TABLE OF CONTENTS – Applied Veterinary Clinical Nutrition, 2nd Edition

List of Contributors

Preface

Acknowledgments

1 Integration of Nutrition into Clinical Practice 1

Sean J. Delaney, Andrea J. Fascetti, Jennifer A. Larsen, and Paul Brentson

Introduction 1

Average Revenue from Food Sales and the Potential 1

Strategies to Increase Product Sales 2

Recommending an Effective Therapeutic Food 2

Establishing Expectations 2

Performing a Nutritional Assessment 3

Monitoring Patient Response 3

Providing a Variety of Options 3

Recommending Therapeutic Treats 4

Recommending Nutraceuticals and Dietary Supplements 4

Creating or Increasing Revenue from Nutritional Advice 4

Nutritional Advice for Healthy Patients 5

Nutritional Advice for Unhealthy Patients 7

References 7

2 Basic Nutrition Overview 8

Sean J. Delaney and Andrea J. Fascetti

Energy 8

Energy Requirements 9

Essential Nutrients 9 Protein and Amino Acids 10 Fat 12 Carbohydrates 13 Minerals 13 Macrominerals 13 Trace Minerals (Microminerals) 14 Vitamins 14 Water Soluble 14 Fat Soluble 14 Storage Pools for Essential Nutrients 15 Essential Nutrient Deficiency Signs and Clinically Available or Relevant Methods of Assessing Nutrient Status 15 Protein 16 Amino Acids 16 Arginine 16 Histidine 16 Isoleucine 16 Leucine 16 Lysine 16 Methionine (Spared by Cystine) 16 Phenylalanine (Spared by Tyrosine) 17 Threonine 17 Tryptophan 17 Valine 17

Taurine 17

Fat 17
Linoleic Acid 17
Arachidonic Acid (Cat, Not Dog) 18
Minerals 18
Macrominerals (Typically Required at 100 mg/Mcal) 18
Calcium 18
Phosphorus 18
Magnesium 18
Sodium 18
Potassium 18
Chloride 19
Microminerals (Typically Required at <100 mg/Mcal) 19
Iron 19
Copper 19
Zinc 19
Manganese 19
Selenium 19
lodine 19
Vitamins 20
Fat-Soluble Vitamins 20
Vitamin A 20
Vitamin d 20
Vitamin E 20
Vitamin K 20

Water-Soluble Vitamins 20

Thiamin, Vitamin B 1 20

Riboflavin, Vitamin B 2 21

Pyridoxine, Vitamin B 6 21

Niacin, Vitamin B 3 21

Pantothenic Acid, Vitamin B 5 21

Cobalamin, Vitamin B 12 21

Folic Acid, Vitamin B 9 22

Biotin, Vitamin H or B 7 22

Choline 22

Diagnostic and Food Analysis Laboratories and Diet Computer Analysis 25

Nutrient Requirements 25

Key Clinical Nutritional Excesses and Signs 26

Additional Education on Nutrition 27

References 27

3 Determining Energy Requirements 29

Jon J. Ramsey

Units 29

Basic Concepts and Terminology 30

Diet Records or History 32

Calculating the Energy Content of a Diet 33

Practical Equations for Predicting the Metabolizable Energy Content of Dog and Cat Foods 37

