

Index

Numbers: **bold**=table, *italics*=figure.

- 4P-ADOT, 64, 67
- 4P-PDOT, 63, **64**, 64, 67
- acetylcholinesterase, 71
- acetylserotonin O-methyltransferase (ASMT), 321
- active-inactive cycles, 13, *190*
- Actiwatch, 367, 369
- AD. *See* Alzheimer’s Disease
- ad libitum* feeding (ALF), 242
- adaptive immunity, 186, *188*, 257, **257**, 263, 267
 - circadian rhythms, 259–260
- adenosine triphosphate (ATP), 145
- adenylyl cyclase, 59, *145*, 321
- adipocytes, 230, 232
- adrenal cortex, 28, 85
- adrenal gland, 5, 85
- adrenocorticotrophic hormone (ACTH), 85
- advanced sleep phase (ASP), 269
- advanced sleep phase syndrome (ASPS), 59, 70
- aerial photography, 364–365
- AeroCube satellites, 363
- aging, 165–182
 - changes in master circadian pacemaker, 167–170
 - circadian rhythm alterations, 166–167
 - hallmarks, 166
 - molecular basis of circadian rhythms, 170–172
- agomelatine, 70, 109
- AHA Scientific Statement (2017), 239
- ALAN. *See* artificial light at night
- allostasis: definition, 84
- allostatic load, 86, 89, 93, 94
 - circadian disruption, 90–93
- allostatic mediators, 90, *91*, 94
- allostatic overload, 86, 93, 94
- Alzheimer’s Disease, 165–182, 196, 369
 - Braak stages, 169
 - changes in master circadian pacemaker, 167–170
 - circadian rhythm alterations, 166–167
 - interactions with aging and circadian rhythm disruption, *166*
 - interactions with circadian rhythm disruption and molecular clock dysfunction, *173*
 - most common form of dementia, 165
 - neuropathological progression, 166
 - strategies to reduce circadian rhythm disruption, 175
- American Medical Association, 137
- American robin (*Turdus migratorius*), 342
- AMPA (α -amino-3-hydroxyl-5-methyl-4-isoxazole-propionate), 33
- amygdala, 85, 88, 135, 141
 - seasonal changes in volume, 39
- amyloid-beta (A β), 165, 167, 173, 175
- androgen, 213, 324
- anhedonia: definition, 107
- animal studies: circadian rhythm disruption and cancer, 317–322
- anterior hypothalamus, 2, 134
- antigen-presenting cells (APCs), 259
- anxiety: circadian rhythm disruption, 111–112
- apoptosis, 263, 313, 324
- Arble, Deanna M., 223–237
- arginine vasopressin (AVP), 2, 27, 29, 30, 34, 37, *168*, 207, 209, 215
- Aronson, K. J., 362
- artificial light at night (ALAN), 13, 100, *See also* light at night
 - avoidance, 339–341
 - biological effects, 340, 342, 349, 351
 - effects across species, 338–355
 - future research, 371–373
 - measurement and analysis (epidemiology), 356–380
 - mitigation, 339, 344, 351
 - offsetting approaches, 350
 - outdoor and indoor, 11
 - restoration or rehabilitation, 350
 - sources, 357
 - spatial resolution and dynamic sensitivity, *370*
- artificial light at night (exposure measurement), 358–370
 - handheld equipment, 365–367
 - interview data, 358–359
 - satellite and aerial data, 360–365
 - wearable devices, 367–370
- artificial light at night (minimization), 341–350
 - changing spectra, 348–349
 - combined effects, 349

artificial light at night (minimization) (cont.)
 dimming intensity of emissions, 341–344, 351
 reduced duration of lighting, 344–347, 351
 reduction in number of lights, 347
 shielding of light sources, 347
artificial lighting: circadian rhythm disruption, 103–104
asthma, 262, 271, 272
astrocytes, 170, 174, 186, 187, 188, 188, 189, 194
Astronaut Photography Database (Haifa), 364
ataxia telangiectasia and rad3 related (ATR) proteins, 311
ataxia telangiectasia mutated (ATM), 311
Australia, 190
autonomic nervous system, 6, 185, 190, 192, 287
 modulation (fasting and eating), 243–244
 role in maintaining normal BP, 243

B cells, 186, 188, 257, 259, 267, 268, 273, 274
Barcelona, 365
bariatric surgery, 225, 226
baroreflex sensitivity, 8, 244
bats, 342, 347, 349
bed nucleus of stria terminalis (BNST), 101
Berlin, 365, 371
beta-arrestin (β -arrestin), 60
beta-catenin (β -catenin), 146, 324
biodiversity, 351
biological clock, 1, 310, 315
biological effects, 87, 340, 342, 349
bioluminescence, 37, 273, 275
BioRender.com, 136, 145, 228, 248
bipolar disorder (BD), 110–111, 116, 117
 characteristics, 110
birds, 340, 345, 363, 371
Birmingham, 364
blackbird (*Turdus merula*), 342
blastocyst, 211, 218
 fertilized egg (implantation success), 217
blood glucose, 9, 227, 229
blood pressure, 8, 287, 292, 293, 295, 296, 299, 366
 acute effects of simulated slam shift schedule, 297
 dipping, 239
 role of ANS, 243
 systolic and diastolic, 242, 295
blood pressure circadian rhythm, 238, 239
 associated with dysregulation of clocks, 245
 clocks (role), 244–245
 food intake timing, 239–242, 248
 future directions, 247–249
 mechanisms underlying timing of food intake, 243–247
 TRF-induced alterations, 246
blood pressure regulation, 238–254
blood-brain barrier (BBB), 186, 188, 194
blue light, 4, 39, 224, 349, 365, 368, 369, 371
blue tit (*Cyanistes caeruleus*), 342, 348
Bmall, 3, 26, 30, 91, 135, 140, 146, 148, 172, 173, 175, 187, 193, 218, 232, 247, 273, 274, 289, 289, 311, 318, 319, 321, 322
 clock gene, 11, 165, 192, 213
 gene and protein levels, 267
Bmall deletion, 11, 172, 244, 245
Bmall expression, 142, 245, 273, 274, 275, 287, 312, 316

Bmall gene, 135, 170, 171, 271, 322, 324
Bmall knock-out mice, 214, 215, 216, 218
Bmall protein, 136, 193
body mass, 41, 223, 224, 226, 229, 232, 268
body temperature, 5, 28, 34, 35, 39, 62, 105, 107, 108, 112, 167, 185
body weight, 36, 38, 39, 92, 225, 227, 228, 229, 231, 242, 299, 368
brain, 73, 84, 85, 87, 90, 91, 104, 140, 230
 afferent and efferent connections, 28
 circadian timekeeping, 100–102
 controls neural and endocrine systems, 209
 postmortem analysis (MDD patients), 108
brain and muscle ARNT-like 1. *See Bmall*
brainstem, 28, 88
breast cancer, 314, 316, 323, 325, 360, 364, 365, 369, 372
 circadian clock (animal studies), 318–320
 correlation with shift work, 313
 increased risk in premenopausal women, 313
 influence of ALAN and sleeping patterns, 358
 mailed questionnaire (California teachers), 359
 risk factors, 315
breast milk, 141
breeding, 7, 36, 38, 39, 214, 344, 345
bright light therapy (BLT), 109, 115–116
Brito, Leandro C., 285–309
Brn3b, 32, 40
Broadman areas, 172
Butler, Matthew P., 285–309
Buuse, M. van den, 240

