

# Subject Index

## A

Abaxial, 2, 3, 14–17, 20, 99, 101–103, 109, 119, 120, 142, 152–156, 219, 266, 295, 296, 316, 329, 406, 416  
Abiotic, 459, 460, 494, 495, 497, 505–518, 522, 525–527  
Above ground net production, 483  
Acclimated, 33, 41, 43–45, 121, 122, 320, 429, 441, 508  
Acclimation, 36, 37, 39, 41, 43, 45, 47, 48, 88, 121–125, 190, 331, 391, 427–429, 439, 440, 494, 500, 505, 508, 509, 511, 514, 515, 518, 527  
Acclimatory adjustment(s), xxxvii, 39, 45, 47, 124, 440, 495  
Acclimatory response(s), 41  
Adaptation, adaptive, xxxvi, 2, 7, 8, 10, 12–14, 18, 20, 21, 60, 84, 87–89, 109, 121–126, 130, 181, 259, 261, 269, 284, 285, 287, 290, 291, 296, 309–314, 325, 417, 427, 428, 433, 435, 442, 468, 487, 489, 495, 497, 505, 527  
Adaptive behavior of plants, 489  
Adaxial/abaxial identities, 2, 3, 15–17, 20, 21, 99, 101–103, 109, 121, 125, 126, 142, 152–156, 219, 258, 295, 316, 329, 406  
Air-equilibrium, 313, 325  
Alder, 437–439, 486, 520  
Allelochemicals, 311, 312, 314, 518  
*Alnus glutinosa*, 486  
*Amborella trichopoda*, 66  
Amino acids, 33, 58, 59, 68, 260, 385, 463, 505  
Amphibious, 2, 9, 10, 273, 314, 321, 323, 325, 333  
Amphistomatous, 103, 109, 126, 152, 185  
Amyloplast, 405  
Anatomy, xxxi, 31, 84–88, 90, 97–128, 177, 178, 184–188, 212, 232, 257, 259–261, 266, 267, 269, 273, 274, 285–291, 293, 294, 299, 326, 328, 402, 404, 409, 442, 459, 460, 466, 512  
Angiosperm evolution, 89  
Angiosperms, 2, 7, 8, 16, 21, 85, 89–91, 107, 114, 118, 144, 181, 256, 266, 289, 308, 309, 320, 322, 463  
Annual leaf fall, 482  
Annual leaf production, 482  
Antheraxanthin, 494, 496, 506, 509–511, 516  
Anthocyanin(s), 71, 124, 323, 375, 494, 502, 522  
Antioxidants, 311, 323, 502, 503, 518  
Aperture, 89, 113, 142–144, 146, 147, 151, 152, 156, 351, 407

Aphid(s), 58, 519, 522, 523  
Apoplast, 35, 38, 56, 57, 60–62, 64, 65, 67, 68, 71–73, 87, 149, 151, 152, 185, 330, 513  
Apoplastically, 31, 32, 35, 37, 38, 56  
Apoplastic loader(s), 33, 39, 40  
Apoplastic loading, 31, 60–63, 67, 68  
Aquaporin, 88, 89, 115, 164, 176, 183, 187–190, 192, 196  
Aquaporins-leaf, 89  
Aquatic  
  ecosystems, 329, 487  
  habitats, xxvii, 309, 516  
*Arabidopsis*, 4–7, 10, 12, 14, 16, 17, 19, 21, 60–62, 68–72, 110, 190, 238, 244, 245, 264, 273  
  *A. thaliana*, xxxvii, 2, 28, 31–33, 41, 42, 44, 46, 48, 59, 89, 106, 110, 112, 115, 119–121, 147, 155, 189, 190, 192, 219, 297, 322, 334, 378, 408, 410, 501, 502, 512–514, 517  
Architecture, xxix, 86, 211–246, 295, 300, 406  
Area-based trait, 452, 453, 456, 457, 467  
Armed mesophyll, 101, 126  
Armed palisade, 101, 126  
Arrangement of leaves, 487  
Art, xxix  
Arthropods, 119, 520–522  
Aseasonal forest, 481  
Assimilation rate, 84, 87, 108, 109, 114, 142, 144, 145, 153, 271, 297, 365, 440  
ATP, 61, 70, 147, 150, 151, 172, 263, 283, 323, 375, 376, 384, 452  
ATPases, 31, 35, 36, 38, 43, 61, 70, 71, 513  
Autumn, 440, 495, 502, 511, 525  
Auxin, 2, 3, 5, 6, 10, 19, 226–229, 403, 405, 406  
Axis, 2–4, 7, 12–18, 143, 171, 222, 224, 404, 452–455

## B

Bacteria(l), 82, 189, 191, 385, 494, 515, 518, 520–523, 525, 526  
Bicarbonate, 175, 176, 190, 256, 313, 326, 329  
Biennial(s), xxxvii, 28, 33, 39, 43, 44, 48, 495, 510, 511  
Bifacial, 2, 17, 99, 100, 102, 126  
Bimodality, 474  
Bimodal pattern of evergreens, 488  
Biofuel(s), xxviii  
Biogeographical trends, 474

