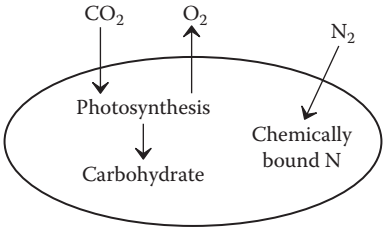



Figure 2.1 Cyanobacteria are remarkable organisms that within a single "simple" prokaryotic cell carry out all the biochemical processes needed to convert atmospheric carbon dioxide to carbohydrate and biomass and that can split the chemically very stable atmospheric nitrogen molecule and convert the nitrogen to chemically and biochemically bound nitrogen.

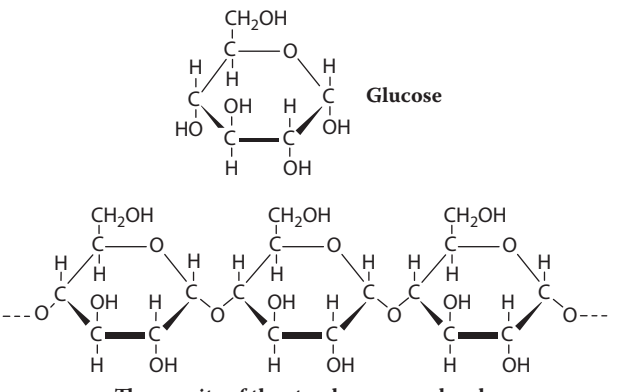



Figure 2.2 Glucose, a monosaccharide, or simple sugar, and a segment of the starch molecule, which is formed when glucose molecules polymerize with the elimination of one $H_2O$ molecule per glucose monomer.

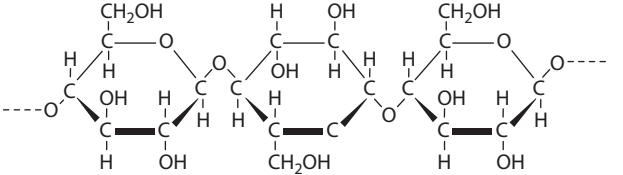



Figure 2.3 A segment of a cellulose molecule. These molecules are biosynthesized from glucose with the loss of one $H_2O$ for each linkage formed.

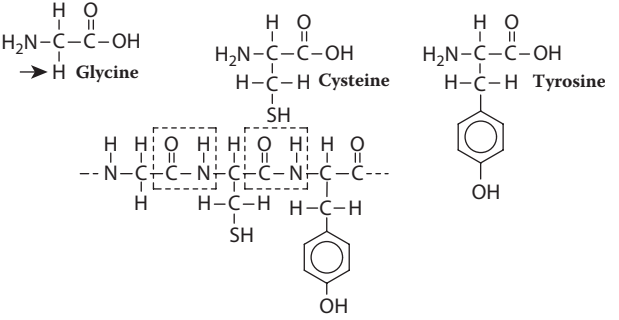
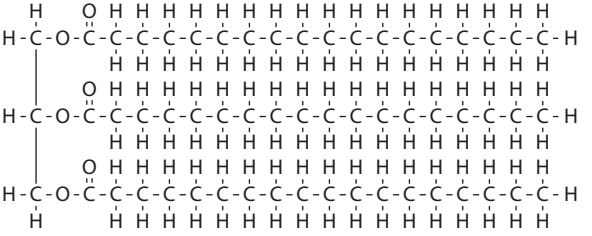
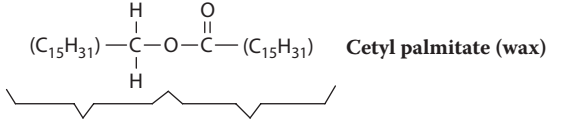



Figure 2.4 Three amino acids. Glycine is the simplest amino acid. All others have the basic glycine structure except that different groups are substituted for the H designated in glycine by an arrow. The lower structure shows these three amino acids are linked together in a macromolecule chain composing a protein. For each linkage, one molecule of $H_2O$ is lost. The peptide linkage holding amino acids together in proteins is outlined by a dashed rectangle.