calcium, 4, 33, 59, 145
California, 360
 children’s health study (2020), 364
 teachers, 364, 372
calpain, 144, 145
cAMP-response element binding protein (CREB), 4, 33, 143, 145, 145, 148
Canada, 190, 360
cancer, 260, 261, 263, 264, 300, 362
 circadian clock gene mutations, 316–317
 circadian rhythm disruption, 310–337
 management and prevention (exploiting clock), 322–325
cancer cells: circadian clock (nodes of interaction), 312
Cancer Genome Atlas, 318
cancer incidence: circadian clock (cellular links), 310–313
cancer risk: environmental circadian disruption, 313–316
Cancer Therapeutics Response Portal, 318
carbamate insecticides, 71–73, 75
carbaryl, 71, 72, 73
cardiac function
 adverse events (morning peak), 285
 circadian regulation, 8
 circadian rhythms, 285–309
 effects of circadian disruption, 286–290
cardiometabolic risk, 239, 296
cardiomyocytes, 287, 289, 289, 297
cardiomyocyte-specific *Bmall* knockout (CBK), 289
cardiomyocyte-specific clock mutant (CCM), 289

- cardiomyopathy, 289, 290, 297
- cardiovascular disease, 207, 261, 296
- cardiovascular function, 6, 292–298
- cardiovascular health, 299–300
- cardiovascular risk
 - circadian disruption (external), 296
 - circadian disruption (internal), 296–298
 - integrating human and comparative studies (limitations and opportunities), 298–299
- cardiovascular system, 13
 - endogenous circadian rhythms, 295
- Carnegie Mellon University, 365
- casein kinase 1 delta (CK1δ), 135, 136, 141, 292
- casein kinase 1 epsilon (CK1ε), 7, 135, 136, 141
 - tau mutation, 292
- castration-resistant prostate cancer (CRPC), 324
- catecholamines, 88, 243, 295
- cells
 - autonomous clocks, 5
 - molecular clock components, 3
- central clock dynamics, 23–57
- central nervous system, 13, 183, 186, 187, 188, 189, 190, 191, 192, 194, 318
 - function (circadian regulation), 6–7
 - injury, 184, 190, 193, 195
- cerebral cortex, 170, 174
- Cermakian, N., 172
- Chang-Guang Satellite Technology Co., Ltd, 362
- checkpoint kinase 1 (CHK1), 311
- checkpoint kinase 2 (CHK2), 311
- childbirth
 - circadian disruption (impact), 217–219
 - postterm and preterm, 218
- China, 363, 371
- Chinese hamster ovary (CHO), 64, 72
- cholecystokinin (CCK), 2, 27, 113
- chromatin structure, 147
- chronic obstructive pulmonary disease (COPD), 273
- chronobiology, 195
- chromomolecules, 75
- chronopharmacology, 70
- chronotherapy, 117, 195, 195, 299–300, 323, 325
 - bright light therapy, 115–116
 - definition, 322
 - discover, develop, deploy, 194–196
 - mental health, 114–116
 - sleep deprivation, 116
- chronotypes, 106, 108, 114, 296
 - genetic factors, 3
 - indicator of metabolic resilience to night shift work, 225
 - larks versus owls, 3
- circadian behaviors: modulation by inverse agonists, 65
- circadian circuits, 101
- circadian clock, 1, 9, 94, 310, 340, 341
 - breast cancer (animal studies), 318–320
 - cancer immunity and metastasis (animal studies), 320–322
 - cancer incidence (cellular links), 310–313
 - definition, 1
 - heart, 286–290
 - molecular links with immune function, 269
 - molecular mechanisms, 3–5
 - nodes of interaction in cancer cells, 312
- circadian control
 - immune system function, 186–187
 - learning and memory (molecular mechanisms), 143–148
 - nervous system function, 185
- circadian disruption, 10, 91, 110, 184, 369
 - allostatic load, 90–93
 - cardiovascular risk, 295–298
 - developmental effects on learning and memory, 140–141
 - effects on cognitive functioning, 137–140
 - heart attacks and heart failure, 290–292
 - impact on fertility (female), 214–217
 - impact on fertility (male), 213–214
 - impact on pregnancy and childbirth, 217–219
 - impact on reproductive function, 212–213
 - impairment of ovulation and implantation, 211
 - implications for health, 73–75
 - inflammation, 272–275
 - link with disease, 42
 - metabolic function, 223–237
 - negative impact on fertility, 206–208
 - reduced libido (shift workers), 217
- circadian genes, 5, 100
- circadian hierarchy (mammalian), 184–185
- circadian immune system, 257–260
- circadian locomotor output cycles kaput (CLOCK), 3, 26, 135
- circadian photoentrainment, 30–34
 - responses to light, 32–33
- circadian re-entrainment: modulation, 68–70
- circadian regulation
 - cardiac function, 8
 - clock disruption, 11–12
 - CNS function, 6–7
 - immune function, 10–11
 - metabolism, 8–10
 - night shift work, jetlag, social jetlag, 13
- circadian responses to light: overt and cellular levels, 31
- circadian rhythm disruption, 102–107, 165–182
 - age-related (strategies to reduce), 175
 - allostatic load and stress, 84–99
 - anxiety, 111–112
 - artificial lighting, 103–104
 - bidirectional relationship with mental health, 117
 - blood pressure regulation, 238–254
 - cancer, 310–337, 314
 - daylight hours (seasonal changes), 106–107
 - immune function, 256–284
 - jetlag, 105–106
 - key contributors and metabolic consequences, 228
 - metabolic signals, 225
 - mood disorders, 107–111
 - neuroendocrine function in fertility, 206–222
 - night shift workers, 223–225
 - schizophrenia, 111–112
 - shift work disorder, 104–105
- circadian rhythms, 1–22, 60, 357, 371
 - activation of MT₁ receptors, 66
 - adaptive immunity, 259–260
 - cardiac function, 285–309
 - cardiovascular function, 292–298
 - cognitive functioning, 134–164