Calculating Energy Requirement from Body Weight 39

Methods of Determining Energy Expenditure and Energy Requirements 39

Methods of Calculating Energy Expenditure and Energy Requirements 42

Energy Requirements for Maintenance 42

Example Calculation 47

Example Calculation 48

Example Calculation 48

Energy Requirements for Growth 48

Example Calculation 50

Energy Requirements for Pregnancy and Lactation 51

Example Calculation 52

Calculating Energy Requirements in States of Disease 53

Summary 55

References 56

4 Nutritional and Energy Requirements for Performance 58

Richard C. Hill

How Much Should Exercising Dogs Be Fed? 58

Energy Requirements for Performance and Work 59

Types of Exercise and Nutrient Requirements 62

The Importance of Training 64

Nutritional Recommendations for Dogs Undertaking Different Types of Exercise 64

Long-Distance Submaximal Aerobic Exercise 65

Short-Distance Supramaximal Anaerobic Exercise 66

Fluid and Electrolyte Requirements, Hydration, and "Sports Drinks" 67

Antioxidants 68

Other Vitamins, Trace Minerals, and Other Essential Nutrients 68

Other Nutritional Supplements 68

Time of Feeding 69

Summary 69

5 Pet Food and Supplement Regulations: Practical Implications 72

David A. Dzanis and Isabel Marzo

US Regulation 72

US Regulation of Pet Foods and Supplements 72

Definitions, Abbreviations, and Acronyms 72

US Regulatory Oversight 73

General Labeling Requirements 74

Labeling Claims 77

Descriptive Terms 77

Supplements 78

Therapeutic Pet Foods 79

Dog Chews 83

Summary 83

European Union Regulation 83

Definitions, Abbreviations, and Acronyms 84

General Pet Food Regulations 85

Complementary Pet Food: Composition, Uses, and Labeling 86

Feed Additives 87

Claims 87

Labeling 87

Dietetic Pet Food 90

Practical Implications 95

Summary 96

6 Using Pet Food Labels and Product Guides 98

Sean J. Delaney and Andrea J. Fascetti

"Reading" a Pet Food Label 98

Overview of Regulatory Oversight 98

Principal Display Panel or Front Display Panel 98

Product Name 99

Back Panel 99

Nutritional Adequacy 100

Ingredient Declaration 100

Nutrient Concentrations or Guaranteed Analysis 101

Company's Contact Information 101

Feeding Directions or Guidelines 101

Calorie Content 101

Caloric Distribution Calculation 102

Using Product Brochures and Guides 103

Converting Nutrient Concentrations to a Dry Matter Basis 103

Converting Nutrient Concentrations to an Energy Basis 104

Converting to Other Units 104

Product Guide Recommendations for Conditions and Diseases 104

Summary 105

Recommended Resources 105

7 Feeding the Healthy Dog and Cat 106

Andrea J. Fascetti and Sean J. Delaney

Feeding the Healthy Dog and Cat 108

How Much to Feed 108

When and How to Feed 112

Free-Choice (Ad Libitum, Self-Feeding) 112

Time-Restricted Meal Feeding 113

Portion-Controlled Feeding 113

Snacks and Treats 113

Jerky Treats and Fanconi Syndrome in Dogs 115

What to Feed 116

Feeding Guidelines for Different Life Stages 117

Gestation and Lactation 117

Cats 117

Dogs 118

Supplementation during Gestation and Lactation 119

Assessment 119

Growth 119

Orphan Kittens and Puppies 119

Assessment 120

Weaning to Adult 120

Kittens 120

Puppies 120

Neutering and the Prevention of Weight Gain in Kittens and Puppies 121

Assessment 122

Adult Cats and Dogs 122

Assessment 122

Senior Dogs and Cats 122

Physiological Changes Associated with Aging 123

Nutrient Requirements of Older Pets 126

