
Principles and Practice of Clinical Electrophysiology of Vision

Editors

JOHN R. HECKENLIVELY, M.D.
Professor of Ophthalmology
Jules Stein Eye Institute
Los Angeles, California

GEOFFREY B. ARDEN, M.D., PH.D.
Professor of Ophthalmology and
Neurophysiology
Institute of Ophthalmology
Moorfields Eye Hospital
London, England

Associate Editors

EMIKO ADACHI-USAMI, M.D.
Professor of Ophthalmology
Chiba University School of Medicine
Chiba, Japan

G.F.A. HARDING, PH.D.
Professor of Neurosciences
Department of Vision Sciences
Aston University
Birmingham, England

SVEN ERIK NILSSON, M.D., PH.D.
Professor of Ophthalmology
University of Linköping
Linköping, Sweden

RICHARD G. WELEBER, M.D.
Professor of Ophthalmology
University of Oregon Health Science Center
Portland, Oregon



St. Louis Baltimore Boston Chicago London Philadelphia Sydney Toronto



Dedicated to Publishing Excellence

Sponsoring Editor: David K. Marshall
Assistant Director, Manuscript Services: Frances M. Perveiler
Production Project Coordinator: Karen E. Halm
Proofroom Manager: Barbara Kelly

Copyright © 1991 by Mosby-Year Book, Inc.
A Year Book Medical Publishers imprint of Mosby-Year Book, Inc.

Mosby-Year Book, Inc.
11830 Westline Industrial Drive
St. Louis, MO 63146

All rights reserved. No part of this publication may be reproduced, stored in a retrieval system, or transmitted, in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission from the publisher. Printed in the United States of America.

Permission to photocopy or reproduce solely for internal or personal use is permitted for libraries or other users registered with the Copyright Clearance Center, provided that the base fee of \$4.00 per chapter plus \$1.00 per page is paid directly to the Copyright Clearance Center, 21 Congress Street, Salem, MA 01970. This consent does not extend to other kinds of copying, such as copying for general distribution, for advertising or promotional purposes, for creating new collected works, or for resale.

1 2 3 4 5 6 7 8 9 0 CL CL MV 95 94 93 92 91

Library of Congress Cataloging-in-Publication Data

Principles and practice of visual electrophysiology / [edited by]

John R. Heckenlively, Geoffrey B. Arden.

p. cm.

Includes bibliographical references.

Includes index.

ISBN 0-8151-4290-0

1. Electroretinography. 2. Electrooculography. 3. Visual evoked response. I. Heckenlively, John R. II. Arden, Geoffrey B. (Geoffrey Bernard)

[DNLM: 1. Electrooculography. 2. Electrophysiology.

3. Electroretinography. 4. Evoked Potentials,

Visual. 5. Vision

Disorders—physiopathology. WW 270 P957]

RE79.E4P75 1991

91-13378

617.7 1547—dc20

CIP

DNLM/DLC

for Library of Congress

Index

A

Abetalipoproteinemia:
hereditary,
electroretinography in,
506

Absolute threshold, 445

Abuse: drugs of, and visual nervous system, 170

Accommodation
aging and, 423
amplitude, objective, 423

Action potentials: from on/off ganglion cell, 367

Acuity
(*See also* Visual acuity)
grating
in infant, 408–409
tests, 462

monocular, measurement, 413

relation of visual evoked potentials to, 136

vernier, in infant, 409–410

Adaptation
dark (*see* Dark adaptation)
effects in
electroretinography, 391–395

light (*see* Light adaptation)

Adaptometry, dark, 449–454
in thioridazine
retinopathy, 604

two-color, in vitamin A deficiency, 739

Adenoma: chromophobe, 559

Adenosine: retinal effects of, 156–157

Adrenergic
beta- (*See* Beta-adrenergic) transmitters,
beta-adrenergic antagonists action to, 156

Age
changes in visual evoked cortical potentials, 417–420
effect of, in electroretinography, 376
electroretinography and, pattern, 294
of onset
of retinitis pigmentosa, 519–520
of Stargardt's disease, 669–670

