Index

3-hydroxypropionate bi-cycle, 3, 21, 25-26, 34 absorption coefficient, 117, 124, 141 Acaryochloris, 5, 27, 128 acclimation to elevated pCO₂, 304 to fluctuating light, 127 to hydrodynamic environment, 89 to light intensity, 124 to light quality, 121 to nutrient availability, 158, 347 to salinity, 196, 198-201, 203 to temperature, 137-138, 141, 145 to UV radiation, 326, 331 Acetabularia, 82, 201 acid mine drainage, 274 Acidobacteria, 5, 22, 24-25 photochemical reaction centre, 23 acidophiles, 273-274 adaptation in diazotrophs, 155 to desiccation, 219 to elevated pCO₂, 304 to extreme environments, 277 to pollutants, 261, 264 to salinity, 196, 204 to temperature, 138, 145, 305 ADP (adenosine diphosphate), 4, 27, 156 Advanced Integrated Wastewater Pond System, 372 affinity for CO2, 8, 103, 139, 299, 303 agar, 369 Akashiwo, 329 akinetes, 80 Alexandrium red tides, 354 algal blooms, 352, 355 alginate, 89, 218, 374 Alismatales, 33-34, 99 alkaline phosphatase, 158 alkaliphiles, 275 alkali-tolerance, 275 allelopathy, 243 allochthonous organic carbon, 155

allophanate, 163 alpha-cyanobacteria, 28, 31 alternative electron cycling, 141 altritol, 202 Alveolata, 31, 34, 70, 282 amelioration strategy, 101 ammonia, 54, 154, 164, 215 ammonium, 87-88, 154-155, 164, 215-216, 236.346 Anabaena, 7, 155, 257, 259, 261 and UV radiation, 325 anaerobic anoxygenic photosynthetic bacteria, 22, 27 anammox, 155, 164 anaplerotic C fixation, 159 anaplerotic β -carboxylation reactions, 47 angiosperms, 33, 97-99, 280, 296 animal feed from algae, 375 anoxygenic, 26 anoxygenic photosynthesis, 6, 10, 22 Antarctic algae and salinity, 198, 201 and temperature, 138, 142 and UV radiation, 327 Anthocerotophyta, 97 antibodies from algae, 372 antioxidants from algae, 370 and desiccation, 217 and UV radiation, 321 Aphanizomenon, 342 aquaculture use of algae in, 369, 375 and nutrient inputs, 349-351 aquaporins, 47, 199 aragonite, 277, 300-301 Archean photoautotrophs, 5, 11, 295 Archaeoellipsoides, 81 Archaeplastida, ix, 21, 30, 33-34, 66-67 genome, 68 Archean, 54 and CO₂, 7 and evolution of photosynthesis, 21-22 and metal availability, 7

More Information

| 388 | Index |
|-----|--------|
| 000 | IIIUGA |

Arctic and Azolla blooms, 280 Arthrospira, 369 articulated coralline algae, 89 ascorbate, 217, 321 ascorbate peroxidase, 126, 263, 278, 321 Asparagopsis, 88, 375 ATP (adenosine triphosphate), 159 cost of osmoregulation, 201 requirement for carbon fixation, 25-26 requirement of nitrogen assimilation, 161 requirement of nitrogenase, 155 ATP synthase, 3, 264 H⁺ ATP synthase, 8, 25, 27–28, 30, 118 Na⁺ ATP synthase, 27 ATPase, 3, 48, 200 and Ca2+ efflux, 277 and HCO3⁻ uptake, 104 ATP-urea amidolyase, 163 auracyanin, 24 aureochrome, 121 Aureococcus, 167 autotrophy, 12 Auxenochlorella, 371 avoidance strategy, 103 Avrainvillea, 86 Azolla, 280 Bacillariophyceae, 71 acidophiles, 274 fossils, 32, 296 as prey, 282 hacteria gene transfer from, 66, 68 in aquatic food webs, 344 and phosphate supply, 165 photosynthetic, 1, 4-6 as prey for mixoplankton, 238 bacteriochlorophyll, 5, 23-24 Bangiomorpha, 30, 32, 82-84 Bangiophyceae, 67, 83-84 basal dinoflagellates Form II Rubisco, 8, 71 light-harvesting, 31, 120 in symbioses, 70 Benson-Calvin-Bassham cycle, 1, 8, 12, 21, 25-26, 28-31, 34, 118, 237, 324 benthic algae, 29, 32, 87 benthic mats, 26 beta-cyanobacteria, 30-31, 46, 48, 52, 67, 72 bicarbonate, 100 use by aquatic embryophytes, 103, 104 equilibria, 50, 296 transport, 48-49, 51 bicarbonate use, 103-105, 299 by aquatic embryophytes, 103 bioactive compounds, 372 biofuels, 374

biological pump, 10, 328 biological soil crusts, 275 bioplastics, 370, 372 bioremediation, 252-253, 261 Black Sea, 25-26, 241 blue light receptor, 121 Bolidophyceae, 71 borers, 277 boring billion, 9, 29 Bostrychia, 203, 205 bottom-up pressure, 242-243 bromocarbon, 218 Bryophyta, 33-34, 97, 276, 281, 342 bryophytes absence of bicarbonate use, 103 Bryopsidales, 86 C₃-C₄ intermediate C assimilation, 47 C₄ photosynthesis, 47, 101-102, 105 cadmium, 262, 348 and CA activity, 348 calcification, 72, 89, 277, 299, 301 calcite, 84, 277, 300 calcium, 275, 342 calcium carbonate, 89, 104, 277, 300 and borers, 277 saturation state, Ω , 300 Caloglossa, 203-204 Calvin-Benson-Bassham cycle. See Benson-Calvin-Bassham cycle Cambrian, 67, 72, 86, 97 oxygenation, 29 canopy boundary layer, 87 carbon isotope fractionation, 3, 10 carbonate δ^{13} C values, 3 equilibria in water, 100, 296 carbonic acid, 296 carbonic anhydrase (CA) α-CA, 50, 104 β-CA, 50 and CCM activity, 49 δ-CA, 50 external CA, 50 δ-CA, 48 in embryophytes, 104 1-CA, 7 metal free CA, 7 ζ-CA, 50 Carboniferous and CCM evolution, 53 CO2 level, 9 and sulphate level, 54 carboxysomes, 49 carotenes, 217 and energy dissipation, 321 carotenoids B-carotene, 369

More Information

Index

389

diadinoxanthin, 125 diatoxanthin, 126 fucoxanthin, 371 as high-value compounds, 370 in light-harvesting, 120 in photoprotection, 319, 321 lutein, 126, 371 peridinin, 31 violaxanthin, 126 zeaxanthin, 126, 371 carposporophytes, 84 carrageenan, 89, 369 catalase, 144, 217, 263, 278, 321 catchments and CO₂ concentrations, 104 and nutrient inputs, 343-344, 349 and salinity, 195 as sources of organic C, 296, 298 Caulerpa, 32, 82, 86, 88 evolution, 296 and Na⁺, 200 and nutrients, 173 CCM. See CO₂ concentrating mechanisms cell size and light-harvesting, 32, 124 and nutrient uptake, 152, 242 and temperature, 137 and UV radiation effects, 318 cell surface area and resource acquisition, 232, 236 cell volume allocation for phototrophy + phagotrophy, 234 changes with salinity, 204 and light-harvesting, 9 cell wall calcification, 89 composition in seaweeds, 89 and desiccation, 218 and external carbonic anhydrase, 50 plasticity under osmotic variability, 204 Si in diatoms, 168 Ceratophyllum nutrient acquisition, 342 Chaetoceros symbiosis with cyanobacteria, 281 UV radiation effects, 328 Chara nutrient uptake, 173 phytochrome, 123 Charophyceae, 67, 168 evolutionary origin, 72 multicellularity, 82 Charophyta and embryophyte evolution, 97 evolutionary origin, 295 chemiosmotic adenosine triphosphate (ATP) synthesis, 3

chemocline in the Black Sea, 25 and sulfide-oxidising bacteria, 26 chemolithotrophic, 3 chemolithotrophs, 5 chemolithotrophy, 1 Chlamvdomonas acclimation to nutrient availability, 165 bicarbonate transporter, 51 CO₂ concentrating mechanism, 49-50 cold acclimation, 138 DNA repair, 320 external CA, 50 Rubisco, 53 Chlorarachniophyceae, 69 Chlorarachniophyta, 21 from secondary endosymbiosis, 34 chlorarachniophyte light-harvesting, 31 Chlorobi, 5, 21 carbon fixation, 25 electron transport, 4 inorganic electron donors, 26 photosynthetic electron transport, 24 photosynthetic reaction centres, 23 Chloroflexi carbon fixation, 25 inorganic electron donors, 26 photosynthetic electron transport, 23-24 photosynthetic reaction centres, 21, 23 Chlorophyceae, 67 CO2 concentrating mechanisms, 50 evolutionary origin, 296 chlorophyll in Alveolata, 70 chlorophyll a, 5, 27 as an index of phytoplankton biomass, 347 chlorophyll b, 27 in Archaeplastida, 67 chlorophyll c, 27 chlorophyll c2, 71 chlorophyll d, 5, 27 chlorophyll f, 27 chlorophyll fluorometry, 213 chlorophylls light absorption, 119 Chlorophyta, 21, 34 chloroplast envelope and Ci transport, 49-50 membranes, 51 chlorosomes, 24 Chondrus, 217 as food, 369 Chromatiales carbon fixation, 25 photosynthetic electron transport, 4 chromatic acclimation, 128

