

Contents

Preface to the Fifth Edition
How to Use This Book

xi
xiii

8. Study Questions and Exercises 58
Recommended Reading 58

Part I Perspectives on the Vitamins in Nutrition

1. What Is a Vitamin?

- | | |
|---|---|
| 1. Thinking About Vitamins | 3 |
| 2. Vitamin: A Revolutionary Concept | 3 |
| 3. An Operating Definition of a Vitamin | 4 |
| 4. The Recognized Vitamins | 5 |
| 5. Study Questions and Exercises | 5 |

2. Discovery of the Vitamins

- | | |
|--|----|
| 1. The Emergence of Nutrition as a Science | 8 |
| 2. The Process of Discovery in Nutritional Science | 8 |
| 3. The Empirical Phase of Vitamin Discovery | 8 |
| 4. The Experimental Phase of Vitamin Discovery | 12 |
| 5. The Vitamine Theory | 14 |
| 6. Elucidation of the Vitamins | 18 |
| 7. Vitamin Terminology | 28 |
| 8. Other Factors Sometimes Called Vitamins | 28 |
| 9. Modern History of the Vitamins | 29 |
| 10. Study Questions and Exercises | 30 |
| Recommended Reading | 30 |

3. General Properties of Vitamins

- | | |
|---|----|
| 1. Vitamin Nomenclature | 34 |
| 2. Chemical and Physical Properties of the Vitamins | 36 |
| 3. Physiological Utilization of the Vitamins | 43 |
| 4. Metabolism of the Vitamins | 50 |
| 5. Metabolic Functions of the Vitamins | 51 |
| 6. Vitamin Bioavailability | 52 |
| 7. Vitamin Analysis | 52 |

4. Vitamin Deficiency

- | | |
|--|----|
| 1. The Concept of Vitamin Deficiency | 60 |
| 2. Clinical Manifestations of Vitamin Deficiencies | 61 |
| 3. Causes of Vitamin Deficiencies | 65 |
| 4. Study Questions and Exercises | 78 |
| Recommended Reading | 78 |

5. Vitamin Needs and Safety

- | | |
|---|-----|
| 1. Dietary Standards for Vitamins | 80 |
| 2. Vitamin Allowances for Humans | 87 |
| 3. Vitamin Allowances for Animals | 89 |
| 4. Uses of Vitamins Above Required Levels | 89 |
| 5. Hypervitaminoses | 96 |
| 6. Safe Intakes of Vitamins | 102 |
| 7. Study Questions and Exercises | 105 |
| Recommended Reading | 105 |

Part II Considering the Individual Vitamins

6. Vitamin A

- | | |
|-------------------------------------|-----|
| 1. Significance of Vitamin A | 110 |
| 2. Properties of Vitamin A | 111 |
| 3. Sources of Vitamin A | 112 |
| 4. Absorption of Vitamin A | 115 |
| 5. Transport of Vitamin A | 118 |
| 6. Metabolism of Vitamin A | 125 |
| 7. Metabolic Functions of Vitamin A | 129 |
| 8. Biomarkers of Vitamin A Status | 137 |
| 9. Vitamin A Deficiency | 139 |
| 10. Vitamin A in Health and Disease | 147 |
| 11. Vitamin A Toxicity | 153 |
| 12. Case Studies | 156 |
| 13. Study Questions and Exercises | 158 |
| Recommended Reading | 159 |

7. Vitamin D

1. Significance of Vitamin D	162
2. Properties of Vitamin D	163
3. Sources of Vitamin D	164
4. Enteric Absorption of Vitamin D	170
5. Transport of Vitamin D	171
6. Metabolism of Vitamin D	173
7. Metabolic Functions of Vitamin D	176
8. Biomarkers of Vitamin D Status	190
9. Vitamin D Deficiency	192
10. Vitamin D in Health and Disease	198
11. Vitamin D Toxicity	202
12. Case Studies	204
13. Study Questions and Exercises	205
Recommended Reading	205