- circadian rhythms (cont.)
 - definition, 1, 165
 - disruption (BD sufferers), 111
 - effects of glucocorticoids, stress, allostatic load, 88–90
 - endogenous (cardiovascular system), 295
 - environmental disruption, 260–268
 - genetic disruption, 269–272
 - innate immunity, 259
 - integrating human and comparative studies (limitations and opportunities), 298–299
 - maintenance of healthy immune and nervous systems, 184–187
 - measurement techniques, 293, 294
 - molecular basis and alterations during aging, 170–172
 - MT₁ receptor-mediated phase shift, 67–68
 - occur throughout body, 5–6
 - regulation of neuroinflammation after TBI and SCI, 183–205
 - regulators of HPA function, 87–88
 - substance use disorders, 113–114
- circadian system, 91, 93, 100, 102, 103, 105, 106, 108, 110, 111, 113, 117, 118, 240, 264, 274
 - melatonin and light, 58–83
- circadian system: harmony with neuroimmune system (disruption), 184
- circadian time (CT), 25, 66, 67
- circadian timekeeping
 - brain, 100–102
 - intrinsic control versus extrinsic influence, 100–102
- circadian timing: learning and memory, 136–143
- circadian waveform, 33
 - plasticity, 34
- circadian-modulated kinase signaling
 - learning and memory, 143–147
- clock disruption, 11–12
- clock gene expression, 171, 175, 272
 - age-related changes (mechanisms), 173–175
 - age-related changes (role in neural function), 172–173
 - light “potent regulator”, 173
 - synchronization, 6
- clock gene mutation: circadian disruption (impact on reproductive functions), 208
- clock genes, 3, 5, 8, 11, 26, 89, 113, 141, 143, 145, 148, 170, 171, 187, 196, 230, 232, 245, 271, 272, 273, 274, 287, 288, 296, 298, 299, 310, 311, 316, 319, 323, 325
 - “genes constituting molecular clock”, 208
 - definition (genes involved in circadian rhythms), 183
 - heterodimers, 173
 - include *Bmal1*, *Clock*, *Per*, *Cry*, *Rev-Erb*, 8
 - mutations, 102, 269
 - polymorphisms, 108, 272
 - rhythms, 172
 - role in pregnancy, 218
- Clock* knockout mice, 245
- Clock* mRNA expression, 170
- Clock* mutant mice, 91, 214, 215, 216, 218, 232, 289, 291
- clock proteins, 135, 136, 187
- Clock* RNA expression, 187
- CLOCK:BMAL1 complex, 275
- CNS. *See* central nervous system
- cognitive functioning, 7
 - circadian rhythms, 134–164
 - effects of circadian disruption, 137–140
- colorectal cancer, 317, 323, 365
- conditional autoregressive (CAR) model, 372
- Connecticut, 359, 360
- constant darkness, 25, 32, 36, 37
- constant light, 31, 33, 37
- constant routine (CR), 293, 295
- core circadian clock genes: definition, 26
- cornu ammonis 1 (CA1), 138, 139, 144
- cornu ammonis 3 (CA3) pyramidal neurons, 140
- CORT. *See* corticosteroids
- cortex, 89, 142, 172, 175
- corticosteroids, 85, 87, 88, 89, 192, 287
- corticosterone, 85, 91, 192, 274
- corticotropin-releasing hormone (CRH), 85, 87
- cortisol, 35, 85, 108, 137, 175, 192, 224, 266, 272, 293
 - circadian disruption (metabolic signals), 225
 - prepares body to wake up, 209
- C-reactive protein (CRP), 262, 265
- CREB-binding protein (CBP), 148
- Crohn’s disease, 271
- Cryptochrome (Cry) genes, 3, 8, 26, 37, 113, 135, 136, 143, 148, 170, 171, 172, 187, 192, 193, 244, 270, 273, 274, 275, 313, 316, 317
 - abnormal expression, 316
- CubeSats, 363–364, 371
 - comparisons among satellites, 361
- cyclic adenosine monophosphate (cAMP), 59, 69, 143, 145
- cyclin dependent kinase (CDK), 194, 311, 317
- CYCLOPS, 298
- cytokine expression, 263, 267
- cytokine production, 267, 276
- cytokines, 89, 174, 189, 191, 192, 256, 257, 260, 261, 262, 268, 271, 273, 274, 275, 320, 321, 342
 - production (peaks and troughs), 259
- cytoplasm, 3, 136
- cytosine-guanosine (CpG), 147, 316, 317
- damage-associated molecular patterns (DAMPs), 191, 259
- daylight hours: seasonal changes, 106–107
- Daysimeter, 368–369, 371
- DEC2 (transcription factor), 271
- deer mice (*Peromyscus maniculatus*), 342
- Defense Meteorological Satellite Program’s Operational Linescan System (DMSP-OLS), 360–362, 363, 364, 369, 370, 372
- delayed sleep phase (DSP), 269
- delayed sleep phase disorder (DSPD), 112, 270
- delayed sleep phase syndrome (DSPS), 59, 70
- dendrite density, 139
- dendritic cells, 186, 189, 259
- dendritic complexity, 140
- Denmark, 359
- dentate gyrus, 138, 139, 142, 174
- deoxyribonucleic acid (DNA), 147, 193, 310
- depression, 106, 108, 261, 365
- desoxycorticosterone pivalate-salt, 244, 245
- DeVries, Brooke M., 206–222
- diabetes, 223, 225, 226, 227, 230, 233, 239

- food intake rhythm and BP rhythm, 240–241
meal timing as effective modulator, 231
- diethylnitrosamine (DEN), 318
- dim light at night, 92, 139, 191, 195, 261, 268
- diurnal species, 7, 136, 227
- dopamine, 41, 63
- dopaminergic neurotransmission, 62, 114
- dorsal raphe (DR), 101
- dorsomedial hypothalamic (DMH) nucleus, 101
- doxorubicin, 323, 325
- drones, 365
quantification of ALAN, 365
skyglow measurement, 365
- drugs: time-of-day recommendations, 196
- D-site-binding protein (DBP), 322
- Dubocovich, Margarita L., 58–83
publications, 77–78
- Duncan, Marilyn J., 165–182
- dystocia: definition, 218
- E2f8* (transcription factor), 318
- early bird, 23
- Earth's rotation, 1, 285, 339, 345
- eating: ANS modulation, 243–244
- E-box activity, 90
- E-box enhancers, 3
- Eckel-Mahan, Kristin, 310–337
- Edison, Thomas, 356
- endocrine profiles, 229, 342
- endometrium, 211, 211, 217, 218
- endothelial cells, 11, 187, 245
- endothelial function, 8
- endotoxin challenge: rats (active versus inactive phase), 10
- energy expenditure, 9, 224, 225, 227, 230
- environment: circadian-system synchronization, 3–4
- environmental circadian disruption protocols, 266
- environmental disruption (of circadian rhythms), 260–268
jetlag, 264
laboratory models, 265–268
shift work, 261–263
sleep deprivation, 264–265
- environmental light field (ELF), 367
- environmental lighting, 11–12
- epidemiological studies, 362, 363, 364, 365, 366, 367, 371, 372
- epidemiology, 358, 360, 371
ALAN (measurement and analysis), 356–380
- epigenetics: circadian control of learning and memory, 147–148
- epinephrine, 134, 287, 293
- epithelial-to-mesenchymal transition (EMT), 313
- estradiol, 216, 217
action, 210
produced in ovary, 210
- estrogen, 64, 210
- estrogen receptors (ER), 319
- estrous cycles: rodent equivalent to menstrual cycles, 215
- eukaryotic chromosomes, 147
- Europe, 11, 70, 75
- European eel (*Anguilla anguilla*), 349
- European Heart Journal*, 299
- Evans, Jennifer A., 23–57
publications, 45–46
- exercise, 2, 5, 5, 6, 149, 175, 176, 195, 227, 261, 275, 295, 299
- external coincidence model, 36
- extracellular signal-regulated kinase (ERK), 33, 145, 146, 325
also known as MAPK, 143
- extra-SCN tissue-specific clocks, 5–6
- Falchi, F., 11, 356, 364
- familial advanced sleep phase (FASP), 270
- familial natural short sleepers (FNSS), 271
- fasting, 231
ANS modulation, 243–244
- Fekry, Baharan, 310–337
- female fertility: circadian disruption (impact), 214–217
- fertility, 91
circadian disruption (effect greater on females), 208
circadian disruption (negative impact), 206–208
circadian rhythm disruption, 206–222
hormonal feedback (brain and peripheral reproductive organs), 210
hormone-release timing (regulation by neuroendocrine system), 209–212
- fight or flight, 84, 90
- Figueiro, M. G., 368, 369
- Finger Lakes Instruments (FLI), 365
- firing rate, 24, 27, 41, 101, 175
- firing rhythms, 25, 27, 169
- fish, 227, 340, 345, 349
- flight attendants, 137, 264, 356
breast cancer risk, 315
- follicle stimulating hormone (FSH), 207, 209, 210, 215, 216
- Fonken, Laura K., 1–22
publications, 16
- food intake, 2, 9, 11
behavioral rhythms, 9
timing critical in BP circadian rhythm, 239–242
- forced desynchrony (FD), 293, 294
- forkhead box O3 (FOXO3), 311
- forskolin, 68, 274
- Franklin, M., 364
- functional responses: modulation of MT₁ inverse agonists, 64–65
- further research
ALAN, 371–373
blood pressure circadian rhythm, 247–249
changes in estradiol or testosterone levels, 217
circadian disruption (impact on male fertility), 214
circadian system, 13
clock as therapeutic avenue for inflammatory diseases, 275
female shift workers (reproductive success), 217
full diurnal profile of inflammatory markers, 262
immune function (changes in working environment), 263
melatonin and reproductive axis (interaction), 216
miscarriage risk (shift work), 219
potential for targeting circadian clock in tumor prevention, 317

