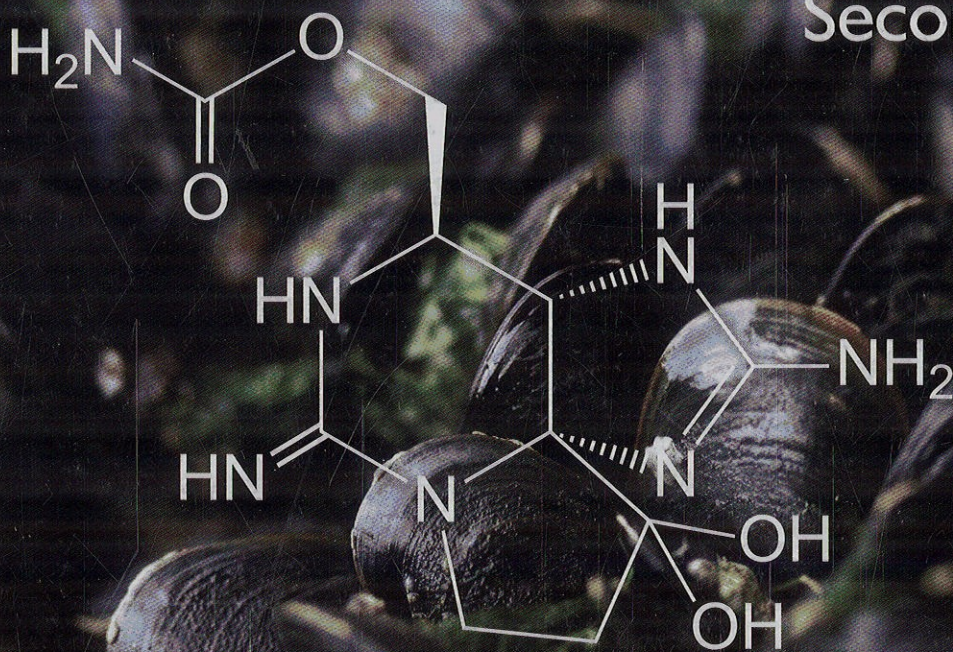




Introduction to

# Food Toxicology

Second Edition



**Takayuki Shibamoto**  
**Leonard F. Bjeldanes**



# Table of Contents

PREFACE .....	X
<b>CHAPTER 1 Principles of Toxicology .....</b>	<b>01</b>
Branches of Toxicology .....	04
Dose-Response.....	05
Potency .....	08
Hormesis .....	09
Margin of Safety.....	10
Biologic Factors that Influence Toxicity.....	12
Absorption .....	13
Types of Membrane Transport .....	16
Toxic Absorption in the Alimentary Tract.....	18
Intestinal Microflora .....	19
The Blood–Brain Barrier.....	20
Xenobiotic Absorption into Lymph .....	21
Translocation .....	22
Distribution.....	23
Storage.....	25
Organ Storage .....	25
Lipid Storage .....	26
Bone Storage .....	26
Excretion .....	27
Kidney.....	27
Effects of Maturation on Kidney Excretion.....	29
Fecal Excretion of Xenobiotics.....	29
<b>CHAPTER 2 Determination of Toxicants in Foods .....</b>	<b>33</b>
Sampling.....	35
Qualitative and Quantitative Analyses of Toxicants in Foods .....	35
Sample Preparation for Analysis of Toxicants.....	36
Isolation and Identification by Chromatography.....	40
Biological Determination of Toxicants .....	41
Acute Toxicity .....	41
Genetic Toxicity .....	42

	Bioassay .....	43
	Metabolism .....	47
	Subchronic Toxicity .....	47
	Teratogenesis .....	48
	Chronic Toxicity .....	50
<b>CHAPTER 3</b>	<b>Biotransformation .....</b>	<b>53</b>
	Phase I Reactions .....	54
	Phase II Reactions .....	57
	Phase I Enzymes .....	61
	Cytochrome P450 .....	61
	CYP3A4 .....	64
	CYP1B1 .....	66
	CYP2E1 .....	68
	Peroxidases .....	70
	Flavin-Containing Monooxygenase (FMO) .....	73
	Epoxide Hydrolase (EH) .....	74
	Esterases .....	76
	Carboxylesterases (CES) .....	76
	Paraoxonase .....	77
	Phase II Xenobiotic Metabolism .....	78
	Glucuronide Conjugation .....	79
	Sulfate Conjugation .....	80
	Glutathione Conjugation .....	81
<b>CHAPTER 4</b>	<b>Chemical Carcinogenesis .....</b>	<b>85</b>
	Definitions .....	85
	Phases of Carcinogenesis .....	86
	Initiation .....	86
	Promotion .....	88
	Progression .....	88
	Angiogenesis .....	89
	Cancer Epidemiology .....	92
	Dietary Guidelines for Cancer Prevention .....	95
<b>CHAPTER 5</b>	<b>Natural Toxins in Animal Foodstuffs .....</b>	<b>99</b>
	Natural Toxins in Land Animal Foodstuffs .....	99
	Bile Acids .....	100
	Vitamin A .....	100
	Transmissible Spongiform Encephalopathies (TSEs) and Prions .....	102
	Discovery of Bovine Spongiform Encephalopathy (BSE) .....	102
	Discovery of Toxic Principle Prion .....	103