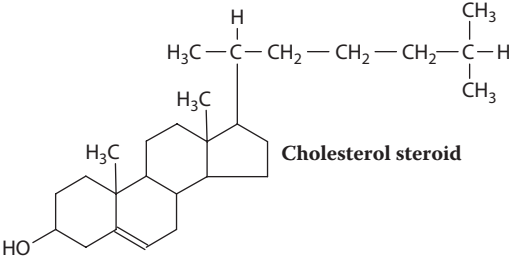


**Triglyceride of stearic acid, $CH_3(CH_2)_{16}C(O)OH$**



**Cetyl palmitate (wax)**

**Part of ester from cetyl alcohol** **Part of ester from palmitic acid**



**Cholesterol steroid**

Figure 2.5 Three examples of lipids formed in biological systems. Note that a line structure is used to show the ring structure of cholesterol. The hydrocarbon-like nature of these compounds, which makes them soluble in organic compounds, is obvious. For interpretation of the line structure of cholesterol, see Chapter 20, Section 20.3.

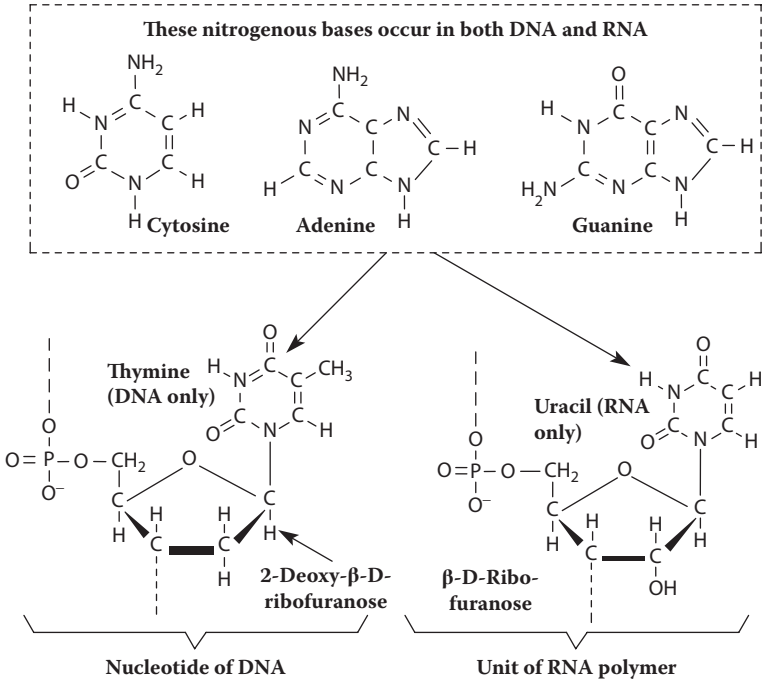



Figure 2.6 Basic units of nucleic acid polymers. These units act as a code in directing reproduction and other activities of organisms. Dashed lines show bonds to next nucleotide unit.

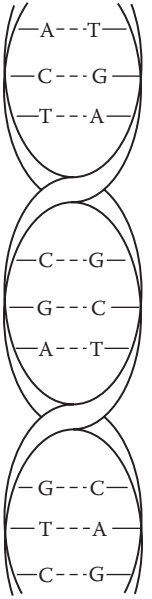



Figure 2.7 Representation of the double-helix structure of DNA showing the allowed base pairs held together by hydrogen bonding between the phosphate/sugar polymer "backbones" of the two strands of DNA. The letters stand for adenine (A), cytosine (C), guanine (G), and thymine (T). The dashed lines, --- , represent hydrogen bonds.