More Information

Chromera in corals, 282 pigments, 31 chromerids, 21 chloroplast envelope membranes, 70 Rubisco, 31, 46 Chromerophyceae, 70 chronic inhibition of photosynthesis by UV radiation, 318 chrysophytes as mixophytes, 238 ciliates as hosts in symbioses, 67, 282 in kleptoplastidy, 282 in mixoplankton, 238, 243 Cl⁻ ATPase, 201 climate change, 295 Cnidaria, 67, 70 as hosts in symbioses, 281 CO₂ diffusion, 50 equilibria in water, 296 and evolution of CCMs, 52 fixation and the origin of photosynthesis, 4, 7 and kinetics of Rubisco, 43, 46 leakage, 48, 50 levels through geological time, 9, 295 predicted future changes, 297 and Rubisco kinetics, 8 through geological time, 2 in water, 100 CO2 assimilation, 3 in anoxygenic photolithotrophic bacteria, 25 in chemolithotrophs, 3 in cvanobacteria. 28 effects of temperature, 303 energy cost, 45 pathways, 26 CO2 concentrating mechanisms, 47 cellular location, 48, 50 distribution among algae, 52 energy cost, 45 evolution, 52 regulation, 53 CO2 diffusion, 52 CO2 to O2 ratio and CCM regulation, 53 and Rubisco activity, 53 cobalt and CA activity, 348 coccolithophores calcification, 300-301 carbonic anhydrase, 348 evolution, 30, 32 fossil record, 72 in mixoplankton, 239 Si requirement, 157

Coccomvxa and CCM activity, 52 and radiation tolerance, 278 as a source of lutein, 371 Codium, 82 desiccation tolerance, 210 nitrate uptake, 173 sulphate as an osmolyte, 201 Coleochaetophyceae multicellularity, 82 co-limitation of nutrients, 154, 347 colonial Charophyceae, 67 definition of, 81 combined nitrogen loss 155 and N₂ fixation, 156 from remineralisation, 155 supply from cyanobionts, 281 yearly production in oceans, 151 compatible solute. See organic osmolytes constitutive mixoplankton (CM), 228, 236, 244 copper (Cu), 262 availability in the Archean, 7 in auracyanin, 24 coral effect of nutrient enrichment, 352 effect of ocean acidification, 299 symbiotic algae, 128, 281-282 and temperature, 136, 144 Corallinales fossil record, 84 coralline algae and diversification of coralline algae, 84 coralline red algae effect of ocean acidification, 299-300, 302 cosmeceuticals from algae, 372 Crassula CAM metabolism, 102-103 Crassulacean acid metabolism (CAM), 102 in aquatic plants, 102 Crocosphaera, 155 N2 fixation, 342 P_i transporters, 166 symbiosis with diatoms, 281 crop protection by algal extracts, 375 crustose coralline algae growth at low light, 33 origins, 89 Cryogenian, 11, 29 green algae persistence, 85 cryptochrome, 121 Cryptonemia and nutrients, 173

More Information

Index

391

Cryptophyta, 21, 71 Form ID Rubisco, 31, 46 light-harvesting in, 31 phycobilins in, 31 pigments, 31 plastid origins, 31 cuticle in aquatic plants, 33, 99 cvanate transporter, 163 cyanelle, 66 Cyanidiophytina, 67 Cyanidioschyzon, 273 Cyanidium, 273 cyanobacteria, 21, 29 in acidic lakes, 274 in biological soil crusts, 275-276 carbonic anhydrase, 49 chromatic acclimation, 121 Ci transport, 48 in endosymbiosis, 66 epizoic growth, 278 at extreme temperatures, 273 evolution of CCMs, 8 evolutionary origin of CCMs, 53 Fe requirement, 7 and global change, 302-303 glycolate metabolism, 45 in lichens, 279 light-harvesting, 119 multicellularity, 80 N₂ fixation, 154, 156, 342 nitrogen regulator gene, 161 orange carotenoid protein, 126 as original oxygenic photolithotrophs, ix origins, 5 oxygenic photosynthesis, 27 photosynthetic electron transport, 27 phytochromes, 123 P_i transporters, 166 P_i uptake, 165 Rubisco, 28 Rubisco kinetics, 46 in soda lakes, 275 as source of bioplastics, 371 state transitions, 127 in symbioses with vascular plants, 280 thylakoids, 9 toxins, 354 and UV radiation, 331 Cyanothece N₂ fixation, 155 cyclic electron transport, 4, 21, 23, 28, 118, 141 under desiccation, 214 cyclobutane pyrimidine dimers (CPDs), 318 Cylindrospermopsis, 300 cytochrome b₆fFe_{nh}, 4-5, 28-29, 117-118

cytochrome bcFenh, 4 cytochrome c, 23 cytochrome c₆, 5, 7, 117 cytoplasmic streaming, 88, 169 D1 protein effect of herbicides, 254 and UV radiation, 318, 320 Dasycladales fossil record, 86 DDT 255 dehydration under hypersaline stress, 196 and thermal tolerance, 212 Deinostema CAM metabolism 102 denitrification, 151, 154-155 and nitrogen loss, 350 under rising O2 levels, 54 deoxygenation and phosphate release, 346 desiccation, 209 and community composition, 209 effects on photosynthesis and respiration, 212 morphological changes, 209 and nutrient acquisition, 215 recovery, 213 and respiration, 212 tolerance, 210, 213 Desmidiales sexual reproduction, 72 Desmodesmus as a source of lutein, 371 diazotrophy. See nitrogen fixation diffusion uptake of CO2, 47 diffusion boundary layer (DBL), 87 and cell size, 32 and water movement, 32 digeneaside, 203 as an organic osmolyte, 203 dimethylsulphoniopropionate (DMSP), 202 under N limitation, 55 Dimorphosiphon fossil record, 86 dinoflagellates, 21 CCMs in, 239 evolution, 30 and kleptoplastidy, 282 mixoplankton, 230, 233 nitrate reductase, 163 pigments, 70 plastid membranes, 70 red tides, 354 Rubisco, 46 Dinophyceae, 70 fossils, 296