P100 peak latency and, 420

Agglutinin: peanut agglutinin-binding molecules, 58

Aging
accommodations and, 423
contrast thresholds and, 420–421
luminance threshold and, 421–422
peak latency changes with, 418–420

pupillary size and, 423

temporal frequency characteristics and, 420

visual evoked cortical potential and, pattern, 417–424

Albinism, 425–434, 773–782
data analysis, 433
electrode montage in, 427, 433
genotype in, 774
luminance flash in, 432
pattern-onset in, 429, 431 response, analysis
procedures in, 427
pattern onset and offset, 426, 432
pedigree in, 777, 778
phenotype in, 774
stimulus mode for, 433
test protocol, 433
testing methodology, 425–434
visual evoked cortical potentials in, methods, overview, 433
visual evoked potential topography in, 430

Alcoholism, 575

Alpha-aminoacidic acid, 103

Alzheimer's disease
electroretinography in, pattern, 795
evoked potentials in, 793–796

Amacrine cells: in retina (in monkey), 36

Amblyopia: and clinical electrophysiology, 589–593

α-Aminoacidic acid, 103

Amplification
double-sided, principle of, 387

synchronous, 250–252

system, standard in ERG, 287

Amplifiers, 183–188
alternating current, 185
bias, 185
calibration of, 194–195
direct current, 185
double-sided, and mains hum reduction, 386–387
dynamic range, 185
frequency response function, 186
gain of, 185
impedance, input and output, 185
linearity, 185
phase distortion and, 187–188
preamplifiers, 183–185
saturation, artifacts in, 389–390

Amplitude
aging and, changes, 417–418
objective, of accommodation, 423

Analog filters, 186–187

Analysis, 229–276
data, 229–276
Fourier (*see* Fourier analysis)
kernel (*see* Kernel)
signal (*see* Signal analysis)

system, and cross-correlation, 248–249

Analysis (cont.)
 techniques, 231–253
 correlation with noise and power spectrum, 246–249
Anesthetics: and visual nervous system, 169
Angiography, fluorescein, 494–500
 as adjunct to electrophysiological testing, 494–500
 in atrophy gyrate, 654
 in Biett's crystalline dystrophy, 684, 686
 in choroideremia, 494–496, 660, 661
 carrier, 663
 dark choroid effect and, 497–499
 in diabetic retinopathy, 626, 628, 629, 632
 in macular schisis vs. edema, 496–497
 of maculopathy, 672
 in night blindness, incomplete-type, 722, 724
 in optic atrophy with disc telangiectasia, 499
 in pattern dystrophy/ retinal pigment epithelium disease, 497
 principles of, basic, 494
 in reticular dystrophy, 701
 in retinal diseases, hereditary, 494–500
 in retinitis pigmentosa, preserved para-arteriolar retinal pigment epithelial, 497
 in Stargardt's disease, 670, 671–672
 in Usher syndrome, type I, 496
Anticholinergics: and visual nervous system, 169
Antiepileptics: and visual nervous system, 169
Arden ratios, 644
Arteries (see Retina, artery)
Artifact(s)
 in amplifier saturation, 389–390
 causes, 384–390
 cures, 384–390
 eye movements, 388–389
 muscle, 388–389
 occurring in new clinic, 384–385
 recognition in visual evoked cortical potential recording, 438–439

rejection, 195
Astrocyte: in retina (in cat), 39
Atrophy
 fovea (*see Fovea, atrophy*)
 gyrate
 angiography of, fluorescein, 654
 of choroid and retina (*see below*)
 dark adaptation curves in, 654
 Goldmann perimetry in, 653
 muscle biopsy in, 655
 pyridoxine-responsive, 650–651, 652
 gyrate, of choroid and retina, 649–658
 biochemistry, 653–655
 clinical description, 651
 diagnosis, differential, 656
 genetics of, molecular, 655–656
 histopathology, 651–652
 history of disease, 649–651
 natural history, 651
 physiology, 652–653
 testing in, relevant, 656
optic (see Optic atrophy)
Autocorrelation, 246–247
 functions of, 247
Autosomal
 dominant cone dystrophy, 542
 recessive cone dystrophy, 542
Averaging, 249–250
 practical considerations on, 250
 response fluctuations, 250
 signal-noise ratio improvement with, 249–250
 small signals, 389–390
 stimulus for, 249
a-wave
 amplitude, drugs reducing, 168
 in retinal damage, 534

