

# Contents

Preface	vii
Acknowledgments	xi
<b>Chapter 1: A Nutritional <i>Conditio Humana</i></b>	<b>1</b>
A Few Glimpses on Biological Anthropology	1
An Early Venus and Breastfeeding: The Quest for Food and Sex as Driving Forces in Biology	1
Lady Europe's Liaison with a Bull: The Spread of Agriculture and Dairy Cultures	10
Basic Concepts on Eating	18
Raw Food for Thought	18
Thermodynamics Made Simple	20
Different Ways of Life	21
The Central Metabolic Pathway	23
A Few Words About ATP	25
<b>Chapter 2: Some Aspects of Nutritional Biochemistry</b>	<b>27</b>
The Central Carbon Pathway	27
Why is Glucose the Central Fuel Molecule?	27
Glycolysis	28
Variations on a Theme	30
Variant Glycolytic Intermediates	36
Lactate and Ethanol Fermentation: A Bit of Biotechnology	38
A Short Running Exercise	41
Liaison Dangereuse: Lactate, Cancer, and the Warburg Effect	42
Glucokinase at the Crossroad of Cellular Life and Death	44
Metabolic Networks	45
De Revolutionibus Orbium Metabolicorum	53
Revolutionary Histories	53
Mitochondria as Bacterial Endosymbionts	54

Pyruvate Dehydrogenase: The Linker Between Pathways	56
On the Value of Mutants	59
Why is the Citric Acid Cycle so Complicated?	60
The Horseshoe TCA Pathway	63
History Might Matter: An Argument on Chance and Necessity	66
Metabolic Crossroads in Ancient Landscapes: NAD or NADP—That’s the Question	70
The Logic and Adaptive Value of Metabolic Cycles	73
<b>Chapter 3: Bioenergetics</b>	<b>77</b>
Oxygen	77
The Origin of the Electrons and Biochemical Cycles: Anatomy of Complex II	77
Fumarate Reductase: The Dangers with Oxygen	81
The Handling of Molecular Oxygen	83
Social Feeding in Worms Explained by Oxygen Avoidance	88
Electrons	91
The Chemiosmotic Hypothesis	91
Anatomy of the Respiratory Chain	93
Cytochromes bc <sub>1</sub> and b <sub>6</sub> f: The Linkers in and between Respiration and Photosynthesis	98
Protons and ATP	101
Proton Pumping and O <sub>2</sub> Reduction	101
Purposeful Wastefulness	105
Fiat Lux	108
The Smallest Motor of the World	114
<b>Chapter 4: The Evolution of Eating Systems</b>	<b>121</b>
The Beginning of Biochemistry	121
A Soup as a Starter? The Origin of Biochemical Cycles	122
On Timescales in Biology	126
The RNA World	128
The Ribosome is a Ribozyme	131
Demise of the RNA World	133
Metabolic Control by Riboswitches	134
Let Others do the Job: Viral Relics of the RNA Worlds	136
Messengers from a Precellular DNA World?	139
The Importance of Being Lipid Enveloped	144
Early Eaters	147
What is at the Root?	147
Hydrogen and Bioenergetics	149
Methanogenesis	151
Methanotrophs	158
Sulfur Worlds	163

Metagenomics and the Strange Appetite of Bacteria	166
Nutritional Interactions	170
Hydrothermal Vents as a Cradle of Life?	174
A Photosynthetic Beginning of Cellular Life?	175
Photosynthesis	180
One Cell for all Seasons: The Nutritional Flexibility of Purple Nonsulfur Bacteria	180
Cyanobacteria and the Invention of Oxygenic Photosynthesis	187
Getting Closer to the Water-Splitting Center: Photosystem II	192
Evolutionary Patchwork: Photosystem I	197
Speculations on the Origin of Photosynthesis	200
The Impact of Oxygen on the Evolution of Metabolisms on Earth	201
The Acquisition of the Atoms of Life	204
The Easy Acquisitions: HOP	204
A Demanding Step: Photosynthetic CO <sub>2</sub> Fixation	208
Recycling in Biochemistry: Rubisco and the Calvin Cycle	213
Alternative CO <sub>2</sub> Pathways in Autotrophic Prokaryotes	217
A Few Numbers on the History of CO <sub>2</sub> Concentrations	218
A Tricky Business: N <sub>2</sub> Fixation	219
Nitrification	225
Closing of the Nitrogen Cycle by Anammox Bacteria	225
Plant Symbiosis for Nitrogen Fixation	227
Sulfur Uptake by Plants	231
Nutritional Interactions in the Ocean:	
The Microbial Perspective	233
Stromatolites and Biomats	233
Read my Lips: Cyanobacteria at the Ocean Surface	235
Problems with Nitrogen Fixation for Cyanobacteria	240
A World of Iron	243
Iron Age in Mythology	243
Another Problem in Cyanobacteria: Iron Limitation	244
Sowing the Sea with an Iron Plow: Where Feeding Impacts on Global Climate	245
Photosynthesis Versus Respiration in the Ocean: The Closing of the Carbon Cycle	250
The Most Abundant Cells on Earth are on a Small Diet	256
Depth Profile	259
Sediments	261
Early Steps in Predation	265
The Phage Way of Life: Bacterium Eaters	270