- Biomass, xxviii, 119, 224, 299, 321, 350, 381, 428, 437, 439, 440, 453, 467, 481–485, 487, 500, 501, 508
- Biome, xxviii, 452, 455, 480
- Biominerals, 106
- Biosphere, xxxii, 527
- Biotic, xxxii, 99, 103, 459, 460, 494, 495, 518–526
- Birch, 426–430, 436–439, 441, 520
- Blue light, 5, 107, 121, 124, 142, 148, 150, 153–155, 173, 194, 195, 272
- Boundary layer, 8–10, 13, 109, 113, 119, 125, 165, 166, 169, 175–177, 180, 260, 330, 332
- Brassicaceae, 6, 62
- Broadleaved, 441, 442, 511, 519, 522, 524
- Bryophytes, 83, 107, 167, 182, 308–310, 314, 319, 322–324, 332
- Buliform cells, 407
- Bundle sheath, 30, 31, 59–66, 71, 88, 89, 91, 100, 103, 104, 110, 114–116, 185, 257, 258, 261, 263, 265, 267, 269, 272, 284, 290
- Bundle-sheath cell, 31, 59–61, 65, 82, 84, 103, 114, 116, 258, 261, 263, 272, 284, 290, 326
- Bundle sheath extensions (BSE), 31, 88, 89, 104, 110, 185
- Burn(ing), xxxi, 505
- C**
- Calmodulin binding transcription activator (CAMTA), 213–215, 217, 234, 235, 240
- Calvin(-Benson) cycle, 98, 147, 256, 283, 323, 412, 505, 506, 508, 514
- Canopy, 89, 104, 121, 123, 145, 358, 406, 408–410, 413–415, 417, 419, 427, 438, 440, 441, 474, 477, 481, 490, 497, 498, 500, 518
- Capacitance, 291, 292
- Capitate, 120, 126
- Carbohydrate(s), 29, 56, 60, 61, 65, 67, 68, 70–73, 98, 103, 150, 261, 282, 283, 293, 320, 321, 372, 374, 376, 378, 385, 389, 430, 434, 438, 494, 498–500, 502–504, 508, 509, 511, 517, 523, 524, 526
- Carbon acquisition strategies, 323, 326, 333
- Carbon dioxide (CO<sub>2</sub>), xxvii, xxxi, xxxii, 29, 36, 107, 190, 323, 347, 414, 499–500, 505, 526, 527
- Carbonic anhydrase, 164, 176, 187, 188, 190, 192, 196, 257, 283, 330, 331, 380
- Carbon isotope discrimination, 165, 168, 193, 268, 463
- Carnivorous, 2, 16, 372, 374, 384–389, 519
- Carotenoid(s), 377, 378, 380, 496, 506–508
- Castanopsis cuspidata*, 488
- Catalpa speciosa*, 67
- Cavitation, 34, 90–92, 114, 295, 516
- Cell cycle, 4, 496, 497
- Cell division, 2–4, 12, 16, 21, 99, 110, 112, 127, 212, 224, 228, 388, 496, 510
- Cell expansion, 4, 12, 99, 218–222, 224, 226–228, 230–233, 235, 236, 240, 243, 244, 246, 375, 403–405, 496, 497, 510
- Cellulose, 103, 217–222, 230, 267, 320, 460, 503
- Cellulose synthase, 217–219, 221, 222
- Cell wall  
  ingrowths, 28, 32, 36, 39, 43, 45  
  invagination, 101, 127, 514
- Centric leaf, 125, 126
- C<sub>4</sub> evolution, 259–262, 264
- Chemical defense, 477, 486
- Chlorenchyma, 127, 259, 271, 287–292
- Chlorophyll  
  deficient, 500  
  fluorescence, xxxvi, xxxvii, 104, 107, 110, 165, 168, 172, 191, 193, 196, 264, 426, 427, 442, 463, 496, 505, 506, 522, 525
- Chloroplast(s), 29, 56, 98, 147–148, 164, 237, 257, 284, 311, 347, 373, 414, 440, 459, 497
- Chloroplast CO<sub>2</sub> concentration, 459
- Chloroplast movement, 106, 124, 178, 192, 271, 273
- Chloroplast surface area, 111, 112, 121, 187, 239, 459, 460, 464, 465
- Chlorosis, 372, 374, 378–380, 499, 504
- Chronosequence, 476, 477
- Civilization, xxvii, xxxi
- Cladode(s), 2, 19–21, 290, 292, 296, xxvi, xxxi
- Climate change, 430, 494, 527
- Climatic conditions, xxxvi, xxxvii, 8, 41–48, 417
- Clouds, cloudy, 89, 475, 506
- C<sub>4</sub> metabolism, 103, 308, 325–328
- Coca, xxx
- CO<sub>2</sub>-concentrating mechanism (CCM), 175, 257–260, 266, 267, 308, 311, 312, 325, 326, 333, 334
- CO<sub>2</sub> concentration, 90, 98, 108, 113, 121, 142, 145–147, 149, 151, 165, 169, 171, 173–175, 178, 189, 191, 193, 195, 239, 300, 325, 328, 329, 331, 348–350, 373, 411, 428–434, 459, 463, 467, 500
- CO<sub>2</sub> diffusion, 84, 107–109, 111–113, 116–118, 125, 144, 164–196, 215, 216, 239, 241, 256, 259, 264, 265, 269, 346, 347, 378, 387, 452, 463, 464, 466, 467, 476, 478
- CO<sub>2</sub> fixation, 36, 147, 174, 179, 299, 372, 377, 378, 380, 387, 389, 412, 459, 506
- Coleus blumei*, 65
- Commerce, xxix
- Compacted soil(s), 363, 371–391, 501, 526
- Compaction, 381–383, 389, 390
- Companion cell(s), 30–38, 42, 44, 46, 57, 58, 60, 61, 63, 64, 69, 128
- Compass plants, 406–407, 410, 413
- Compatible solute(s), 494, 511, 515, 516
- Competition, xxix, 18, 121, 285, 310–312, 485, 490, 494, 518
- Competitors, 82, 497, 518
- Compound leaf, 5–7, 408
- Conductance, 27, 83, 108, 142, 165, 239, 257, 293, 346, 372, 412, 428, 459, 476
- Conifer, xxvii, 16, 85, 91, 181, 182, 184, 461–463, 486, 489, 496, 511
- Constitutive CAM, 287, 289, 293, 297–299

Construction cost of leaves, 474  
 Continuous light, 498–499  
 Convergent evolution, 284, 285, 295, 308, 314  
 Cool conditions, 33  
 Cool-grown, 512, 514  
 Co-ordination, 142, 144–147  
 Copper (Cu), 196, 372, 379  
 Cosine of incidence, 405, 407, 408, 417  
 CO<sub>2</sub> spring, 426–443  
 Cost-benefit model, 474, 476  
 Costs for supporting tissues, 477  
 Cotton golgi-related (CGR), 220  
 CO<sub>2</sub> uptake, 10, 36, 83, 84, 142, 144–146, 175, 284, 285, 287–290, 293, 294, 300, 313, 317, 328, 346, 348, 350, 386, 436, 437, 504, 515  
 C<sub>4</sub> photosynthesis, 256–266, 268, 270, 273, 274, 284, 289, 325–328, 333, 334  
 C<sub>3</sub> plants, 112, 113, 169, 175, 257, 258, 260, 261, 265, 266, 268, 271–274, 283, 285, 297, 327, 515, 517  
 C<sub>4</sub> plants, 31, 112, 121, 126, 142, 175, 256–258, 260–274, 283, 294, 327, 333, 500  
 Crassulacean acid metabolism (CAM), xxxi, xxxvi, 142, 282–300, 305, 325, 326, 328  
 C-repeat binding factor (CBF), 47, 214, 234, 299  
 Crop(s), xxvii, xxx, 28, 60, 92, 143, 145, 156, 212, 239, 245, 246, 274, 299, 300, 348, 349, 359, 365, 375, 383, 461, 508, 517, 527  
 Cryoprotectants, 503  
*Cucumis melo*, 67, 69  
*Cucurbita pepo*, 32, 62  
 Cultural, xxix  
 Cuticle, xxvii, xxxii, 28, 82, 103, 114, 117, 118, 165, 167, 175, 309, 311, 316, 321, 325, 329, 333, 464, 477, 478, 494, 503  
 Cytokinin(s), 5, 354, 355, 363–365, 520, 521

**D**

Daily carbon gain, 242, 411, 476, 477, 481  
 Daily leaf production, 482  
 Darcy's law, 85, 87  
 Dark respiration, 152, 441, 452–457, 489  
 DCMU, 142, 147, 150, 154, 156  
 Deciduous  
   broadleaved trees, 511  
   habit, 480, 481, 487  
 Decomposability, 486  
 Defense, 56, 116, 117, 119, 121, 214, 217, 233, 438, 439, 461, 466, 475–478, 486, 490, 494, 519, 522  
 Defoliation, 413, 498, 499, 519  
 Desert, xxxvi, 119, 286, 291, 292, 326, 406, 410–412, 418, 495, 516  
 Détour effect, 105  
 Diaheliotropic, 407, 408, 410, 411, 413, 417  
 Dicot(s), 28, 56, 61, 62, 65, 99, 218, 261, 266, 269, 285, 286, 295, 522  
 Dicotyledon, 62, 269, 309, 314

Diffusion, xxvii, 30, 62, 66, 67, 83, 84, 98, 99, 108–114, 116, 117, 143, 165, 168, 169, 176–179, 181, 183–190, 192, 264, 268, 285, 293, 294, 296, 313, 317, 319, 325, 332, 347, 414, 460, 463, 466, 478  
 Disaccharide(s), 30, 35, 503  
 Dissipation of excess light energy, dissipation of  
   excitation energy, 323, 413  
*Distylium racemosum*, 488  
 Dorsiventral, 3, 14, 16, 19, 20, 100, 102, 103, 126, 185  
 Dorsiventral mesophyll, 103, 126  
 Downregulated, downregulation, 29, 67, 68, 213, 214, 226, 229, 230, 232, 234, 389, 429, 430, 436–440, 494, 495, 499, 500, 503–505, 509–511, 516–522, 524, 526, 527  
 Drought, 71, 115, 117, 125, 184, 185, 188, 191, 192, 194, 244, 268, 271, 273, 283, 290–293, 295, 296, 299, 371–391, 409, 412, 414, 416, 417, 427–430, 442, 459, 464, 481, 515, 521, 527  
 Dry matter production, 350, 351  
 Dynamic environments, 143, 145  
 Dynamic equilibrium, 474