8. Vitamin E

1. Significance of Vitamin E	208
2. Properties of Vitamin E	208
3. Sources of Vitamin E	210
4. Absorption of Vitamin E	212
5. Transport of Vitamin E	214
6. Metabolism of Vitamin E	219
7. Metabolic Functions of Vitamin E	221
8. Biomarkers of Vitamin E Status	227
9. Vitamin E Deficiency	229
10. Vitamin E in Health and Disease	231
11. Vitamin E Toxicity	239
12. Case Studies	240
13. Study Questions and Exercises	241
Recommended Reading	241

9. Vitamin K

1. The Significance of Vitamin K	244
2. Properties of Vitamin K	244
3. Sources of Vitamin K	245
4. Absorption of Vitamin K	249
5. Transport of Vitamin K	249
6. Metabolism of Vitamin K	250
7. Metabolic Functions of Vitamin K	253
8. Biomarkers of Vitamin K Status	258
9. Vitamin K Deficiency	259
10. Vitamin K Health and Disease	262
11. Vitamin K Toxicity	262
12. Case Studies	263
13. Study Questions and Exercises	264
Recommended Reading	265

10. Vitamin C

1. The Significance of Vitamin C	268
2. Properties of Vitamin C	268
3. Sources of Vitamin C	269

4. Absorption of Vitamin C	272
5. Transport of Vitamin C	272
6. Metabolism of Vitamin C	274
7. Metabolic Functions of Vitamin C	275
8. Biomarkers of Vitamin C Status	283
9. Vitamin C Deficiency	284
10. Vitamin C in Health and Disease	286
11. Vitamin C Toxicity	292
12. Case Studies	293
13. Study Questions and Exercises	295
Recommended Reading	295

11. Thiamin

1. The Significance of Thiamin	298
2. Properties of Thiamin	298
3. Sources of Thiamin	299
4. Absorption of Thiamin	301
5. Transport of Thiamin	302
6. Metabolism of Thiamin	303
7. Metabolic Functions of Thiamin	304
8. Biomarkers of Thiamin Status	308
9. Thiamin Deficiency	309
10. Role of Thiamin in Health and Disease	312
11. Thiamin Toxicity	313
12. Case Studies	313
13. Study Questions and Exercises	314
Recommended Reading	314

12. Riboflavin

1. The Significance of Riboflavin	316
2. Properties of Riboflavin	316
3. Sources of Riboflavin	317
4. Absorption of Riboflavin	318
5. Transport of Riboflavin	319
6. Metabolism of Riboflavin	320
7. Metabolic Functions of Riboflavin	322
8. Biomarkers of Riboflavin Status	323
9. Riboflavin Deficiency	323
10. Riboflavin in Health and Disease	327
11. Riboflavin Toxicity	328
12. Case Study	328
13. Study Questions and Exercises	329
Recommended Reading	329

13. Niacin

1. The Significance of Niacin	332
2. Properties of Niacin	332
3. Sources of Niacin	333
4. Absorption of Niacin	334
5. Transport of Niacin	335
6. Metabolism of Niacin	336
7. Metabolic Functions of Niacin	340