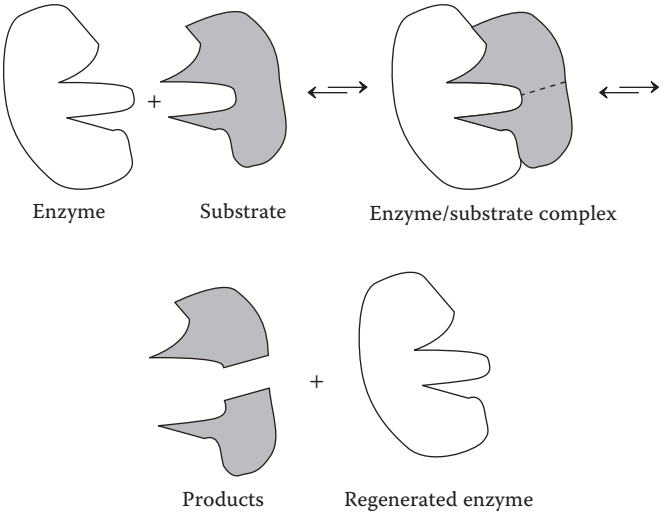



Figure 2.8 Representation of the "lock-and-key" mode of enzyme action, which enables the very high specificity of enzyme-catalyzed reactions.

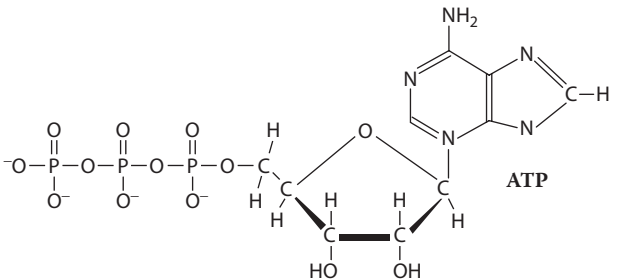



Figure 2.9 Adenosine triphosphate, a molecule strongly involved with energy transfer in living organisms.

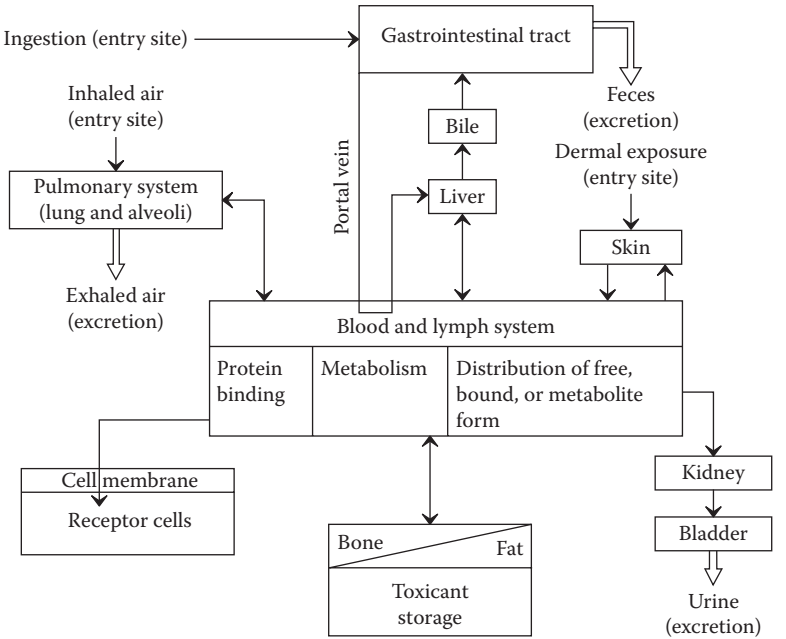



Figure 2.10 Major sites of exposure, metabolism, and storage and routes of distribution and elimination of toxic substances in the body.

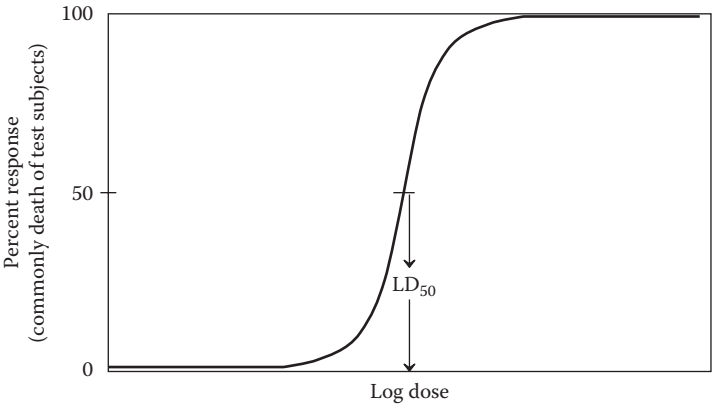



Figure 2.11 A dose–response plot of percentage of a uniform population of subjects responding in a specified way (most commonly death) versus log dose. The dose at which statistically half of the subjects die is designated as the $LD_{50}$.