Feeding Recommendations for Mature Dogs and Cats 128

Summary 129

References 129

8 Commercial and Home-Prepared Diets 136

Andrea J. Fascetti and Sean J. Delaney

Introduction 136

Commercial Diets 136

Types of Pet Foods 136

Dry Food 136

Moist Foods 137

Semi-Moist Foods 137

Raw 138

Terminology 138

Market Segments 140

Commercial Dog and Cat Diet Formulation and Considerations 140

Ingredient Database Population 140

Ingredient Safety and Legality First 140

Ingredient Regulatory Considerations 141

Ingredient Availability and Cost 141

Establishing Reliable Nutrient Profiles for Ingredients 142

Ingredient Procurement 143

Sustainability 143

Consistency 143

Ingredient Declaration 144

Formulation Software 144

Options 144

Limitations 145

Equipment 145

Extruder 145

Canning/Retorting Line 146

Availability of Pilot Plant or Line 146

Guaranteed Analysis Target 146

Ingredient Declaration Order 147

Functionality 147

Shelf Life 147

Palatability 148

Least Cost 148

Stool Quality and Digestibility 149

Labeling 149

Continuous Improvement 149

Home-Prepared Diets 150

Nutritional Adequacy 150

Managing Patients Using Home-Prepared Diets 154

Protein and Amino Acids 154

Fatty Acids 155

Carbohydrates 156

Vitamin and Mineral Supplements 156

General Considerations 156

Assessment while on a Home-Prepared Diet 158

Raw Food Feeding 158

Summary 160

References 160

9 Nutritional Management of Body Weight 163

Kathryn E. Michel and Robert C. Backus

The Health Consequences of Overweightness and Obesity 164

Obesity as a Risk Factor for Canine Orthopedic Disease 164

Obesity as a Risk Factor for Feline Diabetes Mellitus 164

Additional Health Risks of Obesity in Dogs and Cats 165

Increasing Awareness of Overweightness and Obesity 165

Targeting Optimal Weight 166

Body Condition Scoring 166

Understanding the Risk Factors for Weight Gain 170

Accurate Accounting of Caloric Intake 171

Formulation of the Weight-Loss Plan 172

Dietary Considerations 173

Exercise 176

Tailoring the Program to the Patient 176

Assessment of the Weight-Loss Plan 177

Safety and Efficacy of Weight-Loss Programs for Companion Animals 177

Adjustment of the Weight-Loss Plan 178

Summary 180

References 180

10 Nutritional Management of Orthopedic Diseases 186

Herman Hazewinkel

Bone Composition and Calciotropic Hormones 186

Chemical Composition of Bone 187

Mineral Composition During Growth 188

Hormonal Regulation of Calcium 189

The Role of Nutrition During Skeletal Growth and Development 192

Energy 192

Calcium, Phosphorus, and Vitamin d 193

Calcium Deficiency 193

Phosphorus Deficiency 198

Vitamin D Deficiency (Rickets or Hypovitaminosis D) 198

Deficiency of Other Trace Minerals 201

Calcium Excess (Alimentary Hypercalcitoninism) 201

Vitamin D Excess 205

Vitamin A Excess 206

Nutrient Requirements for Skeletal Maintenance in Adult Animals 208

Implementation of Nutrition in Clinical Orthopedics 210

Influence of Nutrition in the Occurrence of Orthopedic Diseases 211

Elbow Dysplasias 211

Role of Nutrition in Elbow Dysplasias 212

Hip Dysplasia 213

Nutritional Influences Seen in Hip Dysplasia 214

Hypertrophic Osteodystrophy (or Metaphyseal Osteopathy) in Dogs 216

Prevention of Nutritionally Related Orthopedic Diseases 217

Diets to Support Treatment of Patients with Osteoarthrosis 218

Causative Role of Nutrition 219

Therapeutic Role of Nutrition 220

Osteoarthrosis in Cats 225

Summary 226

References 226