**E**

Ecotype(s), xxxvii, 37, 39, 41–48, 512, 514  
 Efficiency of photosystem II, 510  
 Efflux channels, 31, 35, 36, 38, 43  
 Electron transport, 142, 147, 148, 150, 166, 172, 173, 191, 256, 323, 373, 376–379, 390, 391, 427–428, 442, 459, 496, 506–508  
 Electron transport rate (ETR), 427–429, 496, 507  
 Elevated CO<sub>2</sub>, 193, 331, 426–430, 432, 433, 435–442, 499, 500, 524  
 Elevated temperature, 515, 516, 527  
 Elliptical, 143  
*Elodea canadensis*, 101, 328, 332  
 Elodeids, 309, 322  
 Embolism, 34, 90, 91, 117, 295, 348, 414  
 Embryophytes, 181, 308–310, 314, 323, 324  
 Endodermis, 103, 126  
 Endoparasite(s), 523, 525  
 Endophytes, 494, 526  
 Endosymbionts, 520  
 Energy balance, 10, 415  
 Energy dissipation, xxxvi, xxxvii, 427–429, 442, 494, 496, 506–511, 515, 516, 521, 526  
 Ensiform leaves, 17, 126  
 Environment, xxviii, xxxii, xl, 2, 10, 13, 30, 45, 47, 48, 68, 69, 90, 98, 99, 106, 107, 109, 119–121, 123–126, 143–145, 148, 149, 152, 154–156, 175, 178, 184, 190, 260, 261, 282, 285, 291, 295, 297, 308–334, 351, 372, 385, 388, 389, 405, 411, 413, 417, 419, 426, 427, 430, 433, 436, 438, 440, 468, 474, 479, 480–484, 487, 493–527  
 Environmental conditions, xxxii, xl, 28, 39, 41, 45, 48, 56, 86, 98, 108, 183, 185, 186, 188, 190, 260, 264, 290, 296, 327, 331, 378, 388, 389, 402, 413, 419, 430, 433, 494, 495, 503, 506  
 Enzymatic activation, 495

- Epidermal, 31, 86, 88, 99, 103, 105, 107, 109, 114, 117, 146–152, 165, 175, 212, 219, 224, 226, 228, 230, 232, 297, 311, 316, 464, 466, 522
- Epidermal peel(s), 146–152
- Epidermis, xxxii, 2, 28, 29, 31, 86, 88, 89, 98, 99, 101–107, 114–119, 147, 151, 175, 177, 228, 287, 288, 293, 330, 332, 348, 358, 477, 478, 502, 520
- Epinastic growth, 406
- Epiphyte(s), xxxvi, 2, 310, 322, 497
- Epiphytic, xxxvi, 284, 290, 291
- Epistomatous, 103, 126, 185
- Ethylene, 10, 190, 321, 322, 381
- Evergreen(s), xxx, xl, 13, 116, 124, 181, 182, 266, 412, 414, 415, 453–457, 461–465, 467, 474, 476, 478, 480, 481, 486, 487, 489, 490, 495, 496, 509, 511, 524
- Evo/devo, 2, 21
- Evolution, evolutionary, 1–21, 40, 61, 81–92, 181, 259, 284, 308, 411, 433, 474, 495
- Evolved, 7, 16, 20, 59, 60, 67, 82, 83, 126, 256, 261, 263, 282, 284, 285, 289, 290, 294–296, 309, 310, 325, 326, 346, 383–385, 436, 479, 495, 505, 523
- Excess energy (E), 427–429, 494, 506
- Excessive PPF, 412, 413
- Excess(ive) light, xiv, xxxvi, 98, 413, 418, 427, 502, 506, 509
- Expansin, 124, 230–233, 239, 515
- Export, xxxii, xxxvi, xxxvii, 28–30, 33, 37, 39, 43–45, 48, 55–73, 87, 89, 92, 330, 494, 495, 500, 502–504, 508, 511, 512, 514, 515, 517, 520, 522, 526
- F**
- Fabaceae, 62, 101, 116
- Facultative CAM, 283, 289, 295, 297–300
- Fallen leaves, 482, 486
- Fast-growing species, 480, 486
- Favorable for photosynthesis, 474
- Favorable period length, 481, 489
- Feedback inhibition, 29, 72, 327, 494, 495, 520, 521
- Ferns, xviii, 4, 7, 8, 28, 85, 89, 90, 107, 181, 182, 321, 463
- Fiber, 28, 122, 128
- Fire, xxvii, xxviii, 381, 494, 505, 527
- Flammable, xxvii
- Flavonoid(s), 323, 494, 502–504
- Floating leaves, 103, 309, 314, 316, 319, 320, 325
- Flooding, 1, 316, 321, 379, 382, 516, 527
- Foliage, 438, 497, 498, 518, 519
- Food, xxvii, xxviii, xxix, 156, 283, 298, 300, 309, 314, 334, 520
- Forest ecosystem, 436, 437, 474, 486, 487
- Fraxinus americana*, 65
- Free air CO<sub>2</sub> enrichment (FACE), 426, 427, 430, 436–438, 440–442
- Free-ending veinlets, 33, 46
- Freezes, 34, 496, 497
- Freeze-thaw, 34, 497
- Freezing temperatures, 114, 495, 511
- Freezing tolerance, 47, 214
- Fructans, 503
- Fructose, 152, 383, 504
- Fruits, xxviii, xxxii, 29, 235, 360, 402, 498, 502, 504, 517
- Fuel(s), xxvii, xxviii, 156, 293, 521, 522
- Functional groups, 125, 181, 318, 373, 453, 455, 456
- Functional leaf longevity, 481, 482
- Fungal, fungi, fungus, 235, 390, 438, 439, 494, 518, 521, 522, 525, 526
- Fusiform, 102, 127
- Fusoid cells, 102, 106, 107, 126
- G**
- Galactose, 30, 35, 64, 320
- Gall(s), 497, 522
- Gas exchange, xxxi, 13, 87, 88, 90, 153, 154, 165, 167–174, 177, 184, 193, 212, 217, 239, 265, 283, 311, 315, 346, 353, 372, 378, 391, 419, 426, 427, 463, 489
- Gene(s), 2–6, 10–17, 19–21, 29, 67–70, 72, 82, 110, 152, 191, 192, 212–224, 226–232, 234–241, 243–246, 264, 273, 285, 286, 297, 316, 320–324, 327, 355, 376, 377, 433, 435, 495, 503, 515, 518, 519, 521
- Genetic constraints, 496
- Genetic factor(s), 2, 6, 10–12, 121, 409
- Genetic variation, 38, 433–435
- Gibberellic acid, 4, 214, 234, 240, 321
- Girdling, 498, 504, 515
- Global warming, 527
- Glopnet, 452
- Glucose, 60, 71, 152, 320, 378, 383, 478, 497, 499, 503, 504
- Glycine decarboxylase complex (GDC), 260
- Grain yield, 145, 346, 351, 355, 365
- Grass(es), xxviii, 101–103, 106, 181, 182, 184, 196, 218, 260, 262, 263, 266, 320, 374, 382, 406, 409, 436, 461, 486, 504, 519, 522, 523
- Gravitropism, 16, 405–406, 410
- Grazing, 438, 439, 519
- Green algae, 271, 308
- Gross primary production, 482
- Growth
  - conditions, xxxvii, 9, 11, 30, 34, 38, 40, 43, 47, 266, 267, 349, 429, 460, 496, 520, 523
  - habit(s), 7, 48, 295, 494, 511
  - light conditions, 43
  - light intensity, growth light intensities, 41, 43, 47, 48, 502, 514
  - temperature(s), 5, 36, 39, 44, 45, 47, 192, 509, 512–514
- Guard cell(s), 86, 107, 115, 142, 143, 147–152, 156, 187, 296, 297, 376
- Gymnosperms, 7, 14, 18, 19, 28, 89, 103, 181, 266
- H**
- Habitat(s)
  - latitude, 41, 47
  - temperature, 41, 43, 47
- Hagen-Poiseuille Law, 34
- Haptophytes, 309
- HCO<sub>3</sub><sup>-</sup>, 9, 193, 256, 257, 264, 265, 283, 284, 308, 311–313, 325–327, 329, 330, 332, 333