8. Biomarkers of Niacin Status	342	10. Pantothenic Acid in Health and Disease	396
9. Niacin Deficiency	343	11. Pantothenic Acid Toxicity	397
10. Niacin in Health and Disease	344	12. Case Study	397
11. Niacin Toxicity	348	13. Study Questions and Exercises	398
12. Case Study	348	Recommended Reading	398
13. Study Questions and Exercises	349		
Recommended Reading	349		
14. Vitamin B₆		17. Folate	
1. The Significance of Vitamin B ₆	352	1. The Significance of Folate	400
2. Properties of Vitamin B ₆	352	2. Properties of Folate	400
3. Sources of Vitamin B ₆	352	3. Sources of Folate	402
4. Absorption of Vitamin B ₆	353	4. Absorption of Folate	404
5. Transport of Vitamin B ₆	355	5. Transport of Folate	406
6. Metabolism of Vitamin B ₆	356	6. Metabolism of Folate	408
7. Metabolic Functions of Vitamin B ₆	358	7. Metabolic Functions of Folate	413
8. Biomarkers of Vitamin B ₆ Status	365	8. Biomarkers of Folate Status	419
9. Vitamin B ₆ Deficiency	366	9. Folate Deficiency	420
10. Vitamin B ₆ in Health and Disease	367	10. Folate in Health and Disease	425
11. Vitamin B ₆ Toxicity	369	11. Folate Toxicity	427
12. Case Studies	369	12. Case Study	427
13. Study Questions and Exercises	370	13. Study Questions and Exercises	428
Recommended Reading	370	Recommended Reading	428
15. Biotin		18. Vitamin B₁₂	
1. The Significance of Biotin	372	1. Significance of Vitamin B ₁₂	432
2. Properties of Biotin	372	2. Properties of Vitamin B ₁₂	432
3. Sources of Biotin	372	3. Sources of Vitamin B ₁₂	433
4. Absorption of Biotin	374	4. Absorption of Vitamin B ₁₂	435
5. Transport of Biotin	374	5. Transport of Vitamin B ₁₂	436
6. Metabolism of Biotin	376	6. Metabolism of Vitamin B ₁₂	439
7. Metabolic Functions of Biotin	376	7. Metabolic Functions of Vitamin B ₁₂	440
8. Biomarkers of Biotin Status	380	8. Biomarkers of Vitamin B ₁₂ Status	443
9. Biotin Deficiency	380	9. Vitamin B ₁₂ Deficiency	444
10. Biotin in Health and Disease	382	10. Vitamin B ₁₂ in Health and Disease	450
11. Biotin Toxicity	383	11. Vitamin B ₁₂ Toxicity	450
12. Case Study	383	12. Case Study	450
13. Study Questions and Exercises	384	13. Study Questions and Exercises	451
Recommended Reading	384	Recommended Reading	452
16. Pantothenic Acid		19. Vitamin-Like Factors	
1. The Significance of Pantothenic Acid	388	1. Is the List of Vitamins Complete?	454
2. Properties of Pantothenic Acid	388	2. Choline	455
3. Sources of Pantothenic Acid	388	3. Carnitine	462
4. Absorption of Pantothenic Acid	389	4. Myo-Inositol	469
5. Transport of Pantothenic Acid	390	5. Ubiquinones	474
6. Metabolism of Pantothenic Acid	391	6. Lipoic Acid	477
7. Metabolic Functions of Pantothenic Acid	393	7. Nonprovitamin A Carotenoids	480
8. Biomarkers of Pantothenic Acid Status	395	8. Flavonoids	487
9. Pantothenic Acid Deficiency	395	9. Orotic Acid	494
		10. Unidentified Factors	495
		11. Case Study	496
		12. Study Questions and Exercises	496
		Recommended Reading	497

Part III Using Current Knowledge of the Vitamins

20. Sources of the Vitamins

1. Vitamins in Foods and Feedstuffs	501
2. Vitamin Bioavailability	508
3. Vitamin Losses in Foods	509
4. Vitamin Fortification	511
5. Biofortification	513
6. Vitamin Labeling of Foods	516
7. Vitamins in Human Diets	517
8. Vitamin Supplementation	521
9. Vitamins in Livestock Feeding	523
10. Case Study	528
11. Study Questions and Exercises	530
Recommended Reading	530

21. Assessing Vitamin Status

1. Nutritional Assessment	531
2. Biomarkers of Vitamin Status	533

3. Vitamin Status of Human Populations	534
4. Global Undernutrition	541
5. Study Questions and Exercises	543
Recommended Reading	543

Appendix A: Current and Obsolete Designations of Vitamins (Bolded) and Other Vitamin-Like Factors	545
Appendix B: Original Reports for Case Studies	549
Appendix C: A Core of Current Vitamin Literature	551
Appendix D: Vitamin Contents of Foods (units per 100g Edible Portion)	559
Appendix E: Vitamin Contents of Feedstuffs (units per kg)	589
Index	593