B
Background illumination (see Illumination, background)
b/a-wave amplitude ratios: in retinal vascular disease, 531–536
Best's disease, 692–699
 clinical observations, 692
 diagnosis, differential, 692–693
rejection, 195
Astrocyte: in retina (in cat), 39
Atrophy
 fovea (*see Fovea, atrophy*)
 gyrate
 angiography of, fluorescein, 654
 of choroid and retina (*see below*)
 dark adaptation curves in, 654
 Goldmann perimetry in, 653
 muscle biopsy in, 655
 pyridoxine-responsive, 650–651, 652
 gyrate, of choroid and retina, 649–658
 biochemistry, 653–655
 clinical description, 651
 diagnosis, differential, 656
 genetics of, molecular, 655–656
 histopathology, 651–652
 history of disease, 649–651
 natural history, 651
 physiology, 652–653
 testing in, relevant, 656
optic (see Optic atrophy)
Autocorrelation, 246–247
 functions of, 247
Autosomal
 dominant cone dystrophy, 542
 recessive cone dystrophy, 542
Averaging, 249–250
 practical considerations on, 250
 response fluctuations, 250
 signal-noise ratio improvement with, 249–250
 small signals, 389–390
 stimulus for, 249
a-wave
 amplitude, drugs reducing, 168
 in retinal damage, 534

electro-oculography in, 695, 696–697
electrophysiological tests in, 694–696
fundus in, 693
histopathology, 693–694
linkage analysis, 694
stages of, 693
synonyms, 693
Beta-adrenergic
 agonists, action of, 156
 antagonists, action to adrenergic transmitters, 156
 mechanisms in retina, 155–156
Beta₂-adrenergic agonists: clenbuterol as, 155
Bicarbonate responses, 163–166
Bietti's crystalline dystrophy of cornea and retina, 495, 683–691
 clinical description, 683–689
 cornea in, 689
 diagnosis, differential, 690
 findings in, 690
 Ganzfeld ERGs in, 688
 Goldmann perimetric visual fields for, 685, 686, 687
 histopathology, 689
 history, 683
 natural history, 683–689
 physiology, 689
 relevant testing, 690
 ultrastructure in, 689, 690
Binary sequence control: effect of, 257
Biology: retinal cell, principles of, 23–84
Biopsy: muscle, in gyrate atrophy, 655
Birdshot chorioretinitis, 640–642
 fundus in, 641
Blindness
 color, early receptor potential in, 319
 cortical, 578–580
 causes, 578
 retrochiasmal lesions and, 562
visual evoked cortical potentials in, 578–580
visual evoked cortical potentials in, works reporting abnormal potentials, 579
visual evoked cortical potentials in, works reporting normal potentials, 579

visual evoked cortical potentials in, works reporting potentials recovery with visual improvements, 579–580
visual signs, general clinical, 578
night (see Night blindness)
Blue cone monochromatism, 753–755
Bone spicule: after chloroquine, 595
Buffer process: K⁺ spatial, of glial cell, 88
Buffering: K⁺ spatial, 87–88
Burian-Allen contact lens, 381
 electrodes, problems with, 381–382
b-wave, 101–111
 amplitudes of, 289
 (in cat), 102
 drugs increasing, 168
 drugs reducing, 168
 linear regression, 378–379
 reduction, relationship to Ganzfeld fields, 393
 rod, change in dark after Ganzfeld field, 394
V-log intensity curves of, 154
beta-adrenergic agents and, 156
cone amplitude, 349
 implicit time, 349
 implicit time distributions, 350
 implicit time, 350
 relationship to Ganzfeld fields, 393
 implicit time, scatter plot and linear regression, 350
current source density profiles, 104, 105
DC component of, 108–109
generation alternate theories, 108
 mechanism of, 103–105
implicit times, 289
 in retinal vein occlusion, central, 617
 for retinal vein occlusion, central, with NVI, 615
in lipofuscinosis, neuronal ceroid, 790
Müller cell origin of, 101–103
alpha-aminoacidic acid, 103