More Information

392

Index

| Dinophysis, 234, 237 | origin of Paulinella, 21 |
|---|--|
| diquat, 254 | origin of photosynthetic eukaryotes, 21 |
| Discosporangiales, 86 | origin of 'red line' of algae, 21 |
| dissolved inorganic carbon (DIC) | secondary and tertiary endosymbiosis, 68, 70 |
| under global change, 297 | timing of primary endosymbiosis, 66 |
| in water, 100 | endosymbiotic specialist non-constitutive |
| diuron | mixoplankton (eSNCM), 228 |
| inhibition of photosynthesis, 254 | energy cost |
| divergence time | of acid-base regulation, 301 |
| of algal evolution, 81 | Benson-Calvin-Bassham cycle, 26 |
| divinyl-chlorophyll, 117 | carbon fixation in Chlorobium, 4 |
| DNA lesions | energy dissipation |
| repair, 320 | via quenching, 126 |
| under UV radiation, 320 | and redox state of plastoquinone, 125 |
| Dolichospermum | via the xanthophyll cycle in diatoms, 126 |
| N_2 fixation 342 | engulfment, 232 |
| toxins 354 | Eremiobacterota, 22, 25 |
| dulcitol | Esthwaite Water 349 |
| as an organic osmolyte 203 | nutrient enrichment 350 |
| Dunaliella | evendolithic evanobacteria and algae 277 |
| and β carotene production 360 | Fuelona |
| CCM activity 50, 202 | D untaka 165 |
| salinity tolerance 107 | r_i uptake, 105 |
| Duringhia 70 | Euglenenbucese 60 |
| dunamia inhibition | acidarbilas 274 |
| af photosynthesis by UV rediction 218 | actuophiles, 274 |
| of photosynthesis by U v radiation, 318 | File Light Receptor in, 121 |
| | Euglenophyta, 21, 34 |
| Ecklonia | euglyphid amoeba |
| morphological plasticity, 88 | and origin of <i>Paulinella</i> , 34 |
| Ediacaran, 72 | Eukarya |
| diversification of metazoans, 90 | age of origin, 73 |
| effective photochemical quantum yield, 318, 324 | Eurhodophytina, 67 |
| Egeria | Eustigmatophyceae, 71 |
| C_4 photosynthesis, 102 | light-harvesting pigments, 31 |
| egestion of plastids by mixoplankton, 237 | Eutreptia, 70 |
| elasticity | Eutreptiella, 70 |
| of algal thalli, 89 | eutrophication |
| electron transport rate | and light quality, 117 |
| estimation by chlorophyll fluorometry, 213 | microalgae, 159 |
| inhibition by UV radiation, 318 | and N_2 fixation, 343 |
| elevated CO ₂ | and wastewater treatment, 355 |
| and CCM downregulation, 51 | excision repair, 320 |
| effects on calcification, 301 | exhabitant, 66, 68 |
| effects on photosynthesis and growth, 298 | in endosymbiosis, 65 |
| evolutionary changes, 304 | Paulinella, 67 |
| shifts in populations, 302 | exploitation strategy, 101, 103 |
| Elodea, 104 | expressed sequence tags (ESTs), 144 |
| root uptake of nutrients, 172 | external carbonic anhydrase, 48 |
| embryophytes | extrinsic light-harvesting complexes, 119 |
| and evanobionts 280 | |
| emerging pollutants 373 | faint young Sun 1 |
| emersion | Fe availability 7 155 |
| and macroalgae 211 | Ee^{2+} oxidation 5 10 23 28 |
| Emiliania | feeding net phagotrophy 232 |
| Linutuntu | recome net phagou opity, 202 |

as mixoplankton, 241

endosymbiosis, ix, 30-31

under elevated CO₂, 299

More Information

Index

393

fertilisers, 350 Firmicutes, 22, 25 fitness, 227, 240-241, 245 flatworm symbiosis with algae, 282 flavodiiron, 126-127 flavodoxin, 5, 7, 29, 157 Florideophyceae, 83 origins, 84 Florideophytes, 84 floridoside, 203, 218 fluctuating light, 127 food web, 344, 355 and toxicants, 252, 258 and UV radiation, 332 fossil calibration, 74, 84-86 fossil record diatoms, 72 macroalgae, 82 of marine eukaryotic algae, 32 Fragilidium, 238 Framvaren Fjord, 26 free radicals detoxification, 320 production under desiccation, 216 scavenging by phlorotannins, 322 scavenging by polyphenols, 321 fructose-1,6-bisphosphatase, 144 frustules abnormalities and herbicides, 254 in biotechnology, 375 and hydrocarbons, 261 in sediments, 349 and Si, 157 and Si transporters, 168 Fucales fossils, 86 nutrient acquisition, 87 organic osmolytes, 202 fucoxanthin, 31, 70-71, 120, 321, 371 in biotechnology, 369-370 Fucus and desiccation, 210-212 desiccation and antioxidants, 217 desiccation and nutrient loss, 215 and emersion, 213 and nutrient acquisition, 172 and salinity, 204 fungi in aquatic food webs, 344 in lichens, 276 and symbiotic algae, 67 Galdieria, 273

GDP-mannose dehydrogenase, 218 Gemmatimonadotes, 22–23 photochemical reaction centre, 23 glaciations, 2, 10-11, 53, 85 Glaucocystophyta, 66 Glaucophyta, 21, 30, 34, 67, 71, 73, 295 Fe requirement, 7 Global Oxidation Event. See Great Oxidation event global warming, 55, 90, 136, 154, 174, 325 and cell size, 303 and desiccation, 211 and salinity change, 194 and stratification of upper mixed layer, 297 and ultraviolet radiation, 304 and ultraviolet radiation stress, 325 Gloeobacter, 8-9, 28, 296 Gloeomargarita, 29-30, 65 Gloeotrichia, 342 glutamine synthetase, 161, 163, 216, 261 glutamine-2-oxoglutarate amidotransferase. See GOGAT glutathione, 156, 217, 264 glutathione peroxidase, 144, 321 glutathione reductase, 144, 217, 321 glycine betaine, 55, 143, 156 glycolate metabolism, 44-45 glycolipids, 157 glyoxalase, 218 glyoxylate, 44-45 **GOGAT**, 163 Gracilaria, 143, 211, 215, 218, 329 as source of carrageenan, 369 Graticula, 85 grazers, 85, 90 in mixoplankton, 234, 238, 243 Great Acceleration, 350 Great Oxidation Event, ix, 1, 5, 7, 9, 23, 43, 66.295 green tides, 354 greenhouse effect, 1-2, 9, 295, 301-303 growth rate potential, 232-233, 235, 236-240, 245 Grypania, 83 Gunnera-Nostoc symbiosis, 280 Haber-Bosch process, 350 haem proteins in N acquisition, 157 Haematococcus in astaxanthin production, 369 ionising radiation tolerance, 278 Halimeda, 82, 86 calcification, 300 Halimedineae, 86 Halodule, 99 Halophila, 99 N acquisition, 170 Halysis, 85

394

Index

Cambridge University Press & Assessment 978-0-521-82298-5 — Evolutionary Physiology of Algae and Aquatic Plants Mario Giordano , John Beardall , John A. Raven , Stephen C. Maberly Index More Information

Hapalidiales, 84 hydrothermal vents, 3-6, 194 Haptophyta, 21, 32, 34, 71 hypersalinity, 195 attached to substrate, 168 ion extrusion, 200 Form ID Rubisco, 31, 46 and plasmolysis, 204 fucoxanthin, 371 stress, 196 light-harvesting in, 31 water efflux, 199 light-harvesting pigments, 31 Нурпеа origins, 72 N acquisition, 173 plastid origins, 31 hystrichospheres, 72 haptophytic embryophytes, 96 heat shock proteins, 143, 275 ice ages, 9, 85 ice algae, 136, 144, 273-274 heat-protective compounds, 143 heavy metals, 262, 346 ice cover, 326 biosorption by algae, 264 and irradiance, 326, 346 and UV radiation, 315 removal from water, 263 tolerance, 156 ice-binding proteins (IBPs), 274 toxicity, 252, 263 immature ecosystems, 240 Heliobacteria, 5, 22 r-select organisms, 241 inhabitants photochemical reaction centre, 23 helmchrome, 122-123 in ciliates, 67 Hemiaulus, 281 in endosymbioses, 68, 70 as host of endosymbiotic cyanobacteria, 155 in endosymbiosis, 65 herbicides gene duplication, 66 toxicity to algae, 253-254 loss of genes, 66 herbivory insecticides and evolution of coralline algae, 89 toxicity to algae, 253-254 of macroalgae, 211 intercellular gas space, 33 heterocysts, 80, 155, 280, 343 intrinsic light-harvesting chlorophyll protein heterotrophy, 11, 228, 238-239 complexes, 119 High Rate Algal Ponds (HRAP), 372 ionising radiation, 278 high-speed jumping ion-pumping rhodopsin, 9, 27, 123, 228 iron, ix, 26, 43, 118, 154, 262, 344, 346 and nutrient uptake, 244 high-nutrient, low-chlorophyll (HNLC) fertilisation, 348 regions, 154 limitation, 125 irradiance, 116

holdfasts, 32, 82, 168 homoiohydric, 209 horizontal gene transfer, 5, 8, 21, 23, 28, 31, 34, 65-67, 70, 89 hormones, 218, 370, 372, 375 Hormosira, 202 NH_4^+ toxicity, 173 vesicle size, 210 hornworts cyanobionts, 280-281 neochrome, 122 hot springs, 273 human population, 349-350, 352, 356 and global carrying capacity, 356 and nutrients, 356 hydraulic flushing effects on biomass, 346 Hydrilla, 104 C₄ photosynthesis, 102 polar leaves, 104 hydrocarbons degradation, 261-262 toxicity, 261