further research (cont.) shift work schedules (types and aspects), 219 sperm and follicle quality (circadian disruption), 219	Guo, Zhenheng, 238–254 gut microbiota, 247
gamma aminobutyric acid (GABA), 27, 28, 29, 33, 34, 38, 168, 168, 346 GABA-A receptor antagonist, 138 GABAergic circuits, 170 inhibitory neurotransmitter, 2	Halberg, F., 186, 256 hamsters, 36, 38, 169 handheld equipment (ALAN exposure measurement), 365–367 hemispherical photography, 367 light meters, 365–366 sky quality meter, 366
Gaofen-2 (GF-2) satellite, 363, 371	haplotype-based association analysis revealed, 111
Garcia-Saenz, A., 372	Harvard Light Exposure Assessment (H-LEA) questionnaire., 359
Gaston, Kevin J., 338–355 publications, 353	heart, 247 circadian clocks, 286–290 circadian clockwork (impact), 288
gastrin-releasing peptide (GRP), 2, 25, 27, 34	heart failure, 290, 291–292
Gaudet, Andrew D., 183–205 publications, 199	hemispherical photography, 367
gene expression, 25, 33, 41, 101, 108, 118	hepatic leukemia factor (HLF), 322
generalized anxiety disorder (GAD): characteristics, 111	hepatocellular carcinoma (HCC), 317, 318, 322
genetic disruption (of circadian rhythms), 269–272 sleep-related, 269–271	hepatocyte nuclear factor four alpha (HNF4α), 317
genetics: circadian disruption and metabolic function, 231–232	heterodimers, 136, 170, 171, 173, 193
geniculohypothalamic tract (GHT), 32	high sensitivity C-reactive peptide (hsCRP), 296
genome-wide association studies, 271	high-density lipoprotein (HDL), 226
Genomics of Drug Sensitivity in Cancer (GDSC), 318	high-frequency spectral power (HFSP), 244
geographically weighted regression (GWR), 372	hippocampus, 85, 88, 89, 104, 113, 135, 138, 139, 140, 141, 142, 146, 148, 170, 172, 175, 191, 192 CA1 region, 146 seasonal changes in volume, 39
Georgia (USA), 360	histone acetyltransferases (HATs), 147, 148
ghrelin, 226, 229 circadian disruption (metabolic signals), 225	histone deacetylases (HDACs), 147, 148
Gibbs, Julie E., 256–284	histone demethylases (HDMs), 147
glia:neuron ratio, 169, 175	histone methyltransferases (HMTs), 147
glial cells, 87, 170, 171	histone proteins, 147, 148
glial scar, 189	Hoffman, R. A., 61
glioblastoma multiforme (GBM), 321	Hoffmann, Hanne M., 206–222
glucocorticoid receptor (GR), 5, 89	Hogenesch, J., 298
glucocorticoid response element (GRE), 88	homeostasis, 9, 13, 84, 85, 187, 190, 192, 226, 256, 310
glucocorticoids, 2, 10, 28, 86, 88, 104, 140, 174, 185, 191, 192, 193, 287 source and function, 5	hormones, 206, 210, 216, 219 work as messengers, 209
glucose, 9, 86, 87, 224, 227, 290 circadian disruption (metabolic signals), 225	Hou, Tianfei, 238–254
glucose homeostasis, 225, 226, 229, 230	housing, 174, 364
glucose regulation, 229, 230, 232	human epidermal growth factor receptor 2 (HER2), 319, 324
glucose tolerance, 230, 231, 232	Hurley, S., 372
GLUT4 expression, 230, 232	hyperglycemia, 232, 240
glutamate, 3, 4, 33 action, 4	hypertension, 8, 238, 240, 245, 247, 299
glycogen synthase kinase 3 beta (GSK3β), 111, 146, 194, 299	hypothalamic–pituitary–adrenal (HPA) axis, 85, 93, 104, 185, 190 function (circadian rhythms as regulators), 87–88 pathways, 191, 192 responses, 86
glymphatic system, 187, 194	hypothalamic-pituitary-gonadal axis aka “reproductive axis”, 210
gonadotropin-releasing hormone (GnRH), 207, 209, 210, 210, 214, 215, 219	hypothalamus, 1, 27, 28, 85 sleep-regulating centers, 185
Gong, Ming C., 238–254	
Gonyaulax polyhedra, 340	
G-protein, 4, 59, 63, 64, 70 pertussis toxin-sensitive, 67	
G-protein-coupled receptors (GPCRs), 59, 60	
granulocyte-macrophage colony-stimulating factor (GM-CSF), 267, 320	
green light, 348, 349	
Greenough, Emily K., 183–205	
GTP, 64, 64, 68, 71, 144	
	immune cells, 188, 257, 297
	immune function, 35, 89, 91, 291 circadian control, 186–187 circadian regulation, 10–11 circadian rhythm disruption, 256–284 molecular links with circadian clock, 269