	Mode of Action of Prion .....	104
	Natural Toxins in Marine Foodstuffs.....	104
	Tetrodotoxin—Puffer Fish Poison.....	105
	Paralytic Shellfish Poisoning (PSP).....	108
	Ciguatera .....	111
	Neurotoxic Shellfish Poisoning (NSP) .....	113
	Amnesic Shellfish Poisoning (ASP).....	115
	Voltage-Gated Na <sup>+</sup> Channels .....	117
	Scombroid Fish Poisoning.....	118
<b>CHAPTER 6</b>	<b>Toxic Phytochemicals .....</b>	<b>123</b>
	Phytotoxins .....	124
	Goitrogens .....	124
	Environmental Antithyroid Substances .....	127
	Favism .....	129
	Neurolethyrism.....	133
	Cyanogenic Glycosides.....	134
	Lectins.....	138
	Vasoactive Amines.....	141
	Caffeine.....	143
	Curare .....	146
	Strychnine .....	147
	Atropine .....	149
	Phytoalexins .....	152
	Herb-Drug Interactions .....	154
<b>CHAPTER 7</b>	<b>Toxins from Fungi .....</b>	<b>159</b>
	Mycotoxins .....	159
	Ergotism.....	160
	Alimentary Toxic Aleukia.....	163
	Fumonisin .....	165
	Aflatoxin.....	167
	Mushrooms .....	176
	<i>Amanita phalloides</i> .....	176
	<i>Amanita muscaria</i> .....	178
	<i>Psilocybe</i> .....	180
<b>CHAPTER 8</b>	<b>Food Contaminants from Industrial Wastes.....</b>	<b>181</b>
	Chlorinated Hydrocarbons .....	181
	Polychlorinated Biphenyls (PCBs).....	181
	Polychlorinated Dibenzo- <i>p</i> -dioxins (PCDDs).....	187
	Heavy Metals .....	192

	Arsenic.....	193
	Lead.....	196
	Mercury.....	202
	Cadmium.....	206
<b>CHAPTER 9</b>	<b>Pesticide Residues in Foods.....</b>	<b>211</b>
	What is a Pesticide?.....	211
	History.....	212
	Pesticides in the Food Chain.....	214
	Regulations.....	216
	Insecticides.....	218
	DDT.....	218
	Chlorinated Cyclodiene Insecticides.....	220
	Organophosphate Insecticides.....	222
	Carbamate Insecticides.....	225
	Herbicides.....	226
	Chlorophenoxy Acid Esters.....	226
	Naturally Occurring Pesticides.....	227
<b>CHAPTER 10</b>	<b>Food Additives.....</b>	<b>229</b>
	Regulations.....	232
	Preservatives.....	237
	Benzoic Acid.....	238
	Sorbic Acid and Potassium Sorbate.....	240
	Hydrogen Peroxide.....	241
	AF-2 [2-( <i>p</i> -furyl)-3-(5-nitro-2-furyl)acrylamide].....	241
	Antioxidants.....	242
	L-Ascorbic Acid (Vitamin C).....	243
	dl- $\alpha$ -Tocopherol (Vitamin E).....	243
	Propyl Gallate.....	244
	Butylated Hydroxyanisol and Butylated Hydroxytoluene.....	244
	Sweeteners.....	245
	Saccharin and Sodium Saccharin.....	245
	Sodium Cyclamate.....	246
	Coloring Agents.....	247
	Amaranth (FD&C Red No. 2).....	248
	Tartrazine (FD&C Yellow No. 4).....	249
	Flavoring Agents.....	250
	Methyl Anthranilate.....	250
	Safrole (1-Allyl-3,4-Methylenedioxybenzene).....	251
	Diacetyl (2,3-butane dione).....	251
	Flavor Enhancers.....	252

<b>CHAPTER 11</b>	<b>Toxicants Formed During Food Processing</b> .....	253
	Polycyclic Aromatic Hydrocarbons (PAHs) .....	255
	Occurrence .....	256
	Benzo[a]pyrene (BP).....	257
	Maillard Reaction Products .....	260
	Polycyclic Aromatic Amines (PAA) .....	261
	Occurrence .....	261
	Toxicity .....	262
	N-Nitrosamines .....	265
	Precursors .....	265
	Occurrence in Various Foods .....	266
	Toxicity .....	267
	Mode of Toxic Action .....	267
	General Considerations .....	268
	Acrylamide .....	269
	Formation Mechanisms of Acrylamide in Foods .....	270
	Toxicity .....	272
	Mode of Action .....	272
	General Considerations .....	273
	Food Irradiation.....	273
<b>CHAPTER 12</b>	<b>Food Factors and Health</b> .....	277
	Probiotics, Prebiotics, and Synbiotics .....	278
	Probiotics .....	278
	Prebiotics .....	278
	Synbiotics.....	280
	Antioxidants.....	281
	The Role of Oxygen in Living Organisms.....	281
	<i>In vivo</i> Balance between Oxidants and Antioxidants .....	282
	Lipid Peroxidation .....	283
	Toxicity of RCCs.....	285
	Functional Components Found in Food for Disease	
	Prevention .....	286
	INDEX.....	293