- Heavy metals, 317, 372, 433, 517  
 Heliotropism, 402, 407, 410  
 Hemiparasite(s), 523, 524  
 Herbaceous, xxix, 31, 39, 44, 45, 48, 60, 64, 87, 107, 109, 266, 295, 348, 453, 455, 456, 461–464, 474, 475, 486, 487, 495, 496, 499, 510, 511  
 Herbicides, 494, 517, 518  
 Herbivore(s), 67, 116, 117, 214, 234, 408, 426, 438, 439, 466, 475, 477, 482, 487, 497, 518, 519, 521, 522  
 Herbivorous, 9, 482, 518, 520, 521  
 Herbivory, 9, 98, 103, 116, 117, 119, 121, 123, 124, 214, 217, 409, 460, 461, 476, 494, 518–521, 526  
 Heterobaric, 89, 102, 104, 110, 111, 115, 117, 127, 185  
 Heterophyllous, xxxvi, 321  
 Hexose(s), 68, 72, 152, 503  
 High(er) CO<sub>2</sub>, xxxvi, xl, 142, 149, 151, 169, 173, 187, 193, 196, 297, 311, 312, 325, 328, 331, 373, 430–435, 499, 500  
 High light, 29, 32, 33, 35, 41–45, 47, 70, 98, 104–106, 109, 112, 114, 121–124, 174, 260, 308, 313, 325, 327, 329, 332, 380, 383, 402, 411, 452, 501, 502, 508–510  
 High(er) temperature(s), 10, 37, 39, 44, 45, 48, 124, 144, 271, 311, 321, 327, 359, 402, 409, 411, 413, 417, 438, 495, 500, 514, 515  
 History, xxx, xxxi, xxxii, xxxvii, 41, 47, 291, 324, 484, 495, 497, 514, 518  
 Holoparasites, holoparasitic, 523, 524  
 Homobaric, 100, 104, 110, 117, 127, 185  
 Homophyllous, 321  
 Hormone(s), 33, 56, 71, 124, 272, 321, 327, 355, 381, 497  
 Hot-grown, 36  
 Hydraulic conductance, 36–37, 48, 84–91, 114–117, 144, 183, 184, 346, 348, 353, 355, 357–359, 382, 478  
 Hydraulic conductivity, 41, 86, 196, 295, 348, 350, 355, 357  
 Hydraulic failure, 260, 295, 516  
 Hydraulic traits, 294–295  
 Hydrenchyma, 287–293, 295  
*Hydrilla verticillata*, 327, 330, 334  
 Hydronastic, 404, 409, 410  
 Hydrotropism, 406  
 Hyperstomatous, hyperstomatic, 103, 127  
 Hyponastic, 404, 408, 410  
 Hypostomatous, 103, 127, 185, 186  
 Hypothetical maximum photosynthetic rate, 475  
 Hypoxia, 516
- I**  
 Idioblast, 125, 127  
 Increased CO<sub>2</sub>, 499  
 Indeterminate leaves, 2, 18–19  
 Inorganic carbon, 175, 308, 312, 313, 323, 326, 329, 331, 332  
 Insect(s), 9, 16, 67, 116, 117, 310, 384, 385, 413, 417, 438, 439, 482, 486, 494, 497, 519–522, 526  
 Instantaneous photosynthetic rate, 474, 475, 481, 484  
 Intercellular air spaces, 105, 111, 128, 165, 166, 176, 178–180, 185, 186, 188, 196, 212, 213, 217, 236, 237, 239, 241, 263, 299  
 Intercellular CO<sub>2</sub> concentration (Ci), 142, 349, 350, 429, 459  
 Intermediary cells, 28, 31, 35, 38, 58, 64–67  
 Internal air space (IAS), 176, 293  
 Interveinal distance, 260–261  
 Intrinsic water use efficiency, 145, 146  
 Invertase, 64, 504  
 Investment in photosynthetic machinery, 476  
 Iron (Fe), 152, 156, 372, 377  
 Isobilateral mesophyll, 127  
 Isodiametric, 101, 127  
 Isoetids, 309, 314, 321, 322, 325, 333  
 Isolateral mesophyll, 127  
 Isoprene, 430, 503, 508, 515  
 Isoprenoids, 508
- K**  
 Kranz anatomy, 31, 103, 260, 262, 273, 290, 326, 328  
 Kranz-type, 257, 258, 260, 267, 270, 272, 273
- L**  
 Lacuna, 312, 314, 316, 317, 321, 325, 329  
 Lake, xxxv, 179, 308, 309, 319, 325, 329, 331, 332  
 Lamina, 2–7, 10–17, 28, 29, 59, 85, 90, 99, 117–119, 223, 316, 386, 402, 403, 405–409, 412–416, 419, 461, 466, 478  
 Laminar density, 478  
 Laminar thickness, 478  
 Large pots, 501, 508  
 Lateral, 2, 3, 12, 16, 19, 20, 102, 110, 127, 177, 185, 271  
 Latitude, 41, 45, 47, 411, 412, 474, 481, 487, 488  
 Laurel(s), xxviii, xxix  
 Leaf(s)  
   anatomy, 87–88, 98–126, 184, 185, 187, 261–262, 269, 274, 288, 293, 294, 299, 326, 459, 460  
   architecture, 211–246  
   area index, 362, 440  
   area per plant, 501  
   biomass, 481, 482, 484  
   blade formation, 2–6  
   curling, 416, 417  
   economic(s) spectrum, 87, 126, 402, 451–468, 474, 478, 480, 487, 489  
   fluttering, 406, 409  
   form, xxvii, xxxii, 5, 7, 15, 16, 47, 99, 288, 290, 314, 315, 321, 416  
   growth, 112, 212, 213, 217, 219, 221, 228, 230, 233, 235, 244, 245  
   index, 2, 7–13  
   lamina movement, 402, 407, 416  
   lifespan (LL), 99, 116, 436, 451–455, 457–461, 467, 468, 489  
   life-time gain, 482  
   lifetime performance, 481–483  
   longevity, 116, 415, 474–482, 484, 486–490