- current source density analysis, 101
intracellular recording, 101–103
in retinal damage, 534
rod vs. cone, 109
scotopic, in diabetic retinopathy, 622–623
- C**
- Calcium concentration: at synaptic terminal of rod, 77
- Calibration, 193–204
of amplifiers, 194–195
of delays due to filtering, 195
of flash with digital photometer, 202
luminance with subjective photometer, 202
of gain, 194–195
procedures in electroretinography, 382
- Carrier detection, introduction to, 709–710
state in congenital stationary night blindness, 711–712
- Cataract effect on electroretinography, 379
focal ERG in, 336–337
in juvenile neuronal ceroid lipofuscinosis, 788
- Cathode ray tubes, 218
- Cell ganglion (*see* Ganglion cell)
glial (*see* Glial cell)
Müller (*see* Müller cell)
photoreceptor (*see* Photoreceptor cell)
pigmented epithelium of retina, cytology and function, 59
postsynaptic (*see* Postsynaptic cells)
retina (*see* Retina, cell)
rod, responses of, 78
- Central nervous system dysfunction, 761–813
- Ceroid lipofuscinosis (*see* Lipofuscinosis, neuronal ceroid)
- cGMP cascade: of phototransduction, 74
- Checkerboard contrast-reversing potential waveshapes elicited by, 269
Fourier analysis and, 244–246
stimuli, comparison with grating stimuli, 409
- Chiasmal lesions, 557–560
- Children electroretinography of, under halothane, 378
- Hospital for Sick Children Study in developmental delay, 582–583
- lipofuscinosis (*see* Lipofuscinosis, neuronal ceroid, juvenile)
management for testing, 279–280
retinitis pigmentosa inversa, juvenile-onset, 677
retinoschisis, 496
X-linked juvenile (*see* Retinoschisis, X-linked juvenile)
testing, 281–282
visual acuity estimation (*see* Infant, visual acuity estimation in)
- Chloroquine foveal atrophy after, 595
retinal toxicity due to, 594–599
- Chlorpromazine, 604–605
- Cholinergics: and visual nervous system, 169
- Chorioretinitis, birdshot, 640–642
fundus in, 641
- Choroid atrophy, gyrate (*see* Atrophy, gyrate, of choroid)
dark choroid effect angiography and, fluorescein, 497–499
in Stargardt's disease, 498
relationships in central retina, light micrograph of (in monkey), 54
- Choroidemia, 659–663 angiography in, fluorescein, 494–496, 660, 661
carriers, 662–663
angiography in, fluorescein, 663
- clinical findings in, 660–663
diagnosis, differential, 663
ERG parameters in, 662
in hemizygotes, male, 660–662
heterozygotes, 662–663
X-linked carrier state evaluation, 744–747
- Chromatic recordings: in electroretinography, 339–347
- Chromaticity diagram: CIE 1931, 219
- Chromophobe adenoma, 559
- CIE 1931 chromaticity diagram, 219
- Circuit(s) equivalent electrical, for current pathways in eye, 89
of postsynaptic cell, 81
retinal, scheme of, 152
specialized, 44–45
voltage drive, of flash stimulator, 223
- Circuitry for cone signals through retina, 41–43
for rod signals through retina, 39–41
- Clenbuterol, 155
- Clinical testing principles, 483–569
- Coat's reaction: in simplex retinitis pigmentosa, 499
- Color blindness, early receptor potential in, 319
in ERG, pattern, 298
production, 218–219
sense abnormality in multiple sclerosis, 807–808
- stimuli filters, 216–217
production of, 215–217
- vision disorders, and rod-cone interaction, suppressive, 472
in Leber's hereditary optic atrophy, 763
in Sorsby's fundus dystrophy, 705
visual evoked potential (*see* Visual evoked potential, cortical, color)
- Common-mode rejection, 387 ratio, 185
- Computer program for band-pass filter, 205–206
- simulation of electro-oculography, 306
- Conductance: changes mediated by L-glutamate, 79–80
- Cone blue cone monochromatism, 753–755
b-wave (*see* b-wave, cone)
degeneration clinical features, 539–541
with drusen, familial, and scotoma, 680
optic atrophy in, temporal, 541
partial, 542
signs and symptoms, 539–541
disorders, management of, 543
- dysfunction, 537–543
hereditary forms, 537
hereditary forms, known, 541–542
partial, 542
syndromes, 512
- dystrophy, 537–543
autosomal dominant, 542
autosomal recessive, 542
early potential receptor in, 319
electroretinography in, 538
fovea centralis atrophy in, 540
hereditary forms, known, 541–542
macula in, 540
progressive, 512
- dystrophy, X-linked recessive, 756–760
biochemistry, 757–758
clinical description, 756–757
diagnosis, differential, 758–760
- Ganzfeld EOG in, 759
Ganzfeld ERGs in, 758
Goldmann-Weekers dark adaptometry in, 759
histopathology, 757–758
history of disease, 756
natural history, 756–757
pathophysiology, 757–758
testing in, 758–760
- electroretinography (*see* Electroretinography, cone)
- perimetry (*see* Perimetry, rod and cone)