11 Nutritional Management of Gastrointestinal Diseases 235

Nick Cave, Sean J. Delaney, and Jennifer A. Larsen

Key Dietary Variables 235

Protein 235

Glutamine 236

Fat 236

Fiber and Prebiosis 237

Fiber Viscosity 239

Fiber as a Luminal Adsorbent 239

Fiber Fermentability 240

Effects of Short-Chain Volatile Fatty Acids on the Colon 240

Effects of Butyrate on Intestinal Immunity 241

Effect of Fiber on Intestinal Flora: Prebiosis 241

Choice of Fiber 242

Immune Response to Dietary Antigens (Oral Tolerance) 243

Immunologic Basis for Oral Tolerance 243

Loss of Tolerance to Dietary Antigens 244

Food Immunogenicity 245

Acute Gastrointestinal Disease 246

Withholding Food for Acute Non-specific Gastroenteritis 246

Provides Bowel Rest 247

Reduces the Risk of Vomiting 247

Decreases Bacterial Proliferation 248

Decreases Osmotic Diarrhea 248

Decreases Presence of Food Antigens 248

Benefits of Luminal Nutrition in Acute Gastroenteritis 248

Intestinal Recovery and Adaptation 249

Effect of Luminal Nutrients on Inflammation 249

Veterinary Evidence 251

Recommendations 252

Chronic Gastrointestinal Disease 254

Periodontal Disease 254

Periodontitis in Feral and Wild Animals 255

Evidence of the Protective Effect of Chewing Activities 255

Dental Diets 256

The Effect of Gingival Stimulation 257

The Influence of Diet on Saliva and the Flora 258

Recommendations 258

Esophageal Disease 259

Motility Disorders and Megaesophagus 259

Esophagitis 259

Small Intestinal Disease 261

Chronic Intestinal Inflammation and Idiopathic Enteropathy 261

Protein-Losing Enteropathies 270

Adverse Food Reactions and Food-Responsive Enteropathy 270

Short Bowel Syndrome 271

Large Intestinal Disease 273

Colitis 273

Acute Colitis 273

Chronic Colitis 274

Idiopathic Large-Bowel Diarrhea 275

Constipation and Megacolon 276

Intestinal Gas and Flatulence 277

Intestinal Gas Transit and Borborygmus 277

Flatulence 277

Summary 279

References 280

12 Nutritional Management of Exocrine Pancreatic Diseases 299

Cecilia Villaverde and Marta Hervera

Pancreatitis 300

Pathophysiology 301

Nutritional Management 302

Controversies Regarding Nutritional Management 302

When to Start Feeding in Acute Pancreatitis? 302

How Low Is a "Low-Fat" Diet? 303

Does Fat Have to Be Restricted in Canine Acute Pancreatitis? 304

How Important Is Fat Restriction in Feline Pancreatitis? 304

Dietary Management 304

When to Feed 305

Route of Feeding 305

Diet Selection 306

Energy Requirements 307

Long-Term Management 307

Foods to Avoid in Chronic Pancreatitis 308

Exocrine Pancreatic Insufficiency 309

Pathophysiology 309

Nutritional Management 310

Controversies Regarding Nutritional Management 310

Is a Low-Fat Diet Important for Management? 310

Are Medium-Chain Triglycerides Preferred over Long-Chain Triglycerides? 311

Dietary Management 311

Summary 313

References 313

13 Nutritional Management of Hepatobiliary Diseases 319

Stanley L. Marks and Aarti Kathrani

Metabolic Alterations in Liver Failure 319

Carbohydrate Metabolic Alterations 320

Protein and Amino Acid Metabolic Alterations 321

Lipid Metabolic Alterations 322

Vitamin and Mineral Abnormalities 322

Malnutrition in Liver Disease 324

Nutritional Management of Common Hepatobiliary Disorders 324

Feline Idiopathic Hepatic Lipidosis 325

Energy 325

Protein 326

Potassium 327

I-Carnitine 327

Cyanocobalamin/Vitamin B 12 328

Other Nutrient Considerations 328

Copper-Associated Hepatotoxicity in Dogs 328

Energy 329