- immune system, 86, 91, 94, 183
 maintenance (circadian rhythms), 184–187
- immunoglobulins (Ig), 260, 265
- immunoreactivity (ir), 62, 169, 171
- Ince, Louise M., 256–284
- inflammation, 90, 261, 262, 263, 264, 265, 267, 268, 271, 296
 as circadian disruption, 272–275
- inflammatory bowel disease, 271, 273
- innate immunity, 186, **257**, 257
 circadian rhythms, 259
- insomnia, 70, 191, 366
- insulin, 3, 86, 91, 92, 224, 226, 229, 230, 232, 240, 287, 298, 299, 323
 circadian disruption (metabolic signals), **225**
- intercellular communication, 34
- interferon alpha (IFN- α), 275
- interferon gamma (IFN- γ), 260, 267, 275, 320
- intergeniculate leaflet (IGL), 32
- interleukin 01 beta (IL-1 β), 90, 262, 263, 268, 273, 275, 320, 321
- interleukin 02 (IL-2), 260, 265, 320
- interleukin 04 (IL-4), 260
- interleukin 06 (IL-6), 260, 263, 268, 275, 296, 320, 321
- interleukin 10 (IL-10), 263, 265, 267, 273, 320, 321
- interleukin 13 (IL-13), 260
- interleukin 18 (IL-18), 321
- internal coincidence model, 36
- International Agency for Research on Cancer, 313
- International Space Station (ISS), 364, 371, 372
- interview data, 358–359, 370
 challenges, 359
- intrinsically photosensitive retinal ganglion cells (ipRGCs), 30, *31*, 32, 33, 40, *101*, 104, 115, 135, 185
 activation, 4
 input from rods and cones, 4
 purpose, 4
 sensitivity to blue light, 4
 subclasses, 32
 subtypes, 4
- inverse agonists, 59, 63, **64**, 70
 efficacy, 60
 modulation of circadian behaviors, 65
 modulation of functional responses, 64–65
- iodomelatonin, 68, 72
- irradiance visual system, 30–32
- ischemia reperfusion injury, 291, 300
- Israel, 360, 371
- Jardim, A. C. N., 369
- jetlag, 32, 92, 112, 114, 117, 137, 138, 139, 207, 227, 229, 291, 315, 317
 characteristics, 106
 circadian rhythm disruption, 105–106
 eastward versus westward, 13, 68, 69, 70, 106, 266, 267
 environmental disruption (of circadian rhythms), 264
 heart health risk, 291
 symptom severity, 106
- JL1–3B satellite, 361, 362, 363, 371, 372
- Joye, Deborah A. M., 23–57
- Jun N-terminal kinase (JNK), 325
- Karatsoreos, Ilia N., 84–99
- kidney, 238, 245, 247, 267, 299
- kisspeptin, 207, 209, 210, 215, 219
- Kloog, I., 360, 372
- Kriegsfeld, Lance J., 134–164
- Kuechly, H. U., 365
- Kyba, C. C. M., 358, 362
- labor timing [childbirth], 218
- LAN. *See* light at night
- lateral habenula (LHb), *101*, 101
- lateral septum (LS), *101*
- LD. *See* light-dark cycles
- learning and memory
 circadian control (molecular mechanisms), 143–148
 circadian timing, 136–143
 circadian-modulated kinase signaling, 143–147
 developmental effects of circadian disruption, 140–141
 epigenetics and circadian control, 147–148
 relevant genes, *145*
- LeGates, Tara A., 100–122
- leptin, 92, 224, 226, 229, 240, 243, 299
 circadian disruption (metabolic signals), **225**
- leukocytes, 11, 262, 263, 265, 266, 272, 273
- Ley, P., 358
- Li, Q., 359
- ligand efficacy, 60
- light, 2, 30
 dominant entrainment factor for SCN, 4–5
 timing and duration (seasonal change), 107
- light at night, 4, 10, 12, 75, 137, 207, 214, 217, 218, 219, 223, 224, 287, *See also* artificial light at night
 circadian disruption and metabolic function, 225–226, 229–230
 little effect on rodent sleep, 229
- light effects: solutions (across species), 338–355
- light exposure, 11, 39, 92
- light meters, 365–366
- light pollution, 11, 42, 100, 103, 342, 356, 365, 366, 371
- light pulses: non-parametric responses, *31*
- light-dark cycles, 13, 25, *31*, 32, 41, 62, 69, 93, 106, 165, 171, 174, 191, 215, 223, 230, 231, 232, 263, 291, 292, 317, 339, *346*
 circadian disruption and metabolic function, 227–229
- light-emitting diodes (LEDs), 11, 348, 357
- light-induced SCN depolarization, 33
- lipid metabolism: LAN effects, 226
- lipopolysaccharide (LPS), 186, 196, 256, 259, 267, 268, 273, 275, 276
- lithium, 111, 194
- liver, 9, 91, 193, 230, 245, 267, 318, 321
 peripheral clock rhythms, 6
- lizards, 340
- locomotor activity, 62
 AD patients, 167
 diurnal versus nocturnal, 7
- locomotor recovery, 193, 194, 196
- locomotor rhythms, 7, 36, 39, 41, 169
- locus coeruleus, 40, *101*
- long-term potentiation (LTP), 142

Longcore, Travis, 356–380
long-term potentiation (LTP), 143, 145, 146, 147, 148
low-density lipoprotein (LDL), 226
low-frequency spectral power (LFSP), 244
lung, 274, 318
lung cancer, 323, 360
luteinizing hormone (LH), 169, 207, 209, 210, 214, 215, 216
 surge, 211
 surge (timing especially important), 211
luzindole, **63**, 63, 64, 65, 67, 68
lymphocytes, 259, 264
LYS Button, 370, 373

macrophages, 90, 186, 188, 193, 256, 259, 276, 320
Madrid, 365
major depressive disorder (MDD), 106, 107–109, 112, 115, 116
 changes in sleep (hallmark), 108
 characteristics, 107
 symptoms (diurnal variation), 108
male fertility: circadian disruption (impact), 213–214
Malpas, S.C., 240
mammals, 6, 13, 23, 24, 26, 34, 285, 340, 345, 348
 melatonin-receptor mediated modulation of rhythmic behavior, 65–70
 photoperiodic responses, 35
Martin, J. S., 367
meal timing, 229, 261
 circadian disruption and metabolic function, 226–227, 230–231
mean arterial pressure (MAP), 242
medial prefrontal cortex, 113
medial preoptic (MPO) nucleus, 101
Meijer, Johanna H., 338–355
 publications, 354
melanoma, 315, 316
melanopsin, 4, 12, 30, 31, 32, 103, 349
melatonin, 4, 5, 28, 35, 35, 36, 37, 40, 75, 108, 110, 140, 141, 172, 185, 191, 195, 226, 232, 233, 293, 297, 298, 319, 321, 342, 344, 348, 368
 5-methoxy-N-acetyltryptamine, 58
 changes in waveform, 36
 circadian disruption (metabolic signals), **225**
 contribution to obesity (opportunity for comparative approach), 231
 endogenous (behavioral functions), 61–63
 endogenous and exogenous, 59
 light-induced reduction in nocturnal release (shift workers), 215
 physiological responses, 59
 reduced in male shift workers, 214
 regulatory role on ovarian function, 216
 released only during darkness at night, 209
 timed treatment, 230
melatonin molecule, 58
melatonin phase shift, 66
melatonin production, 58, 61, 344, 356, 369
melatonin receptor glands: therapeutic potential, 70–71
melatonin receptors, 59–61
 definition, 59
 targets for carbamate insecticides, 71–73
melatonin release, 40, 185, 219

melatonin suppression, 103, 369
melatonin-receptor mediated modulation, 65–70
melatonin-related analogues (efficacy), 63–64
menstrual cycles
 disruption, 216
 irregularity risk (shift workers), 214
mental health
 bidirectional relationship with circadian rhythm disruption, 117
 chronotherapy, 114–116
 disrupted circadian rhythms, 100–122
mental health disorders
 circadian rhythm disruptions “hallmark”, 102
mesolimbic reward system, 113
metabolic disruption, 9, 10, 71
metabolic function, 8
 circadian rhythm disruption, 223–237
 night shift workers, 223–225
metabolism, 1, 13, 94
 circadian regulation, 8–10
metabolites, 9, 30, 187
metastasis, 313, 321
MFOV camera, 363
MI. *See* myocardial infarctions
mice, 2, 4, 7, 8, 29, 30, 34, 37, 42, 61, 62, 66, 67, 68, 69, 92, 138, 139, 141, 142, 146, 148, 165, 169, 171, 174, 191, 193, 194, 195, 241, 244, 247, 256, 267, 268, 275, 288, 291
 actogram (short and long photoperiods), 346
C3H, 70
Clock deficient, 143
clock-linked gene-mutations, 10
Cry double mutant, 143
granulosa cells, 64
heart beat, 298
macrophages, 11
meal timing, 230
 studies shifting light-dark cycle, 228
microglia, 170, 171, 174, 186, 187, 188, 256, 268
misalignment, 92, 93, 94, 104, 105, 106, 115, 265, 266, 296, 315
miscarriage, 217, 218
mitigation hierarchy, 339
mitogen-activated protein kinase (MAPK), 33, 143, 145, 146, 325
Moeller, Jacob S., 134–164
molecular circadian clock, 27, 111
molecular clock, 13, 25, 26, 29, 30, 32, 34, 101, 102, 108, 111, 184, 194, 206, 209, 216, 218, 230, 231, 232, 274, 285, 289, 299, *See also* clock genes
 ovary, 211, 218
 role in childbirth (labor and delivery), 218
molecular clock genes, 213, 217
molecular clockwork, 134–135, 146, 148, 187, 270
 mechanisms responsible for circadian rhythm generation, 136
molecular mechanisms of circadian clock, 3–5
 light “dominant entrainment factor for SCN”, 4–5
 peripheral rhythms (food, exercise, other factors), 5
 synchronization to environment, 3–4
molecular mechanisms: circadian control of learning and memory, 143–148
monocytes, 188, **257**, 259