Cone (*cont.*)
 relative spectral absorbances of, 197
 of retina
 circulating current reduction, due to light flashes (in monkey), 71
 cone-cone coupling, 76
 degeneration, progressive, 64
 electron micrograph of (in monkey), 29
 functional interconnections of, 75–76
 matrix sheath, fluorescence light micrograph of, 62
 off-center pathways (in cat), 42
 on-center pathways (in cat), 42
 pedicle, electron micrograph of, 30
 pedicle, telodendria of, gap junction between two, 31
 photoreceptor density, 49
 photoreceptor density, isodensity maps of, 49
 photoresponse spectral sensitivity of (in monkey), 72
 phototransduction in, 69–75
 rod-cone coupling, 76
 signals, circuitry through, 41–43
 voltage changes produced by light flashes in (in turtle), 70
 vs. rod b-wave, 109
 -rod (*see* Rod-cone)
 single-flash “cone response” in ERG, 288
 spectral sensitivity functions, 476
 Contact lens
 Burian-Allen, 381
 electrode(s), 178–179 of Riggs, 10
 in electroretinography, 330
 stimulator, haptic, 608
 Contrast definition of, 465
 sensitivity measurement, 465–468
 testing methods, 468
 testing, producing stimuli for, 467–468
 testing, results, 468

testing, results for temporal frequencies, 468
 significance of, 465
 spatial, 467 sensitivity, 468
 temporal, 466–467 thresholds aging and, 420–421 mean, 421 vs. pupillary area, 422
 Cornea
Bietti's dystrophy (*see* *Bietti's crystalline dystrophy of cornea*)
 direct dc recording of ERG, 330
 opacity, effect on electroretinography, 379
 recording, direct, electrodes for, 180 toxicity, 594
 Cross-correlation: and system analysis, 248–249
 c-wave, 91–92 in diseases of pigment epithelium, 545–546 normal, 544–545 “off,” 546
 Cyclic nucleotide cascade, 72–73

D

Dark adaptation basic clinical, 449–454 curve(s) in atrophy, gyrate, 654 in drusen, 667 in night blindness, 454 normal, 451 normal, typical, 450 in Oguchi's disease, 716 in electroretinography, 375 cone, 394 rod, 394–395 in fundus albipunctatus, 718, 733 psychophysical, in night blindness, incomplete-type, 721 in retinitis pigmentosa, 520 in retinoschisis, X-linked juvenile, 728
 Dark adaptometry (*see* Adaptometry, dark)
 Data acquisition, 229–276 systems, special-purpose (*see* Special-purpose data acquisition systems)

analysis (*see* Analysis)
 Defocusing: and pattern-onset stimulation, 439
 Dementia: senile, of Alzheimer's type, pattern electroretinography in, 795 Depression: spreading, 130 Deutan(s) patients, early receptor potential in, 344–346 rapid off-response in, 339–344 Developmental delay, 581–584 clinical description, 581 diagnosis, differential, 584 electrophysiological findings, 581–583 historical, 581–582 Hospital for Sick Children Study, 582–583 electroretinography in, 581–584 pathophysiology, 583–584 P100 latency in, 583 in prematurity, 586, 587 visual evoked cortical potentials in, 581–584 flash, 585–588
 Diabetes mellitus electroretinography to detect early functional abnormality, 624 flash response in, 320 retinopathy in (*see* Retinopathy, diabetic)
 Diamox responses, 163–166 Digital filters, 186–187 band-pass (*see* Filter, band-pass, digital)
 photometer for flash calibration, 202
 Diodes (*see* Light-emitting diodes)
 Disc telangiectasia: with optic atrophy, 499 Display system: standard in ERG, 287
 Display tubes, 217–219 color production, 218–219 description, general, 217 patterns/contrast production, 217–218
 Diurnal patterns: in visual evoked cortical potential recording, 438 L-Dopa: and visual nervous system, 168