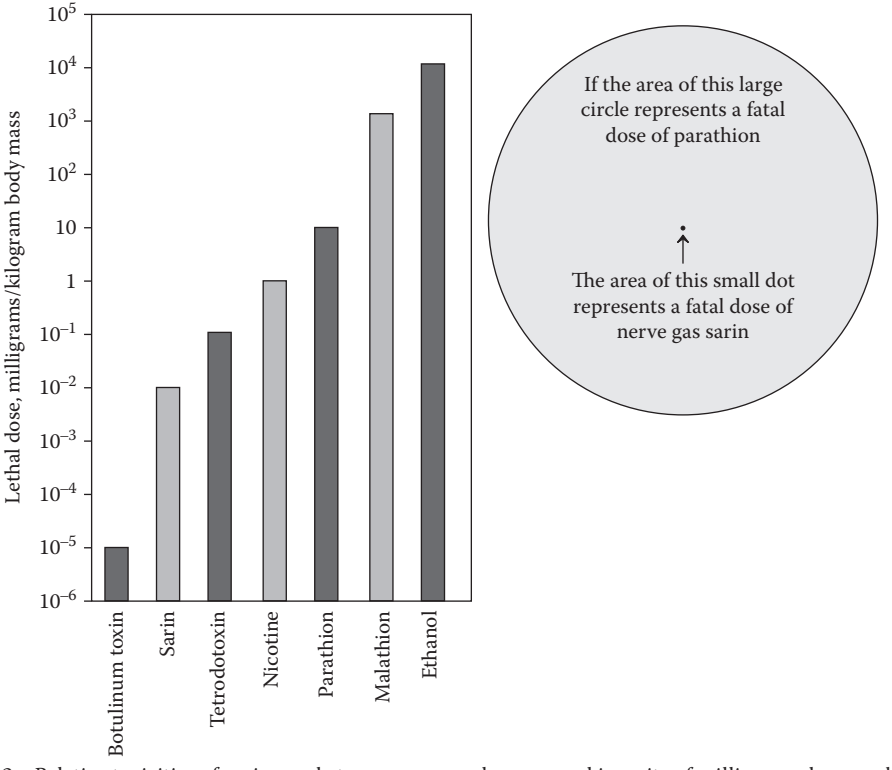



Figure 2.12 Relative toxicities of various substances commonly expressed in units of milligrams dose per kilogram of body mass required to kill 50% of test subjects ($LD_{50}$). Also shown is a comparison of the toxicity of insecticidal parathion to that of another organophosphate compound, nerve gas sarin, in which the toxic dose of parathion is represented by the area of the large circle and that of sarin by the area of the small dot.

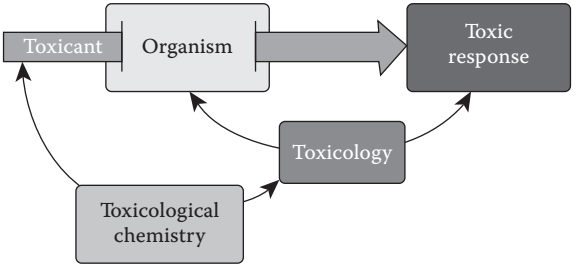



Figure 2.13 Toxicology is the science dealing with various aspects of the effects of poisonous substances on organisms. Toxicological chemistry relates the chemical nature of toxicants and protoxicants to their toxic effects on organisms.

