/SAP/Scientific_Assessment_2010/index.shtml. Accessed June 20, 2012.
33. Gidlow DA. Lead toxicity. *Occup Med*. 2004;54:76–81.
34. Papanikolaou NC, Hatzidaki EG, Belivanis S, Tzanakakis GN, Tsatsakis AM. Lead toxicity update. A brief review. *Med Sci Mon*. 2005;11:RA329–RA336.
35. U.S. Agency for Toxic Substances and Disease Registry. Toxicological profile for mercury. 1999;28:1. Available at: www.atsdr.cdc.gov/toxprofiles/tp.asp?id=115&tid=24. Accessed October 15, 2012.
36. Grandjean P. Health significance of metal exposures. In:Wallace RB, Kohatsu, N., eds. Maxcy-Rosenau-Last Public Health and Preventive Medicine (15th ed.).New York: McGraw-Hill Medical; 2008.
37. Goyer RA. Toxic effects of metals. In: Klaasen CD, ed.Casarett and Doull's Toxicology: The Basic Science of Poisons. New York: McGraw-Hill; 1996.
38. U.S.Agency for Toxic Substance and Disease Registry. ToxFAQs for Arsenic, ToxFAQs for Cadmium, ToxFAQs for Chromium, and ToxFAQs for Beryllium; all available at: www.atsdr.cdc.gov/toxfaqs/index.asp (accessed April 18, 2012).

References

39. Hubbs AF, Mercer RR, Benkovic SA, et al. Nanotoxicology—A pathologist's perspective. *Toxicol Pathol*. 2011;39:301.
40. Witschi HR, Last JA. Toxic responses of the respiratory system. In: Klaassen CD, ed. *Casarett & Doull's Toxicology: The Basic Science of Poisons.* 5th ed. New York: McGraw- Hill; 1996:443–460.
41. Ozonoff D. Failed warnings: asbestos-related disease and industrial medicine. In: Bayer R, ed. *The Health & Safety of Workers: Case Studies in the Politics of Professional Responsibilty.* New York: Oxford University Press; 1988.
42. Case BW. Asbestos, smoking, and lung cancer: interaction and attribution. *Occup Environ Med*. 2006;63:507–508.
43. Robinson BS, Musk AW, Lake RA. Malignant mesothelioma. *Lancet*. 2005;366:397–408.
44. U.S. Occupational Safety and Health Administration. *Fact Sheet: Cotton Dust.* Vol 2007; 1995.
45. U.S. Centers for Disease Control and Prevention. Byssinosis: Mortality. Available at: www2 .cdc.gov/drds/WorldReportData/FigureTableDetails.asp?FigureTableID=2569&GroupRef Number=F04-01. Accessed April 14, 2012.
46. Wang X, Eisen EA, Zhang H, et al. Respiratory symptoms and cotton dust exposure; results of a 15 year follow up observation. *Occup Environ Med*. 2003;60:935–941.
47. Saiyed HN, Tiwari RR. Occupational health research in India. *Ind Health*. 2004; 42:141–148.
48. U.S. Bureau of Labor Statistics. Census of Fatal Occupational Injuries [data]. Available at: www.bls.gov/iif/oshcfoi1.htm. Accessed April 23, 2012.
49. U.S. Department of Labor, Bureau of Labor Statistics, Census of Fatal Occupational Injuries, 2010. Available at: www.bls.gov/iif/oshcfoi1.htm. Accessed April 14, 2012.
50. Canadian Centre for Occupational Health and Safety. *What are the Health Effects of Hand- Arm Vibration?* Vol 2007; 1998.

References

51. Canadian Centre for Occupational Health and Safety. *Work-Related Musculoskeletal Disorders (WMSDs).* Vol 2007; 2005.
52. U.S. Centers for Disease Control and Prevention. Worker Health eChartbook [data]. Available at: wwwn.cdc.gov/niosh-survapps/echartbook/Chart.aspx?id=11669. Accessed April 9, 2012.
53. Mahboudi H, Zardouz S, Oliaei S, Pan D, Bazargan M, Djalilian H. Noise-induced hearing threshold shift among U.S. adults and implications for noise-induced hearing loss: National Health and Nutrition Examination Surveys. *European Archives of Otorhinolaryngology* [serial online]. 2012. Available at: DOI 10.1007/s00405-012-1979-6. Accessed May 7, 2012.
54. Folmer RL, McMillan GP, Austin DF, Henry JA. Audiometric thresholds and prevalence of tinnitus among male veterans in the United States: data from the National Health and Nutrition Examination Survey, 1999–2006. *J Rehabil Res Dev*. 2011;48(5):503.
55. Smith AP. Effects of noise, job characteristics and stress on mental health and accidents, injuries, and cognitive failures at work [conference presentation]. *10th International Congress on Noise as a Public Health Problem 2011 (ICBEN 2011), London, UK.* 2011:486. Available at: http://psych.cf.ac.uk/home2/smith/ASmith_IN2010.pdf. Accessed September 13, 2012.
56. Gan WQ, Davies HW, Demers PA. Exposure to occupational noise and cardiovascular disease in the United States: The National Health and Examination Survey 1999–2004. *Occup Environ Med*. 2011;68:183.
57. McMenamin TM. A time to work: recent trends in shift work and flexible schedules. *Mon Labor Rev.* 2007;130(12):3.
58. Straif K, Baan R, Grosse Y, et al. Carcinogenicity of shift-work, painting, and fire-fighting. *Lancet Oncol*. 2007;8:1065–1066.
59. Fonken LK, Workman JL, Walton JC, et al. Light at night increases body mass by shifting the time of food intake. *Proceedings of the National Academy of Sciences*. 2010;107:18664.

References

60. U.S. Occupational Safety and Health Administration. *Safety and Health Topics: Isocyanates.* Vol 2007; 2006.
61. Burge S. Recent developments in occupational asthma. *Swiss Med Weekl*y. 2010;140:128.
62. Quirce S, Sastre J. New causes of occupational asthma. *Curr Opin Allergy Clin Immunol*. 2011;11:80.
63. Zota AR, Rudel RA, Morello-Frosch RA, Brody JG. Elevated house dust and serum concentrations of PBDEs in California: unintended consequences of furniture flammability standards? *Environ Sci Technol*. 2008;42:8158.
64. Rose M, Bennett DH, Bergman A, Fangstrom B, Pessah IN, Hertz-Picciotto I. PBDEs in 2–5 year-old children from California and associations with diet and indoor environment. *Environ Sci Technol*. 2010;44:2648.
65. Sjodin A, Wong L, Jones RS, et al. Serum concentrations of polybrominated diphenyl ethers (PBDEs) and polybrominated biphenyl (PBB) in the United States population: 2003–2004. *Environ Sci Technol*. 2008;42:1377.
66. Windham GC, Pinney SM, Sjodin A, et al. Body burdens of brominated flame retardants and other persistent organohalogenated compounds and their descriptors in U.S. girls. *Environ Res*. 2010;110:251.