Dietary Copper Restriction 329

Pharmacologic Reduction of Copper 330

Antioxidants 331

Portosystemic Shunts and Hepatic Encephalopathy 332

Dietary Protein 334

Nonabsorbable Disaccharides 335

Antimicrobials 336

Chronic Hepatitis 336

Summary 337

References 337

14 Nutritional Management of Skin Diseases 345

Catherine A. Outerbridge and Tammy J. Owens

Evaluation of Diet in the Context of Dermatologic Disease 345

Nutritional Deficiencies and Excesses 346

Protein 346

Essential Fatty Acids 348

Zinc 350

Zinc-Responsive Dermatoses 350

Zinc-Unresponsive Lethal Acrodermatitis in White Bull Terriers 353

Copper 354

Vitamin A 354

Vitamin E 355

Vitamin B Complex 356

Vitamin c 358

Generic Dog Food Dermatosis 358

Skin Diseases That Benefit from Nutritional or Dietary Management 359

Cutaneous Adverse Food Reactions 359

Clinical Signs 360

Diagnosis and Treatment 362

Cutaneous Xanthomatosis 366

Superficial Necrolytic Dermatitis 366

Clinical Presentation 369

Diagnosis and Treatment 371

Nutritional Supplementation for Management of Skin Disease 372

Fatty Acid Supplementation 372

Zinc Supplementation for Skin Disease 376

B Vitamin Supplementation 376

Vitamin A–Responsive Skin Diseases 376

Vitamin E–Responsive Skin Diseases 377

Therapeutic Diets for Skin Health 377

Summary 378

References 378

15 Nutritional Management of Kidney Disease 384

Yann Queau and Denise A. Elliott

Chronic Kidney Disease 384

Water 384

Energy 385

Protein 385

Stage I/II: Progression 385

Stage III/IV: Uremia 386

Phosphate 387

Electrolytes 389

Sodium 389

Potassium 390

Acid-Base Balance 391

Long-Chain Omega-3 Fatty Acids 392

Fiber 393

Antioxidants 393

Nutrients That Target the Endothelium 394

Clinical Efficacy 395

Administration 396

Concurrent Diseases 396

Home-Prepared Diets 397

Monitoring 397

Acute Kidney Injury 398

Glomerular Disease 400

Fanconi Syndrome 401

Conclusion 401

Summary 402

References 402

16 Nutritional Management of Lower Urinary Tract Disease 412

Joe Bartges and Ronald J. Corbee

Crystal-Related Lower Urinary Tract Disease 412

Urolithiasis 413

Calcium Oxalate 413

Struvite 420

Purines 423

Cystine 428

Compound Uroliths 429

Surgically and Minimally Invasive Management of Uroliths 430

Matrix-Crystalline Urethral Plugs 430

Idiopathic Cystitis 431

Urinary Tract Infections 432

Summary 433

References 433

17 Nutritional Management of Endocrine Diseases 441

Andrea J. Fascetti and Sean J. Delaney

Diabetes Mellitus 441

Nutritional Factors 441

Water 441

Energy 442

Fiber 442

Fat 444

Protein 444

Digestible Carbohydrates 444

Minerals and Vitamins 446

Food Type 447

Feeding Recommendations and Assessment 447

Hyperlipidemia 448

Classification and Etiology 448

Clinical Signs and Diagnosis 449

Management and Assessment 449

Hypothyroidism and Hyperadrenocorticism in Dogs 451

Dietary Hyperthyroidism in Dogs 452

Feline Hyperthyroidism and Idiopathic Hypercalcemia 453

Hyperthyroidism 453

Feline Idiopathic Hypercalcemia 454

Summary 455

References 455

18 Nutritional Management of Cardiovascular Diseases 461

Lisa M. Freeman and John E. Rush

Feeding the Cat with Cardiac Disease 461

Hypertrophic Cardiomyopathy 462

Dilated Cardiomyopathy 465

Hypertension 467

Feeding the Dog with Cardiac Disease 467

Asymptomatic Cardiac Disease (Myxomatous Mitral Valve Disease, Dilated Cardiomyopathy, or Other Cardiac Diseases; American College of Veterinary Internal Medicine [ACVIM] Stage B) 467