Julescraneia, 86 Jurassic, 72 appearance of coralline algae, 89 origin of coral symbiosis, 281 K⁺ transport, 200

attenuation, 116

changes, 116, 123, 125

energy dissipation, 126

and global change, 326

and photoinhibition, 28

changes with shoaling, 298

spectral changes with depth, 117

and UV radiation stress, 326

CAM metabolism, 102-103

variation with depth, 116

Ishigeales, 86 Isoetes, 97, 102

isoetid life form, 171

K_{0.5} (CO₂), 44, 53

 $K_{0.5}(O_2), 44$

© in this web service Cambridge University Press & Assessment

More Information

Index

395

Karenia, 70 red tides, 354 Karlodinium, 70, 241 k_{cat}(CO₂), 44, 46-47 $k_{cat}(O_2), 44$ kleptoplasty, 33, 47, 121, 282 Kryptoperidinium, 70 Lake Baikal 352 Lake Erie, 352 zinc and cobalt limitation, 348 Lake Victoria, 352 Laminaria desiccation 212 as food, 369 nitrate storage, 201 nitrate uptake, 172 solute transport, 88 Laminariales, 86 morphology, 87 Last Universal Common Ancestor (LUCA), 3 leak recovery, 228-229, 238 leakage of metabolites, 228 legacy nutrients, 355 Lemna, 171, 342 Lemnaceae cyanobionts, 280 Leptolyngbya, 28 Lessonia, 211, 217-219 and UV radiation, 322 lichens in biological soil crusts, 276 desiccation tolerance, 209 as extremophiles, 279 microbiome, 279 photobiont, 279 as pioneer colonisers, 276 symbiosis origin, 279 light climate dynamics, 138 underwater, 346 light-harvesting chlorophyll proteins reversible phosphorylation, 127 light limitation polysaccharide excretion, 259 light penetration effect of nanoplastics, 258 into sediment, 116 limiting resource co-existence within diverse communities, 164 and trait-trade-offs, 227 linear electron flow. See linear electron transport linear electron transport, 5, 7, 21, 28, 34, 49, 125, 159, 214 and proton pumping, 28

lipid peroxidation and desiccation, 217 and herbicide toxicity, 254 and metal toxicity, 263 and UV radiation, 329 lipids and elemental stoichiometry, 152 membrane composition under desiccation, 216 and nitrogen depletion, 156 and P limitation, 164-165, 167 and temperature, 143-144, 274 lipoperoxide and desiccation, 217 liquid water in the early Earth, 1-2 modification of light spectrum, 6 Littorella, 170–171 CAM metabolism, 102 Lobelia, 171 gas exchange with sediment, 99 Lomagundi-Jatuli Excursion, 10-11 long-chain polyunsaturated fatty acids, 369 low light and C acquisition, 52 and CAM downregulation, 103 effects in mixoplankton, 234 exposure during mixing, 330 and feeding in mixoplankton, 238 limitation of P uptake, 345 limitation of seaweed growth, 88 limits for growth, 24-25 and photosynthesis, 124 phototactic response, 122 responses of submerged embryophytes, 100 lutein, 321 production for biotechnology, 370 Lycopodiophyta, 97 Lyngbya N₂ fixation, 155 Macroalgae, 32 blooms, 352 distribution of CCMs, 299 DNA repair, 320 ecological importance, 96 effects of UV radiation, 318 evolutionary origins, 32, 65, 69, 81 fossil record, 72 localised acidification and inorganic carbon supply, 48 nutrient acquisition, 169 and ocean acidification, 301 Plimitation 173 planktonic, 96 population structure under climate change, 302 productivity, 96 salinity ecotypes, 204

More Information

396

Index

| Macroalgae (cont.) |
|---|
| Si in cell wall, 157 |
| size, 32 |
| and temperature, 302 |
| UV radiation effects on different life |
| stages, 332 |
| Macrocystis |
| effect of elevated CO_2 , 299 |
| N acquisition, 1/3 |
| limitation of productivity 247 |
| minitation of productivity, 547 |
| magnesium calaita 201 |
| maintenance 23 |
| costs in mixoplankton 235 |
| energy cost 25 |
| in mixonlankton 237 244 |
| of photosynthesis in kleptoplastids 282 |
| maleic hydrazide |
| effects on algae 254 |
| manganese, 43 |
| in carbonic anhydrase, 348 |
| limitation. 348 |
| in superoxide dismutase, 218 |
| mannitol |
| as an organic osmolyte, 172, 201–203 |
| Marchantiophyta, 97, 281 |
| marine heatwaves, 302 |
| Mastigocladus |
| thermophile, 273 |
| Mastigocoleus |
| endolithic borer, 277 |
| mature ecosystems, 240 |
| dominance of mixoplankton, 241 |
| K-select organisms, 241 |
| maximum growth rates |
| and adaptation to temperature, 304 |
| of mixoplankton, 234 |
| and trait-trade-offs, 241 |
| Mehler ascorbate peroxidase pathway, |
| 126–127 |
| membrane damage |
| during desiccation, 215 |
| membrane fluidity |
| and temperature, 143–144, 274 |
| menaquinone, 23–24 |
| Mesodinium |
| in mixoplankton, 244, 282 |
| nutrient uptake, 244 |
| Mesoproterozoic, 10, 82–83 |
| tossils, 83 |
| origin of Rhodophyta, 72 |
| Mesozolc |
| increase in red lines of all the set of the |
| and origing of corpling class, 84 |
| and origins of coralline algae, 84 |
| SUDUALE LAUREDUATION 14, 147 |

metal bioaccumulation, 264 biosorption, 263-264 metal tolerance mechanisms, 275 metallothioneins, 156 metatranscriptome and temperature, 144 under cold acclimation, 144 metazoa diversification, 90 and kleptoplastidy, 282 in symbioses, 282 methane, 356 emissions in ruminants, 375 methylglyoxal, 218 microbial consortia utilisation of organic compounds, 343 microbial fuel cells, 374 Microcvstis colony size, 29 growth rate and temperature, 140 toxins, 354 transformation of pollutants, 373 uptake of PCBs, 256 micronutrients, 341 limitation of phytoplankton growth, 348 'microplasmodesmata', 80 microplastics, 258 toxicity, 259 Miocene brown algae, 86 coralline algae, 84 mitochondria activity and temperature, 144 Complex I, 48 effects of salinity, 198 in endosymbiosis, 11, 29, 65, 68, 70 **GOGAT**, 163 and N assimilation, 159 in photorespiration, 44-45 ROS scavenging, 321 mixoplankton, 228 distribution, 228, 241 evolutionary lineage, 229 size range, 230 and trait-trade-offs, 229, 235 mixoplanktonic growth rate potential, 240 mixotrophic alveolates, 70 molecular clock eukaryogenesis, 11 origin of Excavata, 70 origin of Haptophyta, 72 origin of microalgae, 72 origin of Ochrista, 72 origin of Paulinella, 66