- Montaigne, D., 300
- mood disorders, 42, 106, 115, 185
bipolar disorder (BD), 110–111
circadian rhythm disruption, 107–111
major depressive disorder (MDD), 107–109
postpartum depression (PPD), 109–110
- Moran's I test statistic, 372
- Morris water maze, 7, 138, 142, 143
- moths, 343
- mRNA, 148, 169, 170, 172, 245, 289, 318
- MT₁ and MT₂ ligands, 60
- MT₁ and MT₂ receptors, 58, 59, 60, 62, 63, 64, 70
activation, 66
affinity, selectivity, efficacy, **64**
functional role, 61
- MT₁ inverse agonists: modulation of functional responses, 64–65
- MT₁ knockout mice, 40
- MT₁ mediated effects, 60
- MT₁ signaling, 41
- mTOR, 38, 324
- multiple sclerosis, 260, 271
- muscarinic receptors, 71, 138
- muscle, 91, 230, 232
- myocardial infarctions, 290–291, 297
- myometrium, 211, 218
- National Institutes of Health, 75, 76
- National Oceanic and Atmospheric Administration (NOAA), 360
- National Park Service (USA), 367
- natural killer cells, 189, **257**, 263, 267, 268, 273
- Nelson, Randy J., 1–22
- neocortex, 28, 40
- nervous system function: circadian control, 185
- nervous system: maintenance (circadian rhythms), 184–187
- network effects: intrinsic SCN timekeeping, 28–30
- neural function: age-related changes in clock gene expression, 172–173
- neurocognitive processes, 35
- neurodegeneration, 165, 169, 170, 172, 173, 175, 187, 194
- neuroendocrine axis, 84, 85
- neuroendocrine function: circadian rhythm disruption, 206–222
- neuroendocrine network: relay of light from eye to reproductive axis, 207
- neuroendocrine processes, 35
photoperiodic regulation, 38–39
- neuroendocrine responses, 85
- neuroendocrine signaling, 190
- neuroendocrine system, 190
“postal service”, 209
primary role, 209
regulation of hormone release (fertility), 209–212
- neurogenesis, 139
- neuroimmune activation, 187
- neuroimmune cells, 187
- neuroimmune function, 183
- neuroimmune system: harmony with circadian system (disruption), 184
- neuroinflammation, 165, 172, 183, 184, 187, 191, 194, 195, 195
modulation (targeting clock), 193–194
role in TBI and SPI, 187–189
- neuroinflammatory activation, 187
- neuroinflammatory events: after TBI or SCI (timing and spatial organization), 188
- neurologic recovery, 193–194
- neuronal activity, 62, 101, 102, 146, 287
- neuropeptide S receptor 1 (*Npsr1*), 272
- neuropeptides, 2, 28, 29, 30, 169, 175
- neuroprotection, 184, 188, 189, 192, 193
- neuropsychiatric processes: photoperiodic regulation, 39–41
- neurotransmitters, 168, 187
- neurotrauma, 185, 187, 188, 189
circadian-neuroimmune axis, 190–194
dysregulation of circadian rhythms, 192–193
leveraging chronobiologic strategies, 194–196
linking circadian cues in external environment to internal oscillators, 190–192
recovery enhancement, 194–196
role of internal body clock, 192–194
- neurotrauma (future directions), 194–196
chronotherapies, 194–196
circadian regulation of neurorepair-related events, 194
preclinical insight, 194
promising approaches, 194–196
- neutrophil extracellular traps (NETs), **257**
- neutrophil:lymphocyte ratio (NLR), 273
- neutrophils, 186, 188, 188, 259, 274
- NFOV camera, 363
- NFκB, 90, 272, 273, 274, 275, 321
- nicotinamide adenine dinucleotide (NAD⁺), 311
- night eating syndrome (NES), 226
- night shift workers, 9, 12, 138, 223
circadian rhythm disruption and metabolic function, 223–225
- Nile grass rats (*Arvicanthis niloticus*), 139
- nitric oxide, 8
- NK. *See* natural killer (cells)
- N*-methyl- d-aspartic acid (NMDA), 4, 33, 140, 143, 145
- nobiletin (NOB), 324, 325
- nocturnal animals: activity rhythm, 343
- nocturnal mice, 40, 287, 289
- nocturnal rodents, 33, 40, 92, 227
- nocturnal species, 32, 41, 92, 136, 340, 347
- non-alcoholic fatty liver disease (NAFLD), 317
- norepinephrine, 243, 244
- Northern treeshrew (*Tupaia belangeri*), 342
- Npas2*, 170, 171, 173, 187, 244
- Nr1d1*, 11, 187, 272, 273, 274, 275, *See also* *Rev-Erba*
- nuclear factor erythroid 2–related factor 2 (NRF2), 321
- nuclear receptor subfamily 1 group D, 311, *See also* *Nr1d1*
- nuclear receptors, 135, 193, 318, 320
- nucleus accumbens (NAc), 101
- nucleus of solitary tract (NTS), 85
- nurses, 356
- obesity, 9, 10, 223, 225, 226, 227, 230, 232, 233, 239, 241, 297, 324, 359, 360
food intake rhythm and BP rhythm, 240–241
meal timing as effective modulator, 231