Drugs of abuse and visual nervous system, 170 a-wave amplitude and, 168 b-wave amplitude and, 168 neuropsychiatric, effects on visual nervous system, 167–173 for psychiatric conditions, 167–168 and retinal electrophysiology, 151–162 concentration estimation, 152–153 drug application, 151–153 experimental preparations, 151–153 interpretations of effects, 151–153 systemic drugs and retinal side effects, 158 toxicity pathogenesis, 598 visual evoked potentials amplitude and, 168
 Drusen dark adaptation curves from, 667 dominant, 664–668 clinical findings, 664–665 definition, 664 electrophysiology of, 665–668 psychophysics of, 665–668 electroretinography in, 667 familial, with cone degeneration and scotoma, 680 inherited, 668 DTL fiber electrodes, 179–180 “Dummy patients.” diagrams of, 388 Duplicity theory, 448–449 d-wave, 112–114 ERGs with (in mammal), 113 Dystrophy *Bietti's* (*see* *Bietti's crystalline dystrophy*) cone (*see* Cone dystrophy) pattern, 700–706 clinical findings, 700–701 electro-oculography in, 701, 704 electroretinography in, 703 physiological findings, 701–704 pigmentation in, 703

- retinal pigment epithelium disease, 497
- reticular, 701
- rod-cone (*see* Rod-cone dystrophy)
- Sorsby's fundus, 705
- E**
- Early receptor potential (*see* Receptor potential, early)
- Edema, macular, 524
- vs. schisis, fluorescein angiography in, 496–497
- E-ERG analysis (in cat), 8
- Einthoven and Jolly: ERG recording, 6
- Electric current:
- transretinal, retinal potentials evoked by, 129–130
- Electrical changes produced by light, 69–72
- equivalent circuit for current pathways in eye, 89
- Electrode(s), 177–182
- Burian-Allen, problems with, 381–382
 - cleaning, standard in ERG, 285
 - contact lens, 178–179 of Riggs, 10
 - for corneal recording, direct, 180
 - DTL fiber, 179–180
 - electrode-oculogram, 180–181
 - for electrophysiological testing, 177–182
 - electroretinographic, 177–180
 - in electroretinography, pattern (*see* Electroretinography, pattern, electrodes)
 - gold foil lid-hook, 179
 - ground, standard in ERG, 285
 - impedance, measurement of, 194
 - montage in albinism, 427, 433
 - oculogram electrodes, 180–181
 - placements standard, 92
 - for visual evoked cortical potential recording, 399–406
- positions, ten-twenty designations of, 402–406
- problems, 387–388 checking for, 388
- recording, standard in ERG, 285
- reference, standard in ERG, 285
- skin, 180
- standard in ERG, 285
- stability, standard in ERG, 285
- standards in ERG, 285–286
- for visual evoked cortical potential recording, 399
- visual evoked response, 181
- in vitreous humor (in cat), 109
- Electron micrograph of cone of retina (in monkey), 29
- pedicle, 30
- of foveal neuropil, 35
- of rods of retina (in monkey), 29
- Electron microscopy: in lipofuscinosis, neuronal ceroid, juvenile, 789
- Electronic noise sources, 184
- recording equipment, standard in ERG, 287
- Electro-oculography, 301–313
- applications, clinical, 308–309
 - in Best's disease, 695, 696–697
 - clinical, 301
 - computer stimulation of, 306
 - in diabetic retinopathy, 625
 - in dystrophy, pattern, 701, 704
 - eye movements, 302–303
 - in fundus albipunctatus, 734–735
 - history of, 14–16
 - light peak, 303–305
 - in melanoma, malignant, 644–645
 - models in, mathematical, 305–306
 - monitoring eye positions, 303
 - in night blindness, incomplete-type, 722
 - non-photic stimuli, 307
 - oscillation fast, 308
 - slow, 305, 307–308
 - principle of indirect recording, 301–302
 - response parameters, 305
 - special recording conditions, 306–307
- Electrophosphenes: comparison with magnetophosphenes, 365–366
- Electrophysiology amblyopia and, 589–593
- of drusen, dominant, 665–668
- in fundus flavimaculatus, 681
- in inflammatory states, 611–645
- of Leber's hereditary optic atrophy, 764
- light-emitting diodes in (*see* Light-emitting diodes)
- in lipofuscinosis, neuronal ceroid, 786–789
- parameters in retinitis pigmentosa, 510–527
- in pituitary syndromes, 783–785
- recording systems, digital filter for, 205–210
- of retina (*see* Retina, electrophysiology)
- of Sorsby's fundus dystrophy, 706
- stimulators for (*see* Stimulators for electrophysiology)
- system, typical clinical, major components of, 190
- testing
- angiography, fluorescein, as adjunct (*see* Angiography, fluorescein)
 - in Best's disease, 694–696
 - definitive, examples of, 490
 - electrodes for, 177–182
 - equipment for, 175–228
 - lesion localization by, 486
 - psychophysical techniques relevant to, 445
 - tests, correlation of results with clinical findings, 491–492
 - in tumors, 611–645
 - in vascular disease, 611–645
 - visual, history of, 1–22
- slow, 305, 307–308
- Electroretinography, 488
- in abetalipoproteinemia, hereditary, 506
- adaptation effects in, 391–395
- amplitude(s) distribution of, 289–290 photopic, histograms of, 290
- background illumination in, 372
- Burian-Allen electrode problems, 381–382
- calibration procedures, 382
- in children under halothane, 378
- in choroideremia, 662
- chromatic recordings of, 339–347
- clinical, 9–11
- components, 7–8
- arising in retina, distal, 91–98
 - arising in retina, midretina, 99–100
 - arising in retina, proximal, 99–100
 - distal, interactions between, 97
 - putative underlying, 532
- cone effect of background illumination on, 392–394
- dystrophy, 538
- growth during light adaptation, 391–392
- contact lens on eye, 330
- c-wave of (*see* c-wave)
- dark adaptation in, 375 initial, 287
- in developmental delay, 581–584
- in diabetes, to detect early functional abnormalities, 624
- in diabetic retinopathy (*see* Retinopathy, diabetic, electroretinography in)
- display unit, 331
- in drusen, 667
- duration series (in cat), 354
- d-waves and (in mammal), 113
- in dystrophy, pattern, 703
- E-ERG analysis (in cat), 8
- effect
- of age, 376
 - of cataract, 379
 - of corneal opacity, 379
 - of miosis, 379
 - of ocular pigmentation, 377–378
 - of refraction, 377