- Leaf(s) (*cont.*)  
 mass per area, leaf dry mass per unit leaf area  
 (LMA), 41, 42, 239, 316, 451–453, 456, 462, 474,  
 478, 514  
 movement classification, 403  
 nitrogen content, 346, 352, 353, 355, 357, 363, 456,  
 457, 459  
 optics, 104–107  
 production, 474, 481, 482, 486  
 production rate, 481, 482  
 rolling, 415–417  
 segment(s), 149–151, 272  
 shape, xxxi, 1–21, 28, 219, 232, 236, 314  
 shedding, 474–476  
 size, 10, 12, 13, 113, 212, 228, 231, 236, 381, 416,  
 501  
 thickness, 4, 5, 9, 29, 45–47, 88, 111, 112, 114, 115,  
 117–119, 123–125, 154, 185, 186, 214, 216, 237,  
 241, 287–289, 296, 297, 316, 318,  
 476, 478, 509  
 turnover, 474  
 venation, 87, 282  
 width, 7–11, 113, 212, 222, 223
- Leaf-like organs, 19–21, 182
- Leakiness, 266–268
- Lifetime carbon gain, 474, 481
- Life time gain, 482
- Lifetime leaf loss, 483
- Lifetime photosynthetic gain by a single leaf, 483
- Light absorption, 10, 98, 99, 104–107, 113, 125, 310,  
 322, 386, 389, 390, 460
- Light absorption efficiency, 322
- Light attenuation, 178
- Light collection, 508
- Light compensation point (LCP), 174, 440
- Light gradient, 104–107, 122, 123, 126, 192
- Light harvesting/light-harvesting, 308, 322, 323, 373,  
 377, 378, 383, 459, 497, 500
- Light intensity, 5, 29, 41, 43–45, 47, 104, 105, 107,  
 110, 115, 121, 123, 144–146, 152, 154, 168,  
 171, 192, 194, 195, 214, 216, 271, 297, 348, 380,  
 402, 411, 417, 432, 440, 499, 502, 503, 506, 507,  
 514, 517
- Light interception, 98, 116, 119, 211, 244, 263, 387, 402,  
 408, 412, 413, 417
- Light response curve, 411
- Light saturation, 104, 122, 181, 182, 322,  
 411, 418, 440, 506
- Lignified, 31, 88, 114, 116, 125
- Lignin, 103, 114, 126, 127, 241, 295, 308, 309, 311, 320,  
 321, 460, 503, 504
- Litter trap, 482, 483, 486
- Lockhart equation, 403
- Logistic equation, 485
- Longitudinal, 3, 4, 7, 12, 86, 101, 102, 127, 223
- Low light, low-light, lower light, 5, 29, 32, 33, 36, 39,  
 41, 43, 44, 70, 104–106, 112, 121–123, 192, 242,  
 271, 322, 323, 329, 332, 411, 413, 498–502,  
 508–511
- Low oxygen, 191, 497
- Low temperature(s), xxxvii, 10, 13, 33, 37, 39, 43–45,  
 48, 121, 124, 214, 402, 408, 412, 414, 415, 417,  
 500, 511–514, 526
- Low water potential, 44, 321, 409, 416
- M**
- Macroalgae, 308, 310, 320, 330, 332
- Macrophyte, 308–310, 314–317, 319, 320, 322, 323,  
 325, 326, 328–333
- Maize, 4, 5, 7, 71, 72, 190, 263, 271, 327, 348, 349, 362,  
 363, 380–383
- Major vein(s), 13, 34, 43, 88, 114, 117
- Malic enzyme (ME), 175, 256, 257, 283, 325
- Mallotus, 487
- Malva neglecta*, 39, 40, 510
- Manganese (Mn), 372, 378, 382, 389, 390
- Mangroves, 90, 516
- Mannitol, 64, 66
- Marijuana, xxx
- Marker-assisted selection, 346, 355, 365
- Mass-based trait, 453–457, 467
- Mean annual temperature (MAI), 12, 481, 489
- Mean labor time, 475, 480, 481
- Mechanical disturbance, 409, 497
- Mechanical function, 116–119
- Mechanical stress, 98, 116, 308, 320, 331, 461
- Medial, 101, 127
- Medio-lateral, 12, 101, 102
- Membrane stabilizers, 503
- Meristem(s), 2, 4–7, 12, 14, 15, 18, 19, 99, 101, 121,  
 127, 212, 235, 406, 519
- Mesophyll cell, 30, 31, 35, 42, 55–60, 62–66, 69, 87, 98,  
 101, 103, 105, 108, 112, 115–117, 123–125, 148,  
 150, 170, 176, 178–180, 185, 186, 196, 212, 213,  
 228, 230, 232, 236, 237, 239, 257, 287–290, 293,  
 297, 322, 358, 425, 459, 460, 463–466, 512, 513
- Mesophyll cell surface area, 239
- Mesophyll cell wall, 117, 123, 196, 452, 459, 463–466
- Mesophyll conductance, 108, 109, 111, 112, 121, 125,  
 165–196, 239, 241, 264–266, 274, 347, 358,  
 372–375, 379, 384, 387, 389, 459, 460,  
 463–465, 467
- Mesophyll resistance, 179, 347
- Mesophyll signal, 142, 148, 150–152, 156
- Mesophyte, 124, 522
- Mesophytic, 28, 31, 511, 515
- Mestome sheath, 100, 103
- Metabolic scaling equation, 484
- Microbiome, 518
- Midday and afternoon depression of photosynthesis,  
 353–354
- Midday depression in CO<sub>2</sub> uptake, 515
- Minor vein, 30, 32–43, 46, 48, 57–59, 62, 64, 68,  
 512, 514
- Mistletoe(s), 523–525
- Mitochondria, 112, 171, 175, 178–180, 187, 222, 259,  
 262, 263, 269–271, 283, 463, 504, 505
- Moderate light, 33, 45, 98, 173, 323
- Moderate temperature, 33, 43, 45, 515

- Modulation, 112–113, 165, 189, 214, 225, 232, 236, 246, 493–527
- Modulus of elasticity, 116, 291, 382
- Monocot(s), 16, 17, 19, 21, 68, 99, 101, 218, 261, 266, 270, 285, 286, 294, 382
- Monocotyledon, 19, 300, 309, 310, 314, 327
- Morphology, 9, 13, 14, 16, 19, 61, 62, 70, 87, 98, 99, 110, 119, 154, 212, 223, 226, 269, 285–286, 314, 321, 331, 332, 334, 386, 402, 442, 451, 452, 512
- mRNA, 3, 4, 14, 329, 497
- Mutualistic, 494, 518, 519, 526
- Mycorrhizae, 426, 525, 526
- Mycorrhizal, 390, 494, 518, 525, 526
- N**
- NADPH, 147, 151, 172, 323
- Nastic, 16, 403, 404, 408, 417
- Natural variation, 7–10, 14, 434, 508
- Near isogenic line (NIL), 346, 355–357
- Net carbon gain, 242, 474
- Network(s), 11, 27–29, 64, 81, 82, 86, 89–90, 110, 114, 212, 222, 225–228, 230, 452, 458, 478, 495, 497, 514
- Nitrogen (N), 108, 112, 116, 119, 121, 178, 184, 189, 193–196, 260, 267, 313, 319, 321, 329, 333, 346, 352, 353, 355–357, 363, 365, 372, 373, 413, 428, 433, 434, 437, 452, 454–457, 459, 462, 463, 474, 478, 480, 486, 489, 494, 497, 500, 503, 505, 517, 518, 522, 523, 526, 527
- Nitrogen-fixing, 494, 518, 523, 526
- Nocturnal leaf freezing, 416
- Non-photochemical dissipation, 414
- Nonphotochemical quenching, 496, 506, 507
- Non-photosynthetic tissue, 476, 522
- Nonstructural carbohydrates, 321, 432, 504, 508, 516
- Normalization constant, 484
- Nutrient
- availability, 98, 319, 321, 333, 382, 442, 497, 505, 517
  - limitation, 319, 500, 517
- Nyctinastic, 404, 408, 416
- O**
- Ontogenetic, 99, 119, 127
- Opportunistic annuals, 495
- Optimum timing of leaf shedding, 475
- Osmolytes, 297, 463, 516
- Osmoregulants, 503
- Osmotic, 58–60, 68, 71, 90, 143, 157, 162, 190, 292, 346, 347, 382, 502, 515
- adjustment, 71, 347, 502, 515
  - potential, 58, 60, 292, 382
- Osmotica, 147, 346
- Ottelia alismoides*, 328
- Overexpression, 12, 14, 19, 44, 70, 152, 220, 231, 235–237, 243, 299, 384, 499, 505, 516, 521
- Overheating the leaf lamina, 416
- Oxygen (O<sub>2</sub>), 44, 45, 98, 124, 168, 170–172, 175, 179, 184, 187, 190, 262, 265, 273, 311, 312, 317, 319, 323–325, 333, 372, 378, 379, 381, 412, 497, 501, 502, 505, 511, 512, 514, 516
- Ozone, 517
- P**
- Package effect, 322
- Palisade mesophyll, 41, 42, 60, 287–289, 293, 299, 512
- Palisade tissue, 101–103, 105, 114, 117, 121, 124, 154, 217, 232, 241, 512
- Paradermal, 105
- Paraheliotropic, 390, 402, 407, 408, 410, 411, 413, 416, 417
- Parasite(s), 523, 524
- Parasitic, 1, 7, 35, 494, 522, 523
- Parasitize, 523
- Paraveinal, 101, 116
- Parenchyma, 31, 33, 35, 36, 38–43, 45, 46, 57, 58, 60–62, 70, 71, 73, 98–101, 103, 121, 289, 319, 387, 520
- Pathogen(s), 57, 109, 116, 121, 235, 308, 406, 416, 417, 438, 494, 518, 521–525, 527
- Pathogenic, 521, 525, 526
- Pea, 36, 62, 71, 72, 375, 390, 513, 522
- Pectin methylesterase inhibitor, 211, 235, 238, 240, 243
- Pectin methyltransferase (PMT), 211, 218, 220, 221, 235–236, 240, 243, 246
- Peltate, 2, 14–16, 119, 120
- Perennial(s), 433, 435, 486, 495
- Periclinal, 125
- pH, 124, 151, 178, 190, 313, 329, 330, 377, 380
- Phenolic, 320, 494, 503
- adjustment, 495
- Phenotypic adjustment, 495
- Phenotypic plasticity, 30, 38, 41–48
- Phloem
- loading, 494, 523–525
  - parenchyma cell, 33, 35, 36, 38–43, 45, 46, 58, 61, 62, 70
  - tapping, 494, 523–525
- Phosphoenolpyruvate carboxykinase (PEPCK), 257, 282, 326, 327
- Phosphoenolpyruvate carboxylase (PEPC), 112, 169, 171, 175, 176, 256, 257, 263–265, 269, 282, 283, 325–328, 333
- Phosphorus (P), 313, 319–321, 333, 439, 452, 455, 489
- Photochemical efficiency, 509, 510, 526
- Photoinhibition, 188, 271, 311, 313, 322, 412–414, 419, 428, 430, 494, 509, 526, 527
- Photomorphogenic, 497
- Photon dose, 412
- Photon flux density (PFD), 39, 70, 153, 172, 407, 428, 434, 496, 499, 507
- Photooxidation, 412
- Photoprotection, 311, 323, 414–416, 506
- Photoprotective, 322, 323, 414, 415, 496, 506–508, 510, 511, 516, 521
- Photoreceptor(s), 124, 272, 497