- oligodendrocytes, 186, 189, 194
- oocyte yields, 214
- Opn4* gene, 30, 40
- optic nerve, 207, 209
- orthosteric site, 60, 71, 72
- Osgin1* gene, 318
- osteosarcoma, 317
- ovarian function, **208**, 216, 217
- ovary, 91, 210, *211*, 212, 216, 218, 318
- overt circadian rhythms, 26, 66, 67, 73, 167, 174, 175
- pancreas, 9, 91, **225**, 232, 318
- paracrine signals, 28, 101
- paraventricular nucleus (PVN), 58, 85, 87
 - of hypothalamus, *101*
 - primary efferent pathways, 85
- paraventricular nucleus of thalamus (PVT), *101*
- pars tuberalis, 73
- Patagonian leaf-eared mice (*Phyllotis xanthopygus*), 342
- pathogen-associated molecular patterns (PAMPs), 259
- perception: varies across day, 7
- pericytes, 186, 189
- perinatal depression, 109
- perinatal period, 115
- Period* (*Per*) genes, 3, 26, 34, 88, 102, *136*, *171*, 187, 270
- Period 1* (*Per1*) gene, 3, 37, 62, 135, *144*, 146, 148, 170, 172, 193, 215, 318
 - expression, 142, 145, 171, 173, 174, 273, 287, 313
 - germline deletion, 172
 - knockout mice, 245
 - upregulation, 33
- Period 2* (*Per2*) gene, 3, 8, 37, 113, 135, 140, 142, 148, 170, 171, 172, 173, 174, 273, 274, 311, *312*, 318, 319, 321
 - dampened oscillations, 274
 - germline deletion, 172
 - knockout mice, 291
 - mutant mice, 244, 318
 - rhythm, 146, 175, 267
 - upregulation, 33
- Period 3* (*Per3*) gene, 3, 113, 135, 170, 271, 273
- peripheral clocks, 5, 6, 8, 89, 230
 - aging (decreased coordination with SCN), 174
- peroxiredoxin oxidation, 27
- peroxisome proliferator-activated receptors (PPAR), 230
- PFC. *See* prefrontal cortex
- phagocytosis, 259, 260
- phase advancement method, 116
- Phase Angle of Entrainment, 25
- phase resetting, 32, 42
- phase response curve (PRC), *31*, 32, 34, 36, *66*
- phase shift hypothesis, 107, 115
- phase shift rhythms, 66, 287
- phase shifts, 2, *66*, 66, 67, 108, 113, 115, 137, 138, 145, 174, 227, 267, 274, 292, 342
- phase-response curve (PRC), 66, 67, *343*
 - photic (amplitude), 36
- phosphorylation, *144*, 146
- photic processing, 23, 30–34
- photic resetting, 32, 33, 34, 36
- photic stimuli, 65
- photoentrainment, 30–34
- photoperiodic encoding, 34–41
 - overt responses, 35–36
- photoperiodic modulation, 35
- photoperiodic regulation
 - neuroendocrine processes, 38–39
 - neuropsychiatric processes, 39–41
- photoperiodic responses, 35
- photoperiods, 24, 32, 34, 35, 36, 37, 40, 75, *266*, *346*
- photosensitive retinal ganglion cells (pRGCs), 349
- physiologic cues: coordination of circadian rhythms, 5
- physiology, 13
- pineal gland, 28, 35, 58, 172, 297
 - main source of melatonin production, 58
- Pittsburgh, 365
- pituitary adenylate cyclase activating peptide (PACAP), 4, 33, 102
- pituitary gland, 209, 215
- plasticity, 24, 33, 34, 35, 38, 42, 140, 141, 189, 262
- pMAPK-activated ribosomal S6 kinase (P90RSK), *144*, 146
- polymorphisms, 114, 232, 269, 271, 272, 297, 316
- postpartum depression (PPD), 109–110, 115
 - incidence, 109
- Prairie rattlesnake (*Crotalus viridis viridis*), 342
- prefrontal cortex, 86, 88, 92, 113, 135, 140, 141, 142, 174
- pregnancy, 210, 212, 213, 215, 217
 - circadian disruption (impact), 217–219
- preoptic (PO) area, *101*
- progesterone, 210, 216, 217
 - produced by ovary at high levels after ovulation, 211
- progesterone receptors (PR), 319
- prokineticin 2 (Prok2), 2
- prostaglandins, 8, 191
- prostate cancer, *314*, 316, 323, 360, 365, 372
 - correlation with shift work, 313
- protein CLOCK influences, 101
- protein kinase A (PKA), 143, *144*, 321
- public health, 356, 360, 362
- quality of life, 113
- questionnaires, 358, 372
 - ALAN and breast cancer (non-significant association), 359
 - breast cancer (California teachers), 359
- rabbit, 62, 240
- ramelteon, 66, 67, 68, 70
- raphe nucleus, 2, 28, 89
- rapid eye movement (REM) sleep, 108
- rats, 5, 7, 62, 137, 138, 140, 171, 191, 193, 240, 243, 274, 287
 - aging, 169
- Rea, M. S., 368, 369
- recall bias, 359, 373
- red light, 195, 348, 369
- Reiter, R. J., 61
- remote sensing, 360, 363
- renin-angiotensin-aldosterone system, 243, 246
- Rensselaer Polytechnic Institute, 368
- reproductive failure, 86, 90

- reproductive function, 94
 - circadian disruption (impact), 212–213
 - circadian disruption (mammalian overview), **208**
- retina, 4, 28, 58, 62, 63, 102, 185
- retinal input, 2, 30, 32, *101*
 - SCN cellular responses, 33–34
- retino-hypothalamic tract, 2, 4, 30, 58, *101*, 135, 185
- retinoic acid response elements (RREs), 135, *171*, *312*
- retinoic acid-related orphan receptors (RORs), 3, 26, 135, 187, 193, 271, 311
- retrosplenial cortex, 141, 142
- Rev-Erb* genes, 3, 26, *171*, 187, 193, 194, 196, 292, *312*
- Rev-Erba*, 11, 37, 89, 135, *136*, 187, 193, 230, 232, 272, 273, 289, 320, 324, 325, *See also Nr1d1*
- Rev-Erbβ*, 289, 325
 - nuclear receptors, 135
- rheumatoid arthritis, 10, 260, 262
- RHT. *See* retino-hypothalamic tract
- rhythmic behavior: melatonin-receptor mediated
 - modulation, 65–70
- rhythmic functions: modulation by endogenous melatonin, 61–63
- Richter, C.P., 5
- rodents, 35, 40, 89, 191, 193, 342, 349
 - adaptation of physiological processes to shift work (proxy investigation), 212
 - circadian disruption (impact on reproductive functions), **208**
 - nocturnal (limitations as models for human disease), 216
 - nocturnal locomotor activity, 25
- root mean square of successive RR interval differences (rMSSD), 244
- Rosenthal, Anthony, 100–122
- running wheel, 6, 62, 69, 73, 74
- rural areas, 351
- satellite and aerial data (ALAN exposure measurement), 360–365
 - aerial photography, 364–365
 - CubeSats, 363–364
 - DMSP-OLS, 360–362
 - JL1–3B and GF-2 (China), 362–363
 - satellite comparisons, **361**
 - VIIRS, 362
- schizophrenia
 - circadian rhythm disruption, 111–112
 - key features, 112
- SCI. *See* spinal cord injury
- SCN, 1, 12, 13, 40, 58, 62, 87, 89, 101, 115, 134, *190*, 207, 209, 230, 287, 297, 349
 - circadian-focused properties, 2
 - core and shell regions, 2
 - definition, 41
 - lesions, 2
 - light “dominant entrainment factor”, 4–5
 - location, 2
 - master circadian pacemaker, 1–3, 58, 166, 167–170, 206
 - neuron-firing, 2
 - PERIOD expression, 25
 - proper functioning (female fertility), 215
 - regulation of peripheral processes, 5
 - retinal input, synchronized output, few peripheral feedback mechanisms, 3
 - rhythms ‘entrained by light information’, 2
 - role, 23, *24*
 - sensitivity to light, 102
 - unique circadian-focused properties, 185
 - ventrolateral “core” versus dorsomedial “shell”, 27, 28
- SCN circadian oscillatory protein (SCOP), *144*, 145
- SCN circadian timekeeping, 24–30
 - intrinsic, 28–30
 - membrane and cytosolic oscillators, 24–27
 - network effects, 28–30
 - transcriptional-translational oscillator, 24–26
- SCN clock, 89, 345
- SCN network computations: formal and mathematical models, 29
- SCN network organization, 27–28
- SCN neurons, 25, 27, 29, 101, 102, 342, 346
 - AD-related alterations, *168*
- SCN neuropeptides, 28, 34
 - non-synaptic release, 28
- SCN photic processing, 30–34
- SCN photic resetting: intercellular communication, 34
- SCN photoperiodic encoding, 34–41
- sea snails (*Bulla gouldiana* and *Aplysia californica*), 340
- season of birth, 42
- seasonal affective disorder (SAD), 40, 41, 42, 70, 100, 106, 115
 - circadian phase-shift hypothesis, 107
 - melatonin hypothesis, 107
 - symptoms (summer versus winter), 107
- seasonality, 24
- seasons, 35, 42
- secondary damage, 183, *188*, 189, 194, *195*
- selective serotonin reuptake inhibitors (SSRIs), 109
- semen quality: resistant to circadian disruption, 213
- sensory sensation: varies across day, 7
- serotonin, 41, 70
- sex dimorphism, 245
- shift work, 75, 92, 100, 112, 114, 117, 207, 208, 219, 285, 293, 315, 317
 - adverse coronary events (increased risk), 291
 - circadian disruption (impact on reproductive functions), **208**
 - circadian rhythm disruption, 104–105
 - classified as probable carcinogen, 313
 - definition, 212
 - effects on learning and memory, 137
 - environmental disruption (of circadian rhythms), 261–263
 - impact on reproductive success, 214
 - recommendations, 212
- shift workers, 75, 116, 239, 296, 316, 356
 - circadian disruption (impact on fertility), 212
 - classification, 212
 - reduced fertility (possible primary cause), 212
 - selection bias (underestimation of detrimental effects), 262