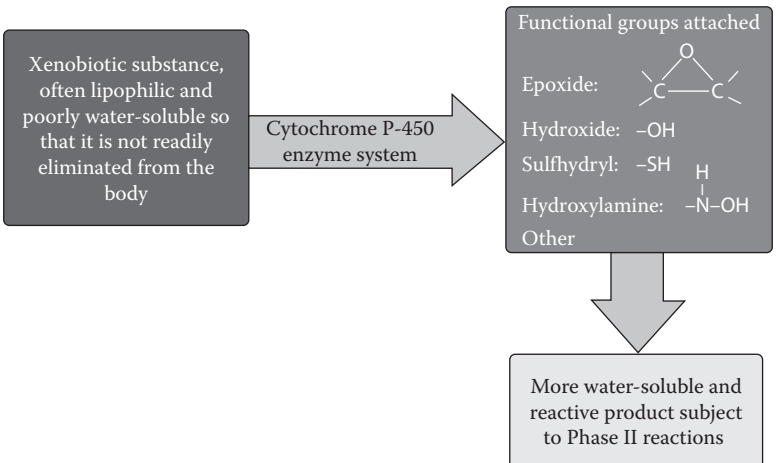



Figure 2.14 Illustration of Phase I reactions in which the cytochrome P-450 enzyme system attaches a functional group, typically –OH. The Phase I reaction product is generally more water-soluble and is amenable to Phase II reactions in which a conjugating agent is attached.

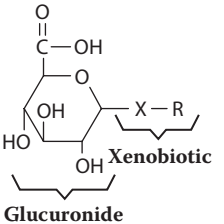



Figure 2.15 Glucuronide conjugate formed from a xenobiotic, HX-R. For example, if the xenobiotic compound conjugated is phenol, HXR is $HOC_6H_5$, X is the O atom, and R represents the phenyl group, $C_6H_5$. For interpretation of the line formulas in this figure, see Chapter 20.

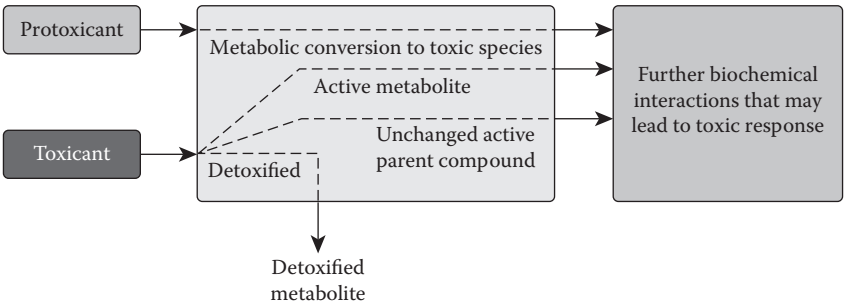



Figure 2.16 Illustration of the kinetic phase of metabolism for toxicants and protoxicants. In this phase, a protoxicant may be metabolically converted to a toxic species. A toxicant may be detoxified and excreted without doing harm, remain unchanged as an active parent compound that may have a toxic effect, or converted to another active metabolite that is potentially toxic.

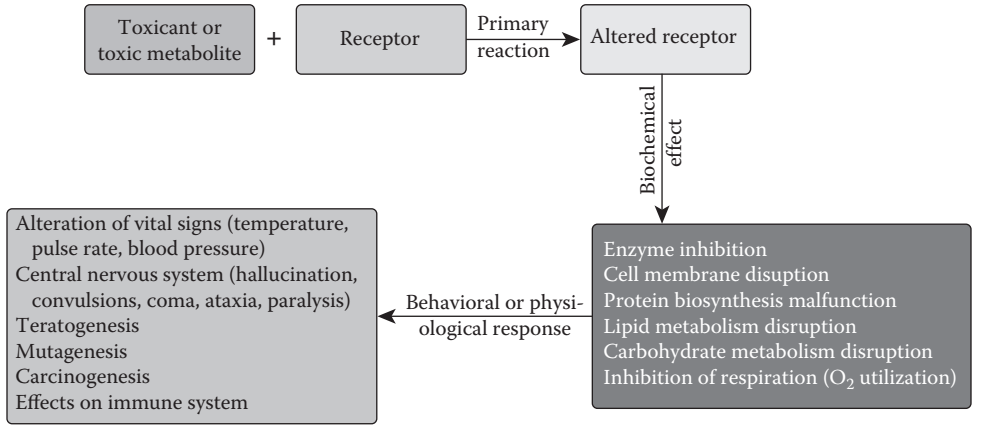
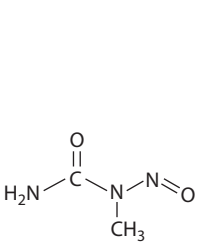
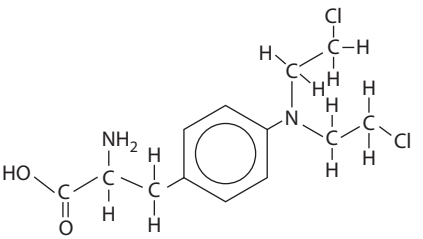


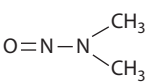

Figure 2.17 The dynamic phase of toxicant action.