More Information

origin of Prasinophytes, 72 nitrate, 88, 154, 216 molecular phylogeny assimilation pathway, 162 of diatoms, 72 conversion to nitrite, 157 of eukaryotes, 30 limitation and cell size, 303 of green algae, 30 and osmotic adjustment, 201 release under desiccation, 215 molybdenum changes in availability over geological time, 54 removal by denitrification, 171 limitation of phytoplankton growth, 348 and rise in O2, 54 nitrate reductase, 157 storage, 201 nitrogenase, 54, 157, 348 transport, 164, 342 monocots uptake, 163, 172, 216 aquatic taxa, 98 uptake and desiccation, 215 evolution, 97 uptake by mixoplankton, 244 seagrass evolution, 99 and water quality, 354 nitrate reductase, 157-158, 161 mosses cyanobionts, 280 and desiccation, 216 desiccation tolerance, 209 and hydrocarbon toxicity, 261 multicellular shoot to root ratio, 170 brown algae, 86 nitrate transport, 161 multicellularity, 67, 80-82, 87-89 nitrification, 155 green algae, 85 under rising O2 levels, 54 and internal transport, 88 nitrite, 154, 163 and resource acquisition, 87 oxidation, 155 multiple stressors and rise in O2, 54 in aquatic ecosystems, 355 transport, 164 Muriellopsis nitrite reductase, 145, 157-158, 163 as a source of lutein, 371 sirohaem, 157 mycosporine-like amino acids, 322 nitrogen Myrionecta acquisition, 87 in mixoplankton, 282 atmospheric deposition, 156, 347 Myriophyllum storage, 87 bicarbonate use, 104 supply in coral symbioses, 281 root uptake of nutrients, 172 uptake, 155 nitrogen fixation, 342, 343, 348 N₂ fixation. 342 in Azolla, 280 Na⁺ ATPase, 200 and elevated CO2, 304 Na⁺ efflux, 200 inhibition by herbicides, 254 Na⁺/HCO₃⁻ symport nitrogen footprint, 350 in CCMs, 49 nitrogen limitation, 347-348 NADH dehydrogenase, 23-24 nitrogen loss NADH: plastoquinone reductase, 118 via denitrification, 156 NAD(P)H dehydrogenase, 5, 28, 45, 48, 118, 318 nitrogenase, 54, 155, 157-158, 343 in CCMs. 48 damage by O2, 28 NADP⁺, 7, 22, 28, 118, 159, 318 inhibition by dissolved inorganic nanoplankton, 71 nitrogen, 155 and UV radiation, 318 vanadium, 157 nanoplastics, 258 nitrous oxide, 155 neochrome, 122 node age, 84 Neogene in evolution of coralline algae, 84 coralline algae, 84 in molecular evolution, 82 Neoproterozoic, 72, 85 Nodularia, 329 origin of green algae, 85 non-constitutive mixoplankton, 228 origin of Paulinella endosymbiosis, 67 non-cyclic electron transport. See linear electron Prasiniophyte origin, 72 transport Neoproterozoic Oxidation Event, 1, 9, 11, 30 non-haem Fe, 237 non-photochemical quenching, 25, 125, 141, 300, nickel in urease, 158, 163 319, 324

Index

More Information

| 398 | Index | |
|-----|--|--|
| | | |
| | Nostoc, 155 | orange carotenoid protein, 126 |
| | in biological soil crusts, 276 | Ordovician, 53, 85–86 |
| | in cycad roots, 280 | organic nutrients, 343 |
| | in <i>Gunnera</i> , 280 | utilisation, 163 |
| | herbicide inhibition of N_2 fixation, 255 | organic osmolytes, 199-203, 219, 274 |
| | in hornworts, 281 | seasonal changes, 201 |
| | poly-hydroxybutyrate production, 371 | organic solute transport, 163, 343 |
| | symbiosis with fungi, 279 | origin of life, 1–2, 12 |
| | and UV radiation, 325 | Oscillatoria |
| | nuclei | in acid lakes, 274 |
| | in endosymbiosis, 69 | plastic degradation, 260 |
| | retention in ciliates, 282 | in soda lakes, 275 |
| | retention in sacoglossans, 283 | osmo-heterotrophy, 228 |
| | nucleotide excision repair, 320 | osmotic adjustment, 197, 200-201 |
| | nutraceuticals | osmotic potential, 198-201 |
| | from algae, 372 | Ostreococcus |
| | nutrient acquisition, 88, 151, 153, 158, 160, 168, | cryptochrome, 121 |
| | 174, 342 | under elevated CO ₂ , 304 |
| | and desiccation, 215 | and global warming, 305 |
| | in mixoplankton, 232–233 | size, 32 |
| | regulation, 167 | urea acquisition, 163 |
| | nutrient enrichment, 173, 350, 352, 355 | Ottelia |
| | and algal blooms, 352 | bicarbonate use, 104 |
| | consequences, 352, 356 | C ₄ photosynthesis, 102 |
| | effect on corals 352 | CAM metabolism 102 |
| | nutrient limitation 174 347 | oxygen 6 |
| | and effects of UV radiation 329 | availability of nutrient elements 43 |
| | in mixonlankton 242 | changes in atmosphere is 9 43 |
| | nolysaccharide excretion 259 | effect on Rubisco kinetics 44 |
| | and stratification 303 | and elemental oxidation state iv |
| | nutrient retention 352 | in photorespiration 45 |
| | in mixonlankton, 238 | inhibition of nitrogenase 155 3/3 |
| | nutrient supply 173 207 303-304 | and iron availability 118 |
| | nutrent suppry, 175, 297, 505–504 | minimum zonos 220 |
| | OA See accor acidification | and nutrient element evailability 54 |
| | OA. See ocean actimication | and agone formation is |
| | ocean acidification, 299, 301 | and ozone formation, ix |
| | effect on calcification, 301 | and Rubisco, 7, 43 |
| | effect on mixoplankton, 239 | and Rubisco kinetics, 46 |
| | effect on motility, 301 | and Rubisco oxygenase, 44 |
| | effects on coccolithophores, 301 | uptake in water–water cycles, / |
| | interaction with temperature, 89, 174 | oxygen evolving complex, 5, 7–8, 29, |
| | Ochrista, 21, 31, 34, 72 | 33, 117 |
| | chloroplast envelope membranes, 71 | oxygenic photosynthesis, 1, 6, 10, 12, 23, 26–28 |
| | Form ID Rubisco, 46 | 43, 65, 69, 117 |
| | light-harvesting pigments, 31 | and N_2 fixation, 155 |
| | plastid origins, 31 | and ozone formation, 315 |
| | Ochromonas | ozone, ix, 315 |
| | hydrocarbon degradation, 373 | depletion, 316–317, 326, 356 |
| | Oedogoniales, 82 | and UV radiation, 315 |
| | oil toxicity, 260–261 | |
| | oligotrich ciliates | P ₆₈₀ , 27, 117 |
| | in mixoplankton, 237-238, 240 | P ₇₀₀ , 27, 117 |
| | oligotrophic waters | package effect, 31-32, 124, 137 |
| | light spectrum, 117, 119 | and cell size, 124 |
| | and mixoplankton, 236 | Padina, 86 |
| | nutrient availability, 159 | and desiccation, 211 |
| | phosphorus uptake, 167 | palaeological studies |
| | and UV radiation, 329 | of lakes, 349 |
| | | |

More Information

Index

399

Palaeoproterozoic, 11, 83 Great Oxidation Event, 9 palatability changes with desiccation, 211 of seaweeds, 211 Paleocystophora, 86 Paleohalidrvs, 86 Palmaria desiccation tolerance, 213 temperature and UV radiation tolerance, 324 Palmophyllophyceae, 67, 73 Paramecia, 85 paramylon, 369 paraquat, 254 Paulinella, 21, 29-30, 33-34, 66-68 time of origin, 68-69 Pavlovophyceae, 71 pectins, 218 peduncle tube phagotrophy, 232 Pelagophyceae, 71 time of origin, 72 Pelvetia, 202 and desiccation, 210, 215 recovery from desiccation, 213 pennate diatoms motility, 73 sexual reproduction, 72 PEPC. See phosphoenolpyruvate carboxylase peridinin, 31, 70, 120, 321 periplasmic space, 80, 104 peroxiredoxin, 321 pН acidophiles, 273-274 bands, 104 and calcium carbonate stability, 300 at cell surface, 48 changes in seawater over time, 89 and CO2 vents, 301 and elevated CO2, 299 and fossil fuel burning, 349 in hot springs, 273 modulation in mixoplankton, 239 ocean acidification, 297 oceanic, 9 and phosphate release, 346 in polar leaves, 104 in xanthophyll cycle, 126 pH gradient, 301 across thylakoid membrane, 126 Phaeocystis manganese limitation, 348 under elevated CO2, 304 under elevated CO2 and UV radiation, 328 P-limitation, 165 virus infection and OA, 302 Phaeodactylum and elevated CO₂, 300, 304