- Electroretinography (*cont.*)
- of sex, 377
 - of vitreous hemorrhage, 379
 - of vitreous substitute, 379–380
 - electrodes, 177–180
 - first published human electroretinogram, 6–7
 - five basic responses, diagram of, 284
 - flash illumination in, 372
 - flicker, 348–351
 - focal, 334–338
 - in cataract, 336–337
 - cone amplitude, 335
 - in macular holes, 337
 - in maculopathy, 336
 - normal values, 335
 - stimulation, 373
 - uses, clinical, 335–337
 - in fundus albipunctatus, 718, 733–734
 - history of, 5–13
 - early discoveries, 5–13
 - I-ERG analysis, 7
 - implicit times, 289–290
 - in infant, 410
 - intensity series, 353, 355, 357
 - intersession variability, 380–381
 - latencies, distribution of, 289–290
 - light adaptation in, 375
 - light calibration in, 373–374
 - light stimulation in, 371–376
 - equipment and procedure for, 329–332
 - in lipofuscinosis, neuronal ceroid, 788
 - measurements, standards for, 287–288
 - monitoring
 - in intensive care unit, 607–610
 - intraoperative, 607–610
 - of Müller cell responses, 103
 - negative response
 - near rod threshold, 352
 - threshold, 353
 - in night blindness (*see* Night blindness, congenital stationary, incomplete-type, electroretinography in)
 - normal
 - with negative ERGs, 532
 - values, 287
 - variation, 376–378
 - ocular media changes in, 379–381
 - origins
 - anatomy, 89
 - determination methods, 88–89
 - intracellular recordings, 88
 - ion recordings, 88–89
 - pharmacology, 89
 - in parkinsonism, 811–812
 - pattern, 291–300
 - age and, 294
 - in Alzheimer's disease, 795
 - amplitude, 291–292
 - color in, 298
 - contrast component, 296–298
 - defocus, 294
 - electrodes, 292–294
 - electrodes, corneal position, 293
 - electrodes, penetrating microelectrodes, 295
 - electrodes, reference position, 293–294
 - evaluation of, 291–292
 - in glaucoma, 549–556, 766–772
 - hints on useful clinical technique, 293
 - latency, 292
 - in Leber's hereditary optic atrophy, 764
 - luminance of, 296–298
 - in multiple sclerosis, 800
 - normal, 292, 294
 - in ocular hypertension, 550, 766–772
 - in optic nerve function, 549–556
 - origin, 294–295
 - pupil size, 294
 - recording, practical
 - problems in recording
 - reliable clinical results, 292–294
 - recording, "steady-state," 292
 - recording, "transient," 291–292
 - research for, clinical and animal, 294–295
 - spatial frequency, 295–296
 - stimulus parameters, 295–298
 - two fractions of, demonstration of, 297
 - pigment epithelium
 - responses, slow, 328–329
 - preparation of patient, 287
 - fixation, 287
 - pre-exposure to light, 287
 - properties of, summary of, 7
 - protocol, 287–288
 - recording
 - corneal dc, direct, 330
 - dc, 329
 - early, 5–6
 - by Einthoven and Jolly in 1908, 6
 - equipment for, 329–332
 - with long time constant, 323–324
 - procedure, 329–332
 - protocols, 328–333
 - with short time constant, 325
 - standards for, 287–288
 - in Refsum's disease, 507
 - relation to PI, PII, and PIII, 7
 - reporting of, 287–288
 - responses, 288
 - flicker, 288
 - maximal, 288
 - oscillatory potentials and, 288
 - "rod," 288
 - single-flash "cone," 288
 - to various wavelengths of light, 11
 - in retinal artery occlusion, 617–618
 - in retinal vein occlusion
 - (*see also* Retina, vein occlusion, central, electroretinography)
 - in retinitis pigmentosa (*see* Retinitis pigmentosa, electroretinography in)
 - X-linked recessive
 - female carrier, heterozygote, detection, 741–743
 - in retinoschisis, X-linked juvenile, 728
 - rod, dark adaptation of, 394–395
 - scotopic threshold response, 122, 352–362
 - signal processing, 331
 - standards for, 283–288
 - stimulation for, local, 215
 - stimulators for, 224–226
 - subject preparation for, 374–375
 - technical issues in, 371–383
 - technology, basic, 285–287
 - in thioridazine
 - retinopathy, 603
 - of vessels in ischemia, 613–618
 - in vitamin A deficiency, 738
 - waveform
 - changes characteristic of disease, 488–491
 - "negative," disorders with, 489
 - Embryological origins, 53–55
 - EOG (*see* Electro-oculography)
 - Epithelium (*see* Pigment epithelium)
 - Equipment
 - electronic recording, standard in ERG, 287
 - for electrophysiological testing, 175–228
 - for ERG recording, 329–332
 - monitoring, 193–204
 - ERG (*see* Electroretinography)
 - ERP (*see* Early receptor potential)
 - Evoked potential(s)
 - in Alzheimer's disease, 793–796
 - topographical (*see* Mapping topographical evoked potential)
 - visual (*see* Visual evoked potential)
 - e-wave, 115
 - Eye
 - (*See also* Ocular) movements
 - artifacts, 388–389
 - in electro-oculography, 302–303
 - neuritis, 800