- Photorespiration, 113, 169, 170, 173, 175, 179, 191, 192, 264, 266, 311–313, 324, 325, 327, 329, 374, 376–380, 383, 391, 428, 505, 515
- Photosaturating, 411, 412
- Photosynthate, 29–34, 37, 55–73, 87, 89, 90, 99, 116, 243, 288, 437, 439, 452, 475, 494, 495, 497–499, 502–504, 506, 508, 515–517, 520–526
- Photosynthesis, 16, 27–48, 56, 81–92, 98, 141–156, 165, 212, 256, 282, 309, 345–365, 371–391, 401–419, 428, 452, 473–490, 494
- Photosynthetic
- apparatus, 116, 120, 372, 373, 376, 378, 380, 403, 412, 418, 499, 502, 509
  - capacity, 37–39, 41, 43–45, 123, 152, 169, 365, 411, 429, 508, 512
  - carbon gain, 411, 508
  - electron transport, 147, 148, 323, 377–379, 390, 391, 442, 496, 506, 507
  - enzymes, 243, 263, 270, 373, 416, 499, 500, 504
  - genes, 29, 495, 503, 519, 521
  - modulation, 493–527
  - oxygen evolution, 40, 45, 502, 511, 512, 514
  - proteins, 121, 452, 458–461, 463, 466, 467, 499, 504
  - reactions, 388, 509
  - stems, 290, 291, 406, 487
  - tissue, 28, 31, 81, 83, 84, 165, 166, 168, 169, 176, 178, 184, 190, 287, 476, 522, 525
- Photosynthetic nitrogen use efficiency (PNUE), 189, 373, 374, 385, 433, 434, 453, 458–460, 466, 467
- Photosystem, 98, 104, 122, 124, 172, 173, 256, 322, 375, 384, 412–415, 427, 496, 506–511, 515, 516, 526
- Photosystem II
- core proteins, 509
  - efficiency, 496, 506–511, 515, 516
  - photochemistry, 509
- Phototropism, 154, 402, 405, 407
- Physical strength, 461
- Phytochrome, 124, 190, 227, 234, 240, 272, 321
- Phytochrome-interacting factors (PIF), 213, 214, 217, 228–230, 232–236, 240, 246
- Pitcher leaves, 2, 15, 16, 21
- Plagiotropic, 121
- Plantago major*, 66
- Plant plastron, 316
- Plasmodesmata(l), 30, 35, 38, 56–69, 71, 267–268
- Pollution, 427, 494, 517
- Polymer trap, 20, 37, 38, 56–58, 63–67, 69, 70
- Populus deltoides*, 63–64, 101
- Populus tremula X alba*, 64
- Pore, 66, 82, 86, 89, 101, 110, 143, 167, 169, 176, 186, 187, 196, 296–298, 319, 381
- Porosity, 99, 109–111, 115, 116, 125, 185, 187, 188, 264, 265, 381, 436, 441, 464
- Potassium (K), 59, 297, 372, 376–377
- Potential leaf longevity, 475–477, 484
- Pots, 186, 390, 436, 442, 443, 500–502, 508
- Precipitation, 31, 45, 47, 109, 125, 330, 358–360, 362–365, 430, 480, 495, 515
- Pressure
- gradient, 30, 59, 92, 416
  - potential(s), 29, 34, 497, 510, 515
- Primordium, 3, 4, 6, 10, 13, 15, 20, 99
- Production of a stand, 486
- Protect, 57, 67, 90, 103, 116, 502
- Proximal-distal, 13–16
- Proximal-distal pattern, 13–15
- Pruning, 498, 500, 505
- PsbS, 506
- Pulvinus, 402, 406–408
- Pumpkin, 32, 33, 35
- Pyriiform, 102
- Pyrophosphatase, 68, 70
- Pyruvate phosphate dikinase (PPDK), 283, 327
- Q**
- Quadratic equation, 485
- Quantitative trait locus (QTL), 346, 355, 357, 358
- Quercus petraea*, 486
- R**
- Radial, 17, 101, 103, 292, 326, 348, 441
- Raffinose, 30, 35, 38, 57, 63–67, 70, 98, 503
- Rate of decline in photosynthetic capacity, 474
- Reactive oxygen, 124, 273, 323, 412, 497
- Realized longevity, 476
- Red light, 106, 107, 124, 142, 147, 148, 150, 154, 217, 321, 518
- Red to far-red ratio, 497
- Reduced oxygen, 501
- Reflection, 98, 99, 105, 119, 310, 322, 518
- Relative growth rate (RGR), 242, 244, 319, 433, 435, 484, 485
- Repeated measurements, 476, 477, 486
- Reproduction, 244, 245, 346, 505, 521
- Resistance, 34, 86–88, 90, 108, 109, 111–115, 117, 119, 125, 146, 165, 169, 171, 174, 178–180, 184–188, 193, 222, 227, 230, 235, 239, 259, 267, 293, 320, 329, 332, 346–353, 359, 361, 362, 381, 383, 402, 414, 417, 423, 526
- Resistance to water transport, 346–353, 361, 362
- Respiration, 150–152, 169–175, 178, 179, 192, 239–246, 264, 266, 291, 297, 311–313, 317, 324, 325, 327, 329, 374, 376–384, 388, 391, 428, 441, 451–457, 459, 467, 481, 482, 484, 489, 504, 505, 511, 515
- Restricted rooting, 499, 501
- Resupinate leaves, 99, 103, 121
- Rhizophytes, 309
- Rhizosphere, 437
- Ribulose bisphosphate (RuBP), 147, 148, 151, 172, 173, 175, 323, 324, 347, 373, 375–377, 379, 384, 505
- Ribulose bisphosphate carboxylase oxygenase, 147, 505
- Ribulose 1,5-bisphosphate carboxylase/oxygenase, 108
- Rice, 12, 16, 17, 21, 60, 68, 72, 112, 185, 186, 189, 191, 192, 195, 261, 263, 264, 327, 334, 346, 348–359, 365, 380, 485