and fucoxanthin production, 371 nitrate assimilation, 163 Phaeophyceae, 65, 86 time of origin, 86, 296 phagocytosis, 230, 232 phago-heterotrophic zooplankton, 228 phago-heterotrophy, 228 phagotrophy, 65, 70, 228, 232, 234-238, 243 343 cell surface allocation, 233 cost of membrane synthesis, 238 in coccolithophores, 239 loss, 229, 239, 244-245 membrane turnover, 238 vs phototrophy, 234 and resource acquisition, 232 and secondary metabolite production, 243 pharmaceuticals, 373 from algae, 372 removal by algae, 373 transformation by algae, 373 phenotypic plasticity in seaweeds, 88 phlorotannins, 322 levels under desiccation, 211 under UV radiation, 322 phosphatase, 343 phosphate release, 346 phosphoenolpyruvate carboxylase, 101-102 phosphoglycerate, 44-45, 52 phospholipid, 157, 165, 348 phosphonate, 166, 172 phosphorus acquisition, 87 concentration changes over time, 349 in fertiliser use, 350 footprint, 350 in inland waters, 344 inputs from agriculture, 351 limitation, 165, 167, 171, 347-348 as a limiting nutrient in lakes, 346 load reduction, 355 sequestration in ocean sediments, 345 storage, 87 uptake kinetics, 165 uptake systems, 165, 167 photic zone carbon export, 328 photoautotrophy, 4, 22-26, 28 photochemical quantum yield, 319 photochemical quenching, 144 photoinhibition, 25, 28, 198, 326, 331 influence of temperature, 324 and N limitation, 329 and nitrogen availability, 329

More Information

| Index |
|-------|
|-------|

photoinhibition (cont.) and phosphorus availability, 329 and ROS, 144 under UV radiation, 318 photolithotrophy, 1, 12, 21-22, 34 photolyase, 121-122, 320 cryptochrome, 121 DNA repair, 320 photo-osmo-mixotrophic phytoplankton, 228 photo-osmo-mixotrophy, 22, 25-26 photo-osmo-organotrophy, 22, 25 photoperiodism, 120 photo-phago-mixotrophy, 22, 32-33, 240 photorespiration, 45, 103, 139 and nitrogen loss, 215 photostasis, 139 photosynthesis. See also anoxygenic photosynthesis; oxygenic photosynthesis ancestral reaction centres, 5 and carbon dioxide, 8 in eukaryotes, 29 evolution, 21 origin, 5 and oxygen, 6 photochemistry, 6 photosynthesis and respiration effects of desiccation, 213 effects of emersion, 212-213 effects on inorganic carbon levels, 100 effects of salinity, 197-198 effects of temperature, 142 effects of trace metals, 157 photosynthesis vs irradiance curves, 124 photosynthetic carbon reduction cycle. See Benson-Calvin-Bassham cvcle photosynthetic electron transport, 118-119 regulation, 141 photosynthetic unit, 24, 124-125 photosynthetically active radiation, 115 absorption by water, 6 lower limits for growth, 25, 27, 33 and stratification, 298 photosystem I, 7, 21-23, 49, 117, 121, 128, 281, 317 under salinity stress, 198 stability under UV radiation, 318 photosystem II, 21-23, 27, 49, 117, 119, 121, 128, 138, 144 under elevated CO₂, 300 under salinity stress, 198 under UV radiation, 318 phototrophy, 21, 23, 34, 232 in mixoplankton, 228, 230, 233-239, 240, 242, 244 in mixotrophy, 239 toxins as secondary metabolites, 243 phototropin, 121-122

phycobilin, 10, 27, 29-31, 67, 71, 120-121, 125, 141, 156 in biotechnology, 369 phycobilisome, 27, 30, 33, 67, 71, 119, 127 flexibility in pigment composition, 128 under iron limitation, 125 phycocyanin, 121 in biotechnology, 369 in thermophiles, 273 phycoerythrin, 117, 119-121 phytochelatin, 156 phytochrome, 121-123 in cyanobacteria, 123 phytoplankton, 34, 96, 229, 241 biomass and P load, 347 cell size and nutrient availability, 303 depth limit for growth, 116-117 elevated CO2 and species composition, 302 evolution and trace element availability, 30 functional traits, 231 iron limitation, 154, 344, 348 as mixoplankton, 228 motility, 252 N acquisition, 160 N transporters, 161, 164 P acquisition, 164 and PCBs, 256 and plastics, 258 sinking, 32 species composition, 117 and temperature, 137, 139, 142 temperature and growth rate, 303 trait-trade-offs, 229 and UV radiation, 322 picoplankton, 29, 32, 71 pit connections, 81 Planktothrix growth rate and temperature, 140 toxins, 354 plant growth enhancers from seaweeds, 375 plasma membrane. See plasmalemma plasmalemma, 24 aquaporins, 200 bicarbonate transport, 49, 104 and CCMs, 50 and Cl- transport, 201 in mixoplankton, 233 and N transport, 161 Na⁺ to phosphate symport, 173 nitrate reductase, 163 potential difference under ocean acidification, 301 role in CCMs, 48 and Si transport, 168 sterol requirement for endosymbiosis, 11

More Information

Index

401

plasmodesmata, 81-82 plasmolysis, 204 plastics degradation by algae, 259 as toxin vectors, 258 plastid carbonic anhydrase, 52 and CCMs, 50-51 endosymbiosis, 30-31, 33, 66-68 Fe requirement, 54 genes, 21, 29, 34, 66, 68 genome, 68 in kleptoplasty, 33, 282 light-harvesting, 31 in mixoplankton, 237, 244 in photorespiration, 44 protein import, 66 retention in kleptoplastidy, 282 terminal oxidase, 8, 126-127 transport of inorganic C, 49 plastidial specialist non-constitutive mixoplankton. See pSNCM plastocyanin, 5, 7, 27-29, 117-118 plastoquinone, 5, 23, 28-29, 117-118, 125, 127, 318 plate tectonics, 2 Pleistocene ice age, 9 pleustophytes, 32, 342 PMF. See proton-motive force poikilohydric, 209 seaweeds, 209 polar bears, 279 and algae, 278 polar leaf, 104 polar regions, 55, 136, 194, 275 pollution, 252, 355-356 polyamines and desiccation, 218 polychlorinated biphenyls, 252, 255, 258 polycyclic aromatic hydrocarbons, 260 degradation, 373 polyols, 202-203 polyphenols, 89, 264, 321-322 Polypodiophyta, 97 polyunsaturated fatty acids, 274, 369 and temperature, 143 population composition shifts under elevated CO2, 302 Porphyra and desiccation, 210, 212-218 as food, 369 and salinity, 197-198 Posidonia bicarbonate transport, 104 P release, 171 positive selection, 72 Potamogeton, 104 P uptake, 172

potassium limitation, 348 in osmotic adjustment, 200 Prasinophyceae, 67 cryptic sex, 71 Prasiola salinity tolerance, 197 Precambrian UV radiation, 315 primary endosymbioses, 65, 69 Prochlorococcus chlorophyll, 27, 119 light-harvesting, 31, 117, 125 N acquisition, 156, 162 P acquisition, 165, 167 picoplankton, 29 Rubisco, 28, 46 Prochloron chlorophyll, 27 light-harvesting, 31 Prochlorothrix chlorophyll, 27, 31 productivity, 4, 9, 10-11, 44, 66, 96 and anoxia, 155 anoxygenic photosynthesis, 22 of aquatic embryophytes, 168 and desiccation, 212-213 effect of ammonium, 160 and fertiliser application, 349 freshwater plants, 97 under global climate change, 304 and hydraulic flushing in lakes, 346 iron limitation, 154, 348 light availability, 100, 346 limitation by inorganic carbon, 101 nitrogen limitation, 346-347 and nutrient availability, 152 nutrient limitation, 346 nutrient limitation in aquatic rhizophytes, 342 and nutrients, 343 and photorespiration, 45 and Rubisco, 43 and temperature, 142-143, 346 and UV radiation, 316-318, 329 proline, 55 as antioxidant, 264 as an organic osmolyte, 202 Prorocentrum urea use, 343 Proteobacteria, 4-5, 22 Benson-Calvin-Bassham cycle, 25 cyclic electron transport, 23 Form II Rubisco, 8 H₂ production, 11 inorganic electron donors, 26 photoinhibition, 25 photo-osmo-mixotrophy, 25-26