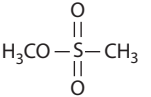

***N*-methyl-*N*-nitrosurea**




**4-[bis(chloroethyl)amino]phenylalanine**
**Melphalan**

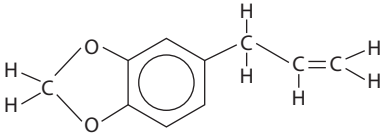



**Dimethylnitrosamine**

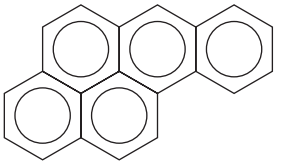



**Methyl methanesulfonate**

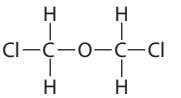
Figure 2.18 Examples of simple alkylating agents capable of causing mutations, including *N*-methyl-*N*-nitrosurea, commonly used as a model compound for alkylation studies; Melphalan, a chemotherapeutic agent used to treat cancer; dimethylnitrosamine; and methyl methanesulfonate.




**Safrole (from sassafras) a natural product that requires bioactivation**



**Benzo(a)pyrene, a synthetic chemical that requires bioactivation**




**Bis(chloromethyl)ether, a synthetic compound that does not require bioactivation**

Figure 2.19 Carcinogens may come from natural and synthetic sources. Most require biochemical activation to cause cancer, although some are direct-acting carcinogens. Safrole is a natural product that requires bioactivation; benzo(a)pyrene is a polycyclic aromatic compound made by both natural and synthetic processes, which is converted to a carcinogenic form by metabolic processes; and bis(chloromethyl)ether is a synthetic compound that is direct-acting as a carcinogen.

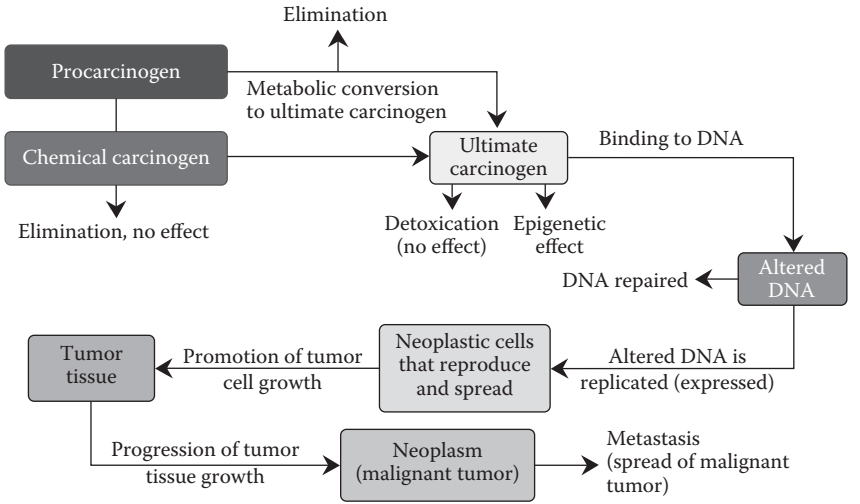
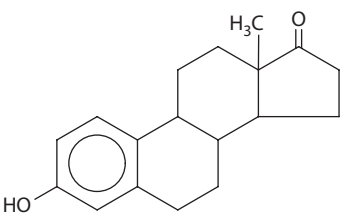
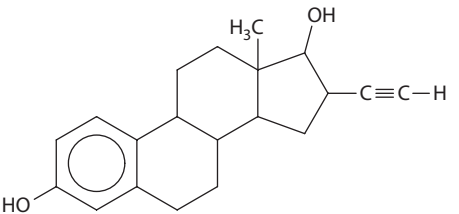