- Root  
   growth, 244, 245, 346, 347, 359, 405, 406, 500, 501, 515, 516  
   surface area, 346, 348, 350, 353, 355, 357  
   system, 7, 45, 346, 348, 359, 362, 365, 436–438, 495, 500, 503, 515, 516, 518–520, 526  
 Rooting volume, 497, 499–501  
 Roots to shoots, 354  
 Rubisco, 108, 113, 122, 164, 169, 171, 174–176, 179, 180, 184, 189, 214, 216, 237, 239–241, 244, 246, 256, 257, 259–264, 266, 284, 285, 287, 294, 299, 323–329, 347, 353, 355, 357, 373–377, 379, 380, 384, 387, 388, 428, 458–463, 466, 467, 505  
 Rubisco activase, 113, 324
- S**
- Salicaceae, 62, 64  
 Salinity, 196, 231, 260, 271, 283, 310, 412, 417, 494, 516–517, 526  
 Scaling exponent, 484  
 Sclereidal cell, 88, 125, 127  
 Sclerenchyma, 117, 374  
 Sclerophyllous, 109, 496  
 Sclerophytic, 31, 511  
 Seagrass, 308, 316, 320–323, 333  
 Seasonal environment, 474, 480–484  
 Seasonal precipitation, 358–360  
 Sediment, 308–310, 317, 319, 325, 326, 333, 405  
 Sedimental amyloplast, 405  
 Seed(s), 11, 29, 47, 68, 72–74, 214, 362, 363, 433, 439, 485, 495, 505  
 Self-shaded, 506  
 Self-shading, 10, 13, 14, 18, 320, 332, 500, 506  
*Senecio vulgaris*, 32, 36, 62  
 Senescence, 27, 346–348, 354, 362, 363, 365, 372, 495  
 Sensitive plant, 409, 419  
 Serrated margins, 12–13  
 Shade leaves, 88, 106–108, 110, 118, 119, 121, 123, 124, 192, 195, 241, 510  
 Shade tolerant, 121, 479  
 Shading, 122, 124, 273, 380, 408, 475, 498, 506, 514  
 Shear, 8, 116, 117  
 Shoot(s), 2, 4–7, 9, 10, 16–20, 99, 114, 119, 121, 122, 214, 235, 244, 309, 312, 313, 317, 320, 321, 325, 332–334, 346–348, 354, 355, 359, 365, 378, 381–383, 403, 405–408, 410, 428, 433, 439, 476, 497, 501, 502, 504, 505, 507, 508, 515–519, 522, 525, 526  
   system, 7, 508, 518, 519  
 Shredders, 72, 497–501, 505, 509  
 Sieve  
   effect, 105  
   element(s), 28–31, 33–36, 38–47, 57, 60, 61, 63, 514  
   tube, 30, 55–58, 60, 63, 64, 71, 512, 514  
 Signal(s), 72, 121, 124, 142, 146–152, 156, 174, 213, 214, 246, 270, 272, 372, 402, 407, 417, 419, 498, 503, 526  
 Signaling, 5, 27, 71, 72, 124, 125, 143, 147, 152, 213–217, 228, 236, 246, 273, 297, 388, 389, 391, 495, 497, 518, 520  
 Silica, 117, 308, 313, 320  
 Single-cell, 4, 61, 257–259, 266, 267, 271, 284, 326, 327, 334  
 Sink  
   activities, 436, 495, 527  
   activity, 29, 73, 494, 495, 497–506, 508, 509, 511, 515–517, 519, 520, 528  
   strength, 72, 497–501, 505, 509  
 Sleep movements, 408  
 Slow-growing species, 480, 486  
 Slow strategy, 487  
 Small peptide, 497  
 Small pots, 501, 502  
 Small RNAs, 56, 497  
 Snow-free period, 488  
 Soil  
   alkalinization, 517  
   compaction, 372, 381–383, 389, 390  
   compactness, 381, 497  
   composition, 497  
   conditions, 84, 348, 364, 365, 373–388, 391, 436, 439, 497  
   water potential, 346–348, 364  
 Soil-plant-atmosphere continuum (SPAC), 347, 348  
 Solar  
   azimuth, 407  
   direct beam, 402, 403, 405–407, 413  
   elevation, 407, 411  
 Solubility, 109, 111, 187, 312–314, 317, 377  
 Solute(s), 30, 44, 57–64, 68, 70–73, 143, 186, 292, 494, 503, 511, 515, 516  
 Sorbitol, 66, 71, 72, 515  
 Source activity, 494, 495, 519, 523  
 Source and sink, 72, 180, 494, 502, 508, 523–527  
 Source leaves, 27, 29, 30, 57, 59, 72, 73, 374, 377, 495, 498, 500, 504, 517, 521–523, 525  
 Source-sink, 72, 180, 494, 502, 508, 523–527  
 Source strength, 498, 500, 505  
 Source to sink, 29, 59, 68, 69, 72, 175, 398, 494, 498–500, 503, 505, 506, 509, 519, 521, 524, 528  
 Soybean, 191, 192, 346, 348, 349, 360, 363, 377, 382, 390, 499, 500, 522  
 Spatial, 14–16, 83, 86, 144, 177–179, 256, 257, 259, 263, 296, 330, 388, 405, 436  
 Species richness, 474, 488  
 Specific activity of Rubisco, 459, 460, 467  
 Specific leaf area, 242, 287, 316, 318, 373  
 Spinach, 33, 39, 70, 104, 324, 377, 379, 513  
 Spongy mesophyll, 176, 287–289, 299, 322  
 Spongy tissue, 16, 101, 103, 105, 114, 117, 121, 154, 177, 212, 232  
 Stachyose, 30, 63–65, 67, 70  
 Starch, 29, 59, 61, 68, 69, 71, 98, 187, 193, 261, 283, 320, 321, 323, 328, 375, 376, 378, 406, 434, 439, 503, 504, 515, 517, 520, 526  
*Stewartia monadelpha*, 488, 489  
 Stiffness, 116–119

- Stoma, 128, 148, 187
- Stomata, 28, 29, 31, 37, 44, 82–84, 87, 88, 90, 98, 99, 103, 107, 109, 114, 115, 120, 142–156, 165–169, 175–177, 180, 182, 183, 185, 188, 193, 196, 230, 260, 282–285, 288, 292, 294, 296–298, 300, 308, 309, 311, 314–316, 321, 347, 350, 353, 376, 384, 416, 417, 428, 440, 460, 463, 520, 521
- Stomatal aperture, 89, 113, 143, 144, 146, 147, 151, 152, 156, 351, 407
- Stomatal behavior, 141–156
- Stomatal conductance, 83–85, 108, 109, 113, 119, 152–156, 166, 168, 177, 178, 181, 184, 189, 191, 267, 293, 294, 297, 299, 300, 346, 347, 349, 350, 353, 357, 359, 362, 373, 375, 377–380, 382, 387, 389, 412, 428, 432, 434, 435, 438, 439, 459, 460, 464, 478
- Stomatal density, 143, 144, 154, 232, 296, 297, 321, 387
- Stomatal opening, 124, 142, 147, 148, 150–152, 154, 282, 375, 376, 389, 406, 510, 516
- Stomatal patterning, 286, 296–299
- Stomatal resistance, 119, 347, 348
- Structural, 27, 28, 31–33, 98, 112, 114, 116, 166, 176, 179, 180, 184–188, 218, 256, 257, 259, 262, 264–269, 273, 307–334, 374, 388, 452, 453, 458–461, 463, 466–468, 476, 478, 494, 512, 514
- Structure, 4, 5, 18–20, 66, 67, 69, 71, 87, 98, 99, 102, 116–118, 120, 126, 154, 176–178, 180, 182, 255–274, 294, 296, 299, 309, 314, 316, 321, 372, 376, 377, 379, 381, 388, 391, 403, 404, 409, 432, 435, 440, 442, 457, 458, 464, 466, 468, 476, 478, 494, 514
- S-type anion, 150, 151
- Subcellular structure, 262–264
- Suberization, 31, 269
- Submerged, 2, 9, 10, 107, 273, 309, 314–318, 320–323, 327–329, 332
- Substomatal cavity, 108, 178
- Succulence, 285–287, 290–295, 299, 300
- Sucrose, 30, 31, 35, 36, 38, 43–45, 47, 56, 61, 64, 66, 67, 98, 143, 152, 323, 375, 376, 378, 383, 412, 497, 504, 508, 512–514  
export, 43–45, 71, 504, 512
- Sucrose export, 43–45, 71, 504, 512
- Sugar  
alcohol(s), 30, 31, 35, 55, 62, 66, 98, 498, 503  
export, 29, 39, 48, 508, 512, 514, 515  
feeding, 34, 499  
flux, 34–36, 39  
loading, 512  
unloading, xxxii
- Sulfur dioxide, 517
- Sulphated polysaccharides, 308, 320
- Summer  
annual(s), 36, 38, 382, 515  
temperatures, 40
- Sunfleck, 123, 313, 414, 427, 506, 507
- Sunflower, 36, 154, 381–383, 390, 407, 515
- Sun leaves, 88, 106, 108, 118, 119, 121, 123, 192, 195, 508
- Surplus production, 482, 484, 486
- SWEET  
proteins, 35, 61, 72  
transporters, 57
- Symbiont(s), 437, 439, 497, 518, 520, 525, 528
- Symbioses, 525–526
- Symbiotic(ally), 526
- Symplast, 35, 60, 62–64, 68, 72, 73, 114, 115
- Symplastically, 32, 35, 37, 38, 57–59, 61, 66
- Symplastic loader(s), 30, 33, 35, 38–40, 58
- Symplastic loading, 30, 56, 57, 62–65, 68, 70
- Symporter(s), 31, 35, 36, 38, 61, 62, 508, 513
- T**
- Tea, xxx
- Temperature  
modulation, 112–114  
regime(s), 32, 37, 41, 45, 514  
response curve, 416
- Temporal, 14, 144, 297–299, 436
- Tension, 34, 81, 83, 90, 353
- Terete leaf, 3, 17, 101, 127
- Thermal energy dissipation (D), 427–429, 442
- Thermonastic, 402, 404, 408, 414, 415
- Thermotolerance, 515
- Thigmonastic, 404, 409, 417
- Thigmotropism, 406
- Tiliaceae, 62
- Tiller angle, 406
- Tillering, 505
- Tillers, 406, 519
- Tobacco, 68, 69, 154, 155, 189, 190, 192, 193, 327, 500, 508, 515, 521, 522, 525
- Tortuosity, 99, 109–111, 125, 128, 185, 186
- Tortuosity factor, 109, 110
- Tracheary element(s), 30, 31, 33, 34, 36–38, 42, 44, 46, 48
- Trade-off, 8, 87, 116, 125, 126, 142, 214, 217, 264, 299, 307–334, 453, 459, 461, 463, 466, 474, 476, 487
- Transcription factor(s), 4, 7, 12, 16, 19, 47, 56, 213, 214, 217, 233, 234, 240, 273, 299, 497
- Transfer cells, 28, 41, 43, 61, 62, 67, 70, 330, 514
- Transgenic, 65, 69, 146, 147, 151, 152, 190, 191, 220, 233, 238, 282, 384, 504
- Translocation, 29, 57, 58, 65, 71, 144, 504, 516, 517
- Transpiration(al), 10, 13, 28, 36, 37, 42–48, 83, 84, 86–88, 92, 99, 108, 113, 114, 125, 142, 144, 145, 167, 169, 232, 264, 283, 285, 292, 295, 296, 311, 347–350, 353, 377, 378, 382, 389, 403, 408, 409, 412, 414, 416, 418, 438, 453, 482, 497  
cooling, 45, 48, 113, 414
- Transporter(s), 58, 60, 66–68, 73, 150, 327, 389, 504, 514
- Transport proteins, 35, 39, 45, 47, 62, 70, 513
- Transverse, 101, 102, 217, 223–225, 272, 358
- Trichome(s), 7, 103, 119–121
- Tropic, 12, 222, 403, 404, 407, 417, 480, 481
- Tuberous, 498
- Tubers, 29, 505
- Tumors, 235, 522