More Information

402

Index

Prorocentrum (cont.) and primary endosymbiosis, 68 reaction centre, 21, 23 Proteorhodophytina, 67 Protista as hosts in symbioses, 281 protists, 227 and mixotrophy, 228, 232, 241 phagotrophy, 237 and symbioses, 237, 281-282 and UV radiation, 315 variability in growth rate, 242 proton gradient, 141 proton: ATP ratio, 118-119 proton-motive force, 3-4, 23-24, 51, 126 Prymnesiophyceae, 71 Prymnesium and mixoplankton, 234 Pseudo-nitzschia red tides, 354 pSNCM, 240, 244 psychrophiles, 136-137, 142-143, 273-274 pteridophytes, 33-34, 97-98 absence of bicarbonate use, 103 in freshwater, 97 purine catabolism, 163 uptake, 160, 343 use, 164 putrescine and desiccation, 218 pyrenoids, 49, 51 and CCMs, 51 and Rubisco, 51 and nitrate reductase, 163 pyrimidine dimers, 320 photoproduct under UV radiation, 318 uptake, 160 pyrimidone photoproduct under UV radiation, 318 Pyropia and desiccation, 210, 214, 217-220 and emersion, 212 as food, 369 trehalose synthesis during desiccation, 219 Rafatazmia, 30, 83 Ralfsia and desiccation, 211

and desiccation, 211 Ramathallus, 83 Ranunculus bicarbonate use, 104 Raphidocelis in toxicity assays, 373 RCI, I, 5, 21–24, 34 RCII, I, 5, 21–23, 34 reaction centre, 1, 5, 12 ancestral, 5 Type 2, 21 reactive oxygen species, 127, 139, 144, 321 and desiccation, 217 and heavy metals, 263 and herbicides, 254 and plastics, 258 and salinity, 198 scavenging, 144, 278, 320-321 and UV radiation, 318-319, 329 Redfield ratio, 152, 341, 350 remediation of nutrient enrichment, 355 remineralisation, 11, 155, 165 renewable energy, 374 reservoirs, 97, 345 of P, 156 as sources of CO2, 298 resource acquisition, 231 in microalgae, 159 in mixoplankton, 232-233, 236, 242 in seaweeds, 87-88 and trait-trade-offs in mixoplankton, 229 respiration, 10-12, 24, 103, 139, 159 and desiccation, 212-213, 219 effect on phosphate release, 346 under elevated CO2, 304 and ion transport, 201 in mixoplankton, 236 of organic C in catchments, 296, 298 and salinity, 197-198 in submerged embryophytes, 100 and temperature, 142, 174 reverse electron transfer, 23-24 reverse tricarboxylic acid cycle, 3-4, 21, 25.34 Rhizaria, 30-31, 66-67, 69, 228, 231, 281-282 rhizoids, 96, 168-169, 342 nutrient uptake, 173 rhizomes, 168 rhizophytes, 168, 342 rhizophytic embryophytes, 96 macroalgae, 32 vascular plants and N acquisition, 169 Rhodophyta, 21, 34, 66-67, 71, 295 and CCM activity, 298 CO2 uptake, 47 and desiccation, 213 in endosymbioses, 68 Fe requirement, 7 Form ID Rubisco, 46 origin, 72 polysaccharides, 89 sexual reproduction, 71

More Information

Index

403

rhodopsins ion-pumping, 27, 123 sensory, 123 ribulose-1,5-bisphosphate carboxylase-oxygenase. See Rubisco Richelia, 155 in cycad roots, 280 N₂ fixation, 342 symbiosis in diatoms, 155, 281 riverine discharge and N inputs, 156 ROS. See reactive oxygen species Rubisco, 3-4, 8, 43, 46 activase, 51 in carboxysomes, 49 and CCM activity, 8 and CCMs, 101 and evolution of CCMs, 30, 52 Form I, 8, 46 Form IA, 28, 30, 52, 66-67 Form IAc, 46 Form IB, 28–31, 52, 65, 67 Form IBc, 46 Form ID, 46-47, 67, 70-71, 299 Form II, 3, 8, 26, 29, 31, 46-47, 70-71 Form III, 3, 47 kinetics, 44, 46-47 levels and light intensity, 124 need for CCM activity, 47 oxygenase, 26, 44 oxygenase activity, 3, 7 and photorespiration, 45 in pyrenoids, 51 regulation, 31 Selectivity Factor S_{rel}, 44 and temperature, 139, 142-143, 303 thermal tolerance, 273 and UV radiation, 318 Saccharina and desiccation, 211, 218 as food, 369 sacoglossans kleptoplasty, 282 retention of algal nuclei in kleptoplasty, 283 Sagittaria CAM metabolism, 102 and UV radiation, 100 salinity, 194 adaptation into different ecotypes, 204 in brine channels, 274 changes over geological time, 194 in different habitats, 194 effects on growth, 197 effects on photosynthesis and respiration, 197 and osmotic acclimation, 198

physiological effects, 196 role of inorganic ions in acclimation, 200 role of organic osmolytes in acclimation, 201 and sea ice algae, 274 stress, 196 tolerance, 196 Sargasso Sea, 96 Prochlorococcus, 165 Sargassum, 96 free-floating, 32 nutrient acquisition, 342 Scenedesmus DDT and morphology changes, 255 growth rate and temperature, 140 as a source of lutein, 371 Schizocladiophyceae, 86 seagrasses, 99 acid-base regulation, 171 ammonium uptake, 170 bicarbonate use, 103 and CCMs, 298 C₄ photosynthesis, 47 ecological importance, 96 evolution 99 hosts in symbioses, 281 nitrate reductase activity, 169 nutrient acquisition, 342 nutrient sources and sinks, 171 origins in the Cretaceous, 296 productivity, 96 and rising temperatures, 346 seals as substrate for algae, 278 Secchi depth, 347 secondary metabolites and desiccation, 211 in mixotrophy, 243 and UV radiation, 321 seed plants, 34 Selectivity Factor S_{rel}. See Rubisco sensory rhodopsin, 123 sewage, 354 health risks, 352 and P enrichment, 349 and pollutants, 373 release, 351 sexual reproduction, 71, 99-100, 120 role of phototropin, 122 shoot to root ratio nitrate reductase, 169 nitrate uptake, 170 phosphate uptake, 172 Silurian, 72, 85-86 sirohaem, 158 Skeletonema effect of plastic, 259

and P availability, 172

More Information

| 404 | Index | |
|-----|-------|------------------|
| | | |
| | SLC4 | requirement, 342 |

bicarbonate transporter, 49-50, 104 sloths, 279 and algae, 279 snow and irradiance, 346 UV reflection, 315 snow algae, 273-274, 278 snowball earth 85 soda lakes, 275 dominance by cyanobacteria, 275 sodium pumping rhodopsin, 27 solute transport, 161-165, 168 cytoplasmic streaming, 88 in mixoplankton, 232 and osmotic adjustment, 200 sorbitol as an organic osmolyte, 203 South Atlantic Ocean effects of global change, 328 South China Sea effects of UV radiation, 322, 327 specific dynamic action, 243, 245 in mixoplankton, 236-238, 241 spermine and desiccation, 218 Spirulina in acid lakes, 274 in soda lakes, 275 spontaneous mutation rate, 71 Sporolithales, 84 state transitions, 126-127 stomata, 33, 99, 171 in CAM plants, 102 stramenopiles, 31, 86, 282 aureochrome, 121 helmchrome, 122-123 stratification and exposure to irradiance, 298 and irradiance, 305, 325-326 and N limitation, 154 and nutrient exchange, 174 and nutrient supply, 297-298, 303-305, 326 and UV radiation, 303 Streptophyta, 21, 34, 67, 168 sexual reproduction, 72 structural support, 99 sulfide oxidation, 24 in cyanobacteria, 28 sulfur, 43 and algal evolution, 55 availability and oxygen, ix, 54-55 compounds in osmoregulation, 55 and fossil fuel burning, 349 oxidation by cyanobacteria, 5 reduction of emissions, 349

storage as DMSP, 55 superoxide, 126, 216, 321-322 superoxide dismutase, 126, 144, 216, 278, 321 surface area to volume, 87 and nutrient uptake, 87 survival, 143, 235 and DNA repair, 320 during ice ages, 85 under low temperature, 137 in mixoplankton, 232, 242 and salinity, 196-197 and temperature, 136 Symbiodiniaceae, 70 in corals, 281 in giant clams, 281 nutrient acquisition, 153 in symbioses, 281-282 symbiosis, 10, 279-280 Synechococcus, 28, 66 chromatic acclimation, 128 and global warming, 305 N acquisition, 162 P acquisition, 167 P uptake, 165-166 Rubisco, 28 Si requirement, 157 transformation of pollutants, 373 Synechocystis bicarbonate transporter, 49 bioplastic synthesis, 371 glycolate metabolism, 45 in soda lakes, 275 phytochromes, 123 sulfide oxidation, 28 UVA receptor, 123 synergism in mixoplankton, 236, 240 Tappania, 83 Tasmanites, 83 temperature adaptation and acclimation, 138 and algal physiology, 136 effects on molecular biology, 144 effects on photosynthesis, 139 effects on productivity, 346 effects on respiration, 142 and extremophilic algae, 273 and global change, 297 and growth, 136 interactions with UV radiation, 324 survival under extreme temperatures, 137 and UV radiation stress, 318 Tetradesmus and removal of organic pollutants, 373