Mild to Moderate Congestive Heart Failure (ACVIM Stage C) 468

Cardiac Cachexia 468

n-3 Fatty Acids 471

Sodium 472

Potassium and Magnesium 472

Antioxidants 472

Arginine 473

Advanced Congestive Heart Failure (ACVIM Stage D) 473

Additional Supplements for Dogs with Cardiac Disease 474

Taurine 474

I-Carnitine 475

Coenzyme Q 10 475

Vitamin d 475

Hypertension 476

General Nutritional Issues for Dogs and Cats with Cardiac Disease 476

Summary 477

References 478

19 Nutritional Management of Oncologic Diseases 484

Glenna E. Mauldin

Cancer-Associated Malnutrition 484

Weight Loss and Cachexia in Humans with Cancer 484

Weight Loss and Cachexia in Cats and Dogs with Cancer 486

Obesity in Humans with Cancer 487

Obesity in Cats and Dogs with Cancer 489

Canine Mammary Tumors and Obesity 489

Nutritional Management of Cats and Dogs with Cancer 490

Energy 490

Calorie Sources 492

Protein and Amino Acids 493

Assisted Feeding 495

Other Nutrients for Cats and Dogs with Cancer 497

Omega-3 (n-3) Fatty Acids 497

Vitamin d 498

Antioxidants 500

Nutritional Fads 502

Supplements and Nutraceuticals 502

Feeding Raw Foods to Cats and Dogs with Cancer 503

Summary 503

20 Enteral Nutrition and Tube Feeding 515

Jennifer A. Larsen

The Case for Enteral Feeding 515

Nutritional Support of Veterinary Patients 515

When to Intervene 516

General Contraindications 518

Enteral Feeding Devices 519

Nasoenteral Feeding Tubes 519

Pharyngostomy Feeding Tubes 520

Esophagostomy Feeding Tubes 520

Gastrostomy Feeding Tubes 522

Jejunal Feeding Tubes 523

Beginning Enteral Feeding 525

Diet Choices 526

Immunomodulating Nutrients 527

Glutamine 529

Arginine 530

Other Nutrients 530

Calculation of Energy Requirements 531

Complications 531

Mechanical Complications 532

Metabolic Complications 534

Gastrointestinal Complications 535

Transitioning Patients to Voluntary Intake 537

Summary 537

21 Parenteral Nutrition 546

Sally C. Perea

History 546

Assessment of Nutritional Status and Patient Selection 547

Nomenclature 551

Determination of Administration Route 551

Catheter Selection and Placement 552

Parenteral Nutrition Components 553

Protein 553

Fat 555

Carbohydrate 556

Electrolytes and Trace Minerals 557

Vitamins 558

Energy Requirements 559

Formulation Calculations 560

Compounding 561

Initiating Parenteral Nutrition 562

Monitoring Guidelines 563

Complications 563

Metabolic Complications 563

Mechanical Complications 566

Septic Complications 567

Discontinuing Parenteral Nutrition 568

Summary 568

22 Abridged Clinical Nutrition Topics for Companion Avian Species 574

Elizabeth Koutsos and Brian Speer

Water 574

Clinical and Welfare Considerations Associated with Water 575

Energy 575

Sources of Energy 576

Clinical Issues Associated with Energy Imbalance: Obesity 576

Food-Based Enrichment 577

Amino Acids and Protein 578

Clinical Issues with Protein/Amino Acids 578

Essential Fatty Acids and Lipids 579

Clinical Issues Associated with Lipid Nutrition: Atherosclerosis 579

Vitamins 581

Clinical Issues Associated with Vitamin Nutrition 581

Minerals 582

Clinical Issues Associated with Mineral Nutrition 582

Other Clinical Nutrition Issues 583

Nutrition and Feather-Damaging Behaviors 583

Appropriate Diets for Birds and Their Role in Animal Well-Being 584

Conclusions 585

References 585

23 Nutrition for Small Mammalian Companion Herbivores and Carnivores 590 Jonathan Stockman and Olivia A. Petritz

General Nutrition for Small Mammalian Companion Herbivores 590

Lagomorphs (Rabbits) and Caviomorphs (Chinchillas and Guinea Pigs) 590

Gastrointestinal Physiology and Anatomic Features 591

Rabbit, Chinchilla, and Guinea Pig Normal Diet 592

Protein 592

Carbohydrate and Fiber 593

Hay and Other Plant Considerations 594

Fat 595

Vitamins and Minerals 595

Water 596

General Warning about Energy-Dense Foods and Treats 596

Nutrition-Related Diseases of Small Mammalian Companion Herbivores 597

Lagomorphs (Rabbits) and Caviomorphs (Chinchillas and Guinea Pigs) 597

Dental Disease and Malocclusion 597

Obesity 598

Gastrointestinal Stasis or Ileus 599

Urolithiasis 599

Critical Care Nutrition for Small Mammalian Companion Herbivores 600

Energy Calculations for Rabbits, Chinchillas, and Guinea Pigs 601

General Nutrition for Small Mammalian Carnivores 602

Ferrets 602

Digestive Physiology 602

Nutrition-Related Diseases of Small Mammalian Companion Carnivores 602

Ferrets and Considerations for Mink 602

Marine Food Sources: Hypovitaminosis E/Nutritional Steatitis, Thiamine Deficiency, and Salt Toxicity 602

Considerations for Mink 602

Nutrition-Related Diseases of Small Mammalian Carnivores 603

Ferrets 603

Obesity 603

Urolithiasis 603

Ferret Pancreatic Islet Beta-Cell Tumor (Insulinoma) 605

Inflammatory Bowel Disease 605

Critical Care Nutrition for Small Mammalian Companion Carnivores 606

Ferrets 606

References 606

Index 610.