- Siberian hamster (*Phodopus sungorus*), 35, 40, 138, 139, 140
signaling pathways: non-canonical, 59, 60
Simpkins, Devin, 256–284
simulated jetlag, 34, 37
simultaneous autoregressive (SAR) model, 372
single nucleotide polymorphisms (SNPs), 111, 113, 316, 322
Sirtuin 1 (Sirt1), 273, 311
 histone deacetylase, 274
sky quality meter (SQM), 364, 366
skyglow, 339, 340, 342, 344, 350, 351, 365
 satellite image, 12
sleep, 89, 185
 genetic disruptions, 269–271
 REM and NREM stages, 71
sleep apnea, 71, 93, 238
sleep deprivation, 174, 191
 chronotherapy in mental health, 116
 environmental disruption (of circadian rhythms), 264–265
sleep disorders, 69, 70, 73, 75
sleep disruption, 105, 109, 112, 191, 192, 224
 effects on vaccination efficacy, 260
sleep duration, 247, 364
sleep loss, 4, 92
sleep phase: genetic disruption of circadian rhythms, 270
sleep quality, 366, 368
sleep-wake cycle, 87, 105, 167, 172, 174, 207, 214, 247
 cardiovascular regulation, 8
small-interfering RNA, 193
smartphones, 370, 372, 373
social cues, 2, 5
social jetlag, 93, 106, 112, 224, 228, 247, 264, 270, 293, 296, 297, 315
 definition, 13, 285
South Korea, 190
spatial pattern, 363, 371, 372
spectra, 339, 341, 348–349
spinal cord injury, 183, 184, 190, 191, 192, 193, 194, 196, 274
 role of neuroinflammation, 187–189
Spitschan, M., 358
spontaneously hypertensive rats (SHRs), 243
Stevens, R. G., 369
street lighting, 346, 350, 362
stress, 86, 89, 94, 185
 physiological versus psychological, 85
stress axis, 85–86
stress system, 84, 91, 93, 94
subjective night, 32, 33, 67
subparaventricular zone (SPZ), 101
substance use disorders (SUDs), 106
 circadian rhythms, 113–114
sunlight, 103, 137, 315, 357
suprachiasmatic nucleus. *See* SCN
Sutton, E.F., 242
synaptic plasticity, 104, 116, 118, 142, 147, 148
Syrian hamster (*Mesocricetus auratus*), 7, 26, 139, 170, 291, 342

T cells, 186, 188, **257**, 259, 260, 263, 268, 273, 274
 pleiotropic roles in immune function, 260

T lymphocytes, 189
Tamar wallaby (*Macropus eugenii*), 345
tau, 7, 26, 146
TBI. *See* traumatic brain injury
T-cycles, 31, 32, 37
testosterone, 210, 214
 reductions in sex drive of female shift workers, 217
 role (in ovary), 216
 shift workers, 213
thalamus, 2, 28, 32, 40, 58, 73
Thosar, Saurabh S., 285–309
timeless (TIM) protein, 113, 270, 271, 311
time-restricted eating (TRE), 239, 248
 active phase (translational potential), 241–242
time-restricted feeding (TRF), 239, 241, 242, 243, 244, 247
 BP circadian rhythm (modulation of clocks), 246
 definition, 6
tissue-specific clocks, 5–6
toll-like receptors (TLRs), 259
torpor, 36, 39, 59, 62
 definition, 61
transcriptional-translational feedback loops (TTFLs), 3, 24, 26, 27, 87, 88, 89, 90, 91, 135, 170, 244, 268, 345
 disruption in immune cells, 92
 genetic disruptions, 92
transcriptional-translational oscillator, 24–26
transforming growth factor beta (TGFβ), 321
transforming growth factor beta1 (TGFβ1), 325
traumatic brain injury, 183, 184, 190, 191, 192, 193, 194, 196
 role of neuroinflammation, 187–189
tricyclic antidepressants (TCAs), 109
triglycerides, 91, 92, 226, 227, 229
 circadian disruption (metabolic signals), **225**
tumor necrosis factor alpha (TNFα), 90, 260, 263, 265, 267, 268, 273, 275, 296, 320
turtle, 347, 367
type 2 diabetes, 90, 226, 230, 232, 238, 240, 241, 261, 299

ubiquitin, 194, 270, 311
UCSF7447 and UCSF3384 **64**, 68, 69, 75
ulcerative colitis, 271, 273
ultraviolet (UV) radiation, 311, 316, 340, 349
United States, 11, 70, 75, 190, 196, 224, 360

variable number tandem repeat (VNTR), 271
vasoactive intestinal polypeptide (VIP), 25, 27, 34, 38, 113, 168, 170, 175, 207, 209, 215
 immunoreactivity, 169
 regulates SCN function, 29
vasopressin, 169, 170, 172
ventral tegmental area (VTA), 101, 101, 113
VIP receptor 2 (VPAC2), 2, 169
visible infrared imaging radiometer suite (VIIRS), 361, 362, 363, 364
visible near-infrared (VNIR), 360

wake times: alarm-clock versus natural, 106
waveform of daily rhythms, 34
wearable devices, 358, 373

wearable devices (ALAN exposure measurement), 367–370	Yaw, Alexandra M., 206–222
Actiwatch, 367	Yin, Xiaozhe, 356–380
Daysimeter, 368–369	Young, M., 289
LYS Button, 370	
Wheeler, Robert, 23–57	Zebra finch (<i>Taeniopygia castanotis</i>),
white light, 115, 295, 369	342
Wilkinson, M. J., 242	zebrafish, 227, 340
women, 169, 176, 217, 262, 313, 359, 364, 372	Zeitgeber Time (ZT), 11, 25
weight-gain risk (night shift work), 225	Zeitgebers (time givers), 2, 13, 109, 110
World Atlas of Artificial Night Sky Brightness	Zhang, C., 58, 62
(WAANSB), 364, 366	Zheng, Q., 372
Wright, K. P., Jr, 265	Zhong, C., 364