Turgor, 31, 58, 71–73, 84, 91, 92, 99, 107, 115, 117–119, 143, 147, 212, 221, 222, 291–293, 346, 382, 402, 403, 405, 407, 409, 515  
 Turgor pressure, 31, 56, 72, 73, 107, 117, 118, 212, 221, 292, 403, 407, 409

**U**

Ultraviolet radiation, 323  
 Unfavorable period, 480, 481, 487  
 Unifacial leaf, 17, 101, 128  
 Unifacial leaves, 2, 16–18, 100, 102  
 Uniseriate, 120, 128  
 Upregulated, 36, 43, 45, 61, 213, 230, 231, 327, 328, 494, 502, 518  
 Upregulates, 37  
 Upregulation, 30, 33, 34, 41, 43–45, 48, 67, 223, 226, 229, 232, 234, 240, 374, 377, 428–430, 494, 495, 498, 500, 501, 504, 509–512, 514, 519, 521, 522, 524, 525

**V**

Vacuolar storage, 285, 292, 299  
 Vapor  
   pressure deficit, 37, 42, 46, 145, 346, 348, 353, 359, 383, 412  
 Vascular  
   bundles, 31, 99, 101, 103, 114, 258, 262, 263, 270, 272, 294, 358, 520  
   tissue, 59, 60, 117, 175, 257, 262, 476, 522–525  
 Vasculature, 27–48, 87, 99, 101, 103, 114, 115, 185, 212, 290, 294–296  
 $V_{\text{cmax}}$ , 433, 434  
 Vein density, 28–30, 32–34, 36–39, 42–44, 47, 48, 71, 87–90, 257, 261, 262, 297, 508  
 Vein evolution, 90  
 Veinlets, 28, 33, 46  
 Venation, 28, 31–33, 82, 86, 87, 212, 294, 295, 458, 478  
 Verbascode, 30  
*Verbascum phoeniceum*, 33, 39, 40  
 Vertical leaf position, 413, 416  
 Vessel, 88, 90, 295, 312, 320, 442  
 Violaxanthin, 496, 506, 507  
 Violaxanthin de-epoxidase, 506  
 Virus(es), 62, 67, 70, 218, 219, 494, 521, 525  
 Volatile organic compounds, 494, 503, 508

**W**

Warm conditions, 33, 512  
 Warm-grown, 512–514  
 Water  
   availability, 47, 81, 84, 115, 125, 128, 156, 260, 292, 297, 310, 311, 328, 383, 384, 389, 390, 407, 408, 412, 416, 417, 440, 443, 487, 495, 497, 515–516, 525  
   conservation, 45, 334, 416  
   flux, 30, 347, 348

logging, 497  
 loss, 36, 37, 43, 48, 84, 103, 109, 119, 142–145, 260, 285, 296, 297, 300, 315, 346, 347, 387, 409, 414, 416, 418, 515  
 potential, 29, 30, 37, 44, 82, 84, 86, 87, 89, 91, 92, 117, 260, 261, 291, 292, 295, 310, 321, 346–348, 351, 353, 361, 362, 364, 382, 409, 411, 414, 416, 515  
 storage, 257, 261, 262, 287–289, 292, 296  
 stress, 89–92, 118, 125, 189, 271, 273, 308, 311, 316, 321, 332, 346, 353, 359, 383, 384, 389–391, 393, 411, 428, 500, 515, 516, 524, 526  
 transport, 34, 36, 37, 45, 47, 81–92, 98, 99, 114–116, 125, 346–353, 362  
 uptake, 292, 347–348, 355, 406  
 use efficiency (WUE), 109, 119, 120, 143–146, 156, 184, 192, 282, 283, 293, 296, 300, 374, 408, 412, 416–418, 434, 440, 464  
 vapor, 34, 44, 82, 83, 86, 88, 113, 143, 165, 167, 183, 296, 515

Waxes, 503

Wheat, 144, 193, 346, 359, 360, 363–365, 373, 390, 515, 520

Wilting, 402, 404, 409, 410, 412, 414, 416, 418, 516

Wind

  speed, 10, 113, 114, 310, 432  
 swept canopy, 406

Winter

  annual(s), 28, 33, 36, 37, 39, 43–45, 47, 48, 71, 412, 418, 495, 499, 511, 512, 514  
 temperatures, 40, 414, 418, 480  
 tolerance, 415

Witches' broom(s), 525

Wood, 220, 406, 441, 522

Woodiness, 295, 296

Woody biomass, 487

Woody plants, 31, 90, 426, 478, 486, 523

Woody species, 32, 64, 117, 372, 453, 455, 456, 461, 463

Wounding, 521

**X**

Xanthophyll cycle, 311, 323, 412, 414, 496, 506–510

Xeromorphic, 109, 125

Xylem

  evolution, 82, 83  
 pressure, 295  
 stomata coordination, 88  
 tapping, 494, 523, 524

Xyloglucan endotransglucosylase/hydrolase (XTH), 223, 230–235

**Y**

Young's modulus, 118

**Z**

Zeaxanthin, 494, 496, 506–511, 515, 516

Zinc (Zn), 372, 374, 380, 382, 389