Contents

| Ļ | The genomic architecture of eukaryotes | 1 |
|---|--|----|
| | Eukaryotic evolution | 1 |
| | Eukaryotes are chimeras | 1 |
| | OXPHOS and the electron transport system | 3 |
| | Massive genomic restructuring | 6 |
| | The mitochondrial genome | 9 |
| | The retention of a mt genome | 9 |
| | Co-location for redox regulation (CORR) | 10 |
| | The endpoint of gene transfer | 13 |
| | Characteristics of mitochondrial genomes | 15 |
| | Classes of genes and abbreviations | 18 |
| | Summary | 18 |
| 2 | Forms and consequences of incompatibility | 20 |
| | Oxidative phosphorylation via the electron | |
| | transport system | 20 |
| | Arenas of mitonuclear interaction | 24 |
| | Protein-protein interactions | 26 |
| | Protein–DNA interactions | 28 |
| | Protein-RNA interactions | 30 |
| | Anterograde and retrograde signals | 32 |
| | Evidence for mitonuclear coadaptation | 33 |
| | Cybrid cell lines | 34 |
| | Somatic cell nuclear transfer | 38 |
| | Hybrid backcrosses | 39 |
| | Hybrid crosses: Classic studies with <i>Tigriopus</i> copepods | 44 |
| | Within-species mitonuclear studies | 47 |
| | Summary | 48 |
| 3 | Compensatory coevolution | 49 |
| | Mutational erosion | 49 |
| | The problem with non-recombining genomes | 49 |

x • Contents

| | The mitonuclear compensatory coevolution hypothesis | 52 |
|---|---|----------|
| | Compensatory vs complementary coevolution | 52 |
| | Evidence for compensatory coevolution | 54 |
| | Evidence for N compensation for deleterious mt genes | 56 |
| | Experimental evidence of compensatory coevolution | 58 |
| | Patterns of mutation and selection in mt and N genomes | 59 |
| | Rates of evolutionary change among mt, N, and N-mt genes | 59 |
| | Alternative explanations for patterns in comparative data | 64 |
| | Whole-gene and whole-genome mechanisms of compensatory | |
| | coevolution | 68 |
| | Compensation through protein subunits | 68 |
| | Mitochondrial introgression as a compensatory | |
| | mechanism | 72 |
| | Summary | 75 |
| 4 | Coevolution, co-transmission, and conflict | 77 |
| | Co-transmission and coevolution | 78 |
| | | 78 |
| | The tradeoff between co-transmission and evolability Sex chromosomes | 70 80 |
| | | 80 81 |
| | Sex linkage and co-transmission Genomic conflict | |
| | | 86 |
| | Nuclear restorer genes Which distates substration constantion on conflict? | 91 |
| | Which dictates eukaryotic evolution: Cooperation or conflict? Within-individual conflict: Mito vs mito | 92 |
| | | 92 |
| | Endosymbionts | 93 |
| | Conflict arising from third genomes | 93 |
| | Summary | 94 |
| 5 | The evolution of sex and two sexes | 96 |
| | The evolution of sex | 97 |
| | The necessity of recombination | 97 |
| | The evolution of sex in light of mitochondrial evolution | 100 |
| | Avoiding mutational meltdown | 104 |
| | The evolution of two sexes | 106 |
| | The evolution of anisogamy | 106 |
| | Anisogamy, mating types, and mitochondrial inheritance | 110 |
| | Genomic conflict within an individual | 110 |
| | Selection against heteroplasmy and selection for | |
| | mitonuclear coadaptation | 112 |
| | Conflict versus coadaptation | 115 |
| | Summary | 115 |
| | | |

| 6 | Life eternal in the face of senescence | 117 |
|---|---|-----|
| | mt DNA mutation | 119 |
| | What underlies mutations in the mt genome? | 119 |
| | The evolution of germ lines | 121 |
| | Strong selection on germ cells before proliferation and atresia | 121 |
| | Strong selection on germ cells after proliferation and atresia | 125 |
| | Why plants and most other eukaryotes don't have a germ line | 126 |
| | Selection on the male germ line | 131 |
| | Selection across developmental stages | 132 |
| | Evolution of senescence | 133 |
| | Antagonistic pleiotropy | 133 |
| | The mitochondrial theory of aging | 135 |
| | The free radical theory of aging | 136 |
| | The replication error theory of aging | 138 |
| | Apoptotic threshold | 140 |
| | Summary | 141 |
| 7 | Mitonuclear speciation | 143 |
| | Traditional species concepts | 144 |
| | Speciation fundamentals: Dobzhansky-Muller incompatibility | 146 |
| | The mitonuclear compatibility species concept | 151 |
| | Mitonuclear coevolution when gene flow is disrupted | 151 |
| | mt DNA barcodes as evidence for mitonuclear speciation | 155 |
| | Mitonuclear speciation driven by mitochondrial-based adaptation | 158 |
| | Mitonuclear interactions and gene flow | 160 |
| | Allele dominance and introgression of mt and N genes | 160 |
| | Sex linkage and speciation | 166 |
| | Effects of sex linkage on mitonuclear gene interactions | 166 |
| | Darwin's corollary to Haldane's rule | 169 |
| | What does mitochondrial introgression mean for speciation? | 171 |
| | Other potential drivers of mt introgression | 173 |
| | Cytoplasmically inherited bacteria | 173 |
| | Co-introgression of coadapted mt and N-mt genes | 173 |
| | A unified concept of species | 177 |
| | Summary | 178 |
| 8 | Mitonuclear mate choice | 179 |
| | Mate choice basics | 180 |
| | Choice for shared mt genotype | 184 |
| | The mitonuclear compatibility hypothesis of sexual selection | 184 |
| | Ornamentation gaps coincide with barcode gaps | 185 |
| | | |

| Sex linkage and sexual selection | 187 |
|---|-----|
| ZW sex determination and ornamentation | 187 |
| Linkage of ornamental traits | 189 |
| Assessment within species | 391 |
| Signals of mitochondrial function | 193 |
| Species-typical vs condition-dependent ornamentation | 194 |
| Carotenoid coloration in birds as a signal of mitochondrial function | 196 |
| Summary | 197 |
| 9 Adaptation and adaptive radiation | 199 |
| Environments to which mitochondrial adaptation is responsive | 200 |
| Mechanisms for mitonuclear adaptation | 202 |
| Mechanisms of thermal adaptation | 202 |
| Mechanism of adaptation to partial pressure of oxygen | 209 |
| Mechanisms of adaptation to diet | 212 |
| Mechanisms of adaptation to salt and hydrogen sulfide | 213 |
| The next generation of studies of functional mitochondrial adaptation | 214 |
| Evidence for adaptive evolution of mt and N-mt genes | 216 |
| Adaptation arising from standing variation in mt genotypes | 216 |
| Adaptive divergence at species boundaries | 229 |
| Adaptation via mitochondrial introgression | 234 |
| Signatures of adaptive evolution | 235 |
| Adaptive radiation via mt evolution | 236 |
| Human mt genotypes and environment | 241 |
| Summary | 242 |
| 10 Epilogue | 244 |
| | |

| References | 249 |
|------------|-----|
| Index | 295 |