Phages in the Microbial Loop of the Food Chain	274
On Starvation, Sporulation, Cannibalism, and Antibiotics: Near Death Experiences	277
Increasing Complexity	282
The Birth of the Eukaryotic Cell	282
The Story of O and the Malnourished Ocean	290
Vita Minima: The Reductionist Lifestyle of Protist Parasites	292
Primary Endosymbiosis: The Origin of Chloroplasts	295
Predator Protozoa . . .	302
. . . And How Bacteria Get off the Hook	303
Algal Slaves	306
Diatoms and the Marine Food Chain, on Toxins and Armors, Art, and Purpose	309
Diatom Nutrition	319
Dinoflagellates	325
The First Animals	328
The Origins and the Sponges	328
The Ediacaran Fauna	336
Cnidarians: From Sea Pens and Different Feeding Habits . . .	342
. . . To Reef Bleaching as Expression of Their Dynamic Symbiotic Relationships	350
The Cambrian Revolution	358
Vertebrates	362
Toward Vertebrates: An Inconspicuous Beginning as Filter Feeders	362
The Middle Paleozoic Marine Revolution: A Story of Jaws and Teeth	370
Putting Four Feet on the Ground	380
Mesozoic Gigantism: The Crown of the Terrestrial Carnivores?	384
The Invention of the Egg, Brooding and Parental Care	395
Mammals: Not so Modest Beginnings?	403
Mammals: Seamless Nutrition	407
<b>Chapter 5: The Ecology of Eating Systems</b>	<b>419</b>
Eat or be Eaten: Anatomy of the Marine Food Chain	419
Overview	419
Algae and the Story of DMS	420
Copepods and Krill	423
Planktivorous Fish	428
Piscivorous Fish	433
Piscivorous Mammals	436

Killer Whales: Effect of a Top Predator	
Down the Food Chain	438
The Fall of the Whales	444
Life Histories Between the Land and the Sea	445
Nutritional Ecology	452
Trophic Cascades Across Ecosystems	452
The War of the Senses: The Example of Echolocation	455
Antipredation Strategies	462
Mimicry	467
Predator–Prey Cycles: From Chaos in the Food Web	
to Infectious Diseases	469
Toxic Predator–Prey Arms Races	477
Herbivory	485
Terra Firma—Bacteria and Plants Conquer the Land	486
Lignin Synthesis and Degradation	490
Taking to the Air: Early Insects	498
Early Herbivorous Vertebrates	509
A Bite of Plant Material by an Omnivore Like us	512
A Bioreactor Fueled by Grass	526
Plant Defense Against Herbivory	532
The Enemy of My Enemy is My Friend	541
Herbivores: Patterns of Predation	547
<b>Chapter 6: Eating Cultures</b>	<b>551</b>
Choosing Food	551
To Eat or Not to Eat	551
Food Separating Species	564
Behavior	568
Sharing Food and Other Goods: On Cheating	
and Altruism	568
Communicating on Food	577
Animal Technology	583
The Invention of Agriculture: Fungal Gardens of Ants	583
Tool Use and Caches in Crows	591
On Stone Tools and Culture in Apes	594
Human’s Progress?	599
The Diet of Australopithecus	599
From Hominid Stone Tools to the Control of Fire	602
Hunters and Gatherers: The Origin of Grandmother’s	
Recipe	608
On Neanderthals and Cannibalism	613
The Hobbit: Wanderer Between the Worlds	617
Late Pleistocene Megafauna Extinction: An Early	
Blitzkrieg?	619
The Spread of Early Agriculture	630

Domestication	633
The Garden of Eden: Domestication of Crops	633
Taming the Beast	647
Domestication of Moulds: <i>Aspergillus</i>	649
Fishery	651
Contemporary Fishery Problems	651
In Cod We Trust	652
History of Fishing	653
Aquaculture	658
The Lesson of the Lake Victoria	660
On Fishery, Bushmeat, and SARS	664
<b>Chapter 7: We as Food and Feeders</b>	<b>671</b>
Prey of Microbes	671
A Lion's Share?	671
The Haunted Hunter . . .	673
. . . And the Risks of Animal Farming	676
Problems of Food Safety: BSE	684
Going for our Blood	688
Real-life Draculas	688
Hitchhiking the Blood Sucker	692
Going for our Gut	698
The Land Where Milk and Honey Flows	698
The Thin Line Between Symbiont and Pathogen	706
Janus Faces: The Case of <i>Vibrio cholerae</i>	714
From Gut to Blood: The Battle for Iron	721
Viruses Going for Gut or Genome	727
Portrait of a Killer Virus	727
A Glimpse into the World of Retroelements	735
The Sense of Life	738
<b>Chapter 8: An Agro(-Eco)nomical Outlook: Feeding the Billions</b>	<b>743</b>
Malthus: Doomsday Versus Science and Technology?	743
From the Green Revolution to Organic Farming	748
From Biodiversity to the Wood Wide Web:	
On Rice and Grassland Productivity	753
The Rice Blast Fungus: A Threat to World	
Food Security?	759
Sowing Golden Rice in the Field?	763
A Story Without End?	770
References	775
Biochemical Back-ups	837
Index	849