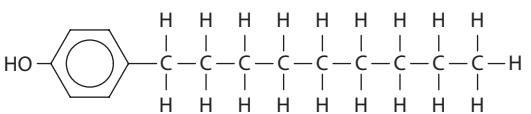

Figure 2.20 Outline of the process by which a carcinogen or procarcinogen may cause cancer. There are several steps in which the process of causing cancer can be stopped. A procarcinogen can be metabolically converted to a carcinogen, but it or a carcinogen may be eliminated without harm. An ultimate carcinogen, which may be formed metabolically from a procarcinogen, may be detoxified without ill effect. The ultimate carcinogen may exert an epigenetic effect that does not involve binding with DNA or it may alter DNA, which can be repaired by repair enzymes. Altered DNA that is not repaired may form neoplastic cancer cells that reproduce and spread. These can lead to tumor cell growth and development of tumor tissue. Progression of tumor tissue growth can occur, leading to a neoplasm (malignant tumor). Ultimately, metastasis, the spread of malignant tumor tissue, may occur.



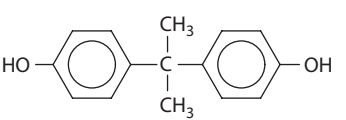

**Estrone (a natural estrogen)**




**17α-Ethynylestradiol (oral contraceptives)**




***p*-Nonylphenol (from surfactants)**




**Bisphenol A (epoxy and polycarbonate resins)**

Figure 2.21 Examples of estrogenic agents found in water. Estrone is a natural estrogen, 17α-ethynylestradiol is an ingredient of oral contraceptives, *p*-nonylphenol comes from surfactants used in cleaning agents, and bisphenol A is an ingredient in some epoxy and polycarbonate resins.

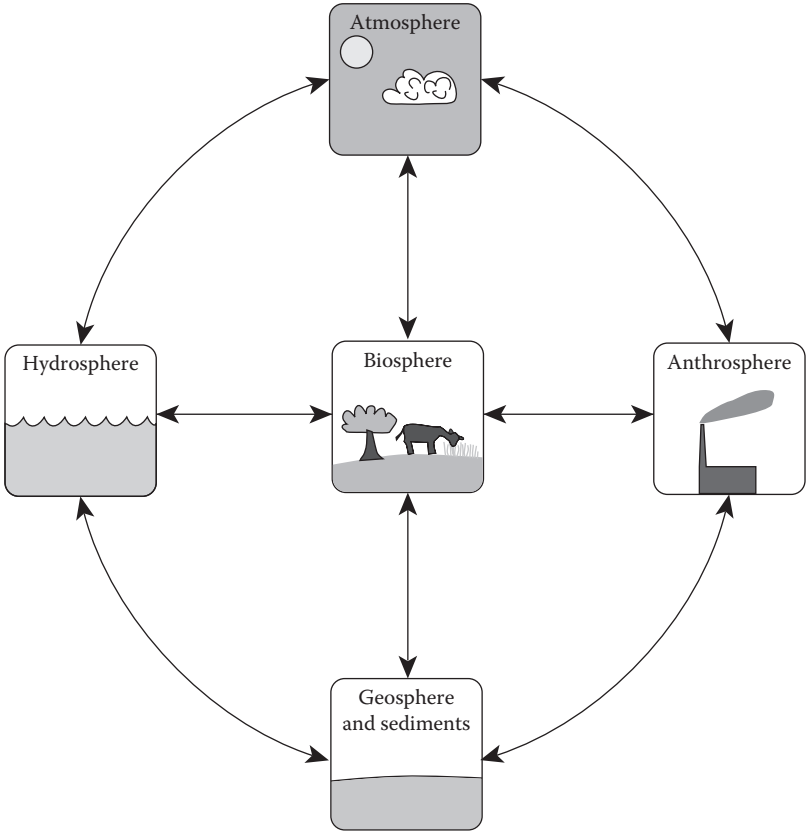



Figure 2.22 Transfers of substances among the various environmental spheres, especially those involving the biosphere, are very important in determining their ecotoxicological effects.