More Information

Index

405

Tetraselmis and P limitation, 167 symbiosis with flatworms, 282 Thalassiosira bicarbonate transporter, 49 C₃-C₄ intermediate C assimilation, 47 and elevated CO₂, 300 P uptake kinetics, 165 Rubisco kinetics, 53 Thallophyca, 85 thermophiles, 136-137, 273-274 Thermosynechococcus, 273 thermophile, 273 thvlakoid carbonic anhydrase, 51 changes under desiccation, 214 effects of salinity on structure, 198 glycolate dehydrogenase, 45 inorganic carbon transport, 48 location of photosynthetic processes, 9 pH gradient, 126 photosynthetic electron transport chain, 117 redox and protein pumping components, 29 thylakoid lumen H⁺ accumulation. 8 phycobilins in Cryptophyta, 71 and proton pumping, 28 tintinnids, 228 Tonian, 85 top-down pressure, 241-243 toxin production in mixoplankton, 231, 243 toxins in cyanobacteria, 354 and harmful algal blooms, 352 in mixoplankton, 243 in 'red tide' algae, 354 trace elements in N and P acquisition, 157 as nutrients, 157 and phytoplankton evolution, 30 trace metals availability and changes in oxygen over time, 54 stoichiometry, 341 toxicity, 262 trait-trade-offs (TTOs), 227, 235, 236 within and between mixoplankton, 243 cell surface area, 232 cell volume, 234 growth rate potential, 240 maintenance, 236 and organism size, 228 survival, 242 transcription effect of temperature, 144 effect of UV radiation, 320 under P stress, 167

of plastid genes, 66 regulation by temperature, 143 transcriptomics and desiccation, 218 translation of plastid genes, 66 regulation by P limitation, 167 regulation by temperature, 145 transport of nutrients, 159 Trebouxiophyceae, 67 cryptic sex, 71 evolutionary origin, 296 in lichens, 279 as photobionts, 282 trehalose in desiccation. 219 as an organic osmolyte, 203 trehalose phosphate synthetase in desiccation, 219 Trentepohliales, 82 Tribophyceae, 71 as prey, 282 trichocysts, 232 Trichodesmium, 155 and elevated CO2, 304 N₂ fixation, 154, 342 P uptake kinetics, 165 toxins, 354 tridacnid giant clams symbiotic Symbiodiniaceae, 281 trumpet hyphae and solute transport, 88 turgor pressure and role of organic osmolytes, 200 and salinity, 196, 199 turtles as a substrate for algae, 278 Type 1 reaction centre. See RCI Type 2 reaction centre. See RCII ubiquinone, 23 UCYN-A, 281 N2 fixing cyanobacterium, 155 Udotea, 86 C₄ photosynthesis, 47 ultraviolet radiation cellular consequences of stress, 322 changes over geological time, 315 defence systems, 319 effects of dissolved and particulate organic matter, runoff and mixing, 330 and elevated CO2/ocean acidification, 328 and global warming, 324 interaction with nutrient availability, 328 interactions between PAR, UVA and UVB, 326

More Information

| 406 | Index | |
|-----|---|--|
| | | |
| | ultraviolet radiation (cont.) | violaxanthin, 321 |
| | levels in water bodies, 315 | in light-harvesting, 120 |
| | and ozone formation, ix | in xanthophyll cycle, 125 |
| | targets in algae, 317 | Viridiplantae, 66 |
| | UVA wavelengths, 315 | Form IB Rubisco, 31 |
| | UVB wavelengths, 315 | light-harvesting, 31 |
| | UVC wavelengths, 315 | phototropin, 122 |
| | wavelengths, 298, 316 | viruses, 238 |
| | Ulva | in aquatic food webs, 344 |
| | cell wall and desiccation, 218 | vitamins |
| | cell wall and effects of salinity, 204 | nitrogen requirement, 156 |
| | and desiccation, 211-212, 215 | Vitrella |
| | effect of inorganic N species, 173 | chloroplast envelope membranes, 70 |
| | energy costs of ion transport for osmotic | pigments, 31 |
| | acclimation, 201 | Volvox, 82 |
| | free-floating, 32 | phototropin, 122 |
| | green tides, 354 | |
| | nitrate reductase under desiccation, 216 | warming |
| | and nutrients, 173 | adaptation and acclimation, 304 |
| | and salinity, 201 | and algal blooms, 304 |
| | sulphate as an osmolyte, 201 | and CO_2 solubility, 297 |
| | Ulvophyceae, 67, 82 | effects on aquatic biota, 297 |
| | and ancestral green plastids, 69 | of upper mixed layer, 117 |
| | in lichens, 279 | wastewater treatment, 354, 369 |
| | origin, 72, 85 | emerging pollutants, 373 |
| | Undaria | energy requirement, 372 |
| | as food, 369 | High Rate Algal Ponds, 372 |
| | upper mixed layer | nutrient removal. 354–355 |
| | inhibition of photosynthesis, 328 | P stripping, 356 |
| | shoaling and exposure to solar radiation, 298 | and power generation, 374 |
| | shoaling and nutrient input, 298 | pharmaceuticals, 373 |
| | upwellings, 244 | Water Framework Directive, 354 |
| | and nutrient inputs, 154 | water potential |
| | Urban Wastewater Treatment Directive, 354 | and organic osmolytes, 203 |
| | urea | and salinity, 196 |
| | acquisition, 173 | and water flux through aquaporins, 200 |
| | assimilation in the sacoglossan <i>Elvsia</i> , 282 | and water influx/efflux, 198 |
| | as a source of ammonium, 158 | water, energy and food sustainability nexus, 350 |
| | transporters, 163, 173 | water-water cycle, 7–8, 126, 159 |
| | urea amidolyase. <i>See</i> ATP-urea amidolyase | energetics, 141 |
| | urea cycle. 163 | wax laver. 33, 209 |
| | urease 158 163–164 173 | Windermere |
| | Utricularia, 33 | phosphorus changes over time 349 |
| | carnivory 343 | Wood-Liungdahl nathway 3 |
| | UVA See ultraviolet radiation | Hood Djuliguani panivay, 5 |
| | UVA receptor | Xanthonbyceae 71 |
| | and phototaxis 123 | light_harvesting nigments 31 |
| | UVB See ultraviolet radiation | time of origin 72 |
| | UVR See ultraviolet radiation | xanthonhyll 319 321 |
| | o vix. See unraviolet radiation | and high light acclimation 326 |
| | Valeria 83 | light_harvesting yanthonbylls_321 |
| | vallisnaria | vanthonhull cycle 321 |
| | CAM metabolism 102 | and high irradiance avacaute 221 |
| | CAWI metabolishi, 102 | and high madiance exposure, 551 |
| | vonodium | and non photophomical anonohing 1/15 |
| | vanadium | and non-photochemical quenching, 125, |

More Information

Index

407

zeaxanthin, 126, 321, 371 production for biotechnology, 370 zinc, 262, 348 in carbonic anhydrase, 348 zonation and desiccation tolerance, 211 intertidal, 210 zooplankton, 229, 233 comparison of traits with mixoplankton and phytoplankton, 232 functional traits, 231 in mixoplankton, 228 organic nutrient transporters, 232 trait-trade-offs, 227, 232 Zostera, 103, 171 N uptake, 170 nitrate reductase, 170 nitrate uptake, 170 translocation of inorganic nitrogen, 170 and UV radiation, 100 Zygnematales, 67 sexual reproduction, 72 Zygnematophyceae, 33, 97