F

- Fast-oscillation trough, 95–96
- intraretinal recordings during, 95
- Feedback loops: in retina, 45–47
- Filter(s)
 - analog, 186–187
 - band-pass, 186
 - band-pass, computer program for, 205–206
 - band-pass, digital, 205–210
 - comparisons with other filters, 206–207
 - testing hints, 207
- band-reject, 186

- BP-FIR, 206
 color stimuli, 216–217
 digital, 186–187
 high-pass, 186
 low-pass, 186, 206
 smoothing, digital, 206–207
 3-dB, 207
- Filtering**
 calibration of delays due to, 195
 phase-free, 243
 technique in oscillatory potential recording, 322
- Flash**
 illumination in electroretinography, 372
 luminance (*see* Luminance, flash)
 response in diabetes, 320
 stimulator, voltage drive circuit of, 223
 visual evoked cortical potential in developmental delay, 585–588
 visual evoked potential (*see* Visual evoked potential, flash)
 visual evoked response (*see* Visual evoked response, flash)
- Flicker**, 465–466
 electroretinography, 348–351
 implicit time in diabetic retinopathy, 623
 responses, 349
- Fluorescein (*see* Angiography, fluorescein)**
- Fluorescence**
 light micrograph of cone matrix sheath, 62
 microscopy of retinal radial section (in dogfish), 79
- Focal electroretinography (*see* electroretinography, focal)**
- Fourier analysis**, 237–243
 checkerboards and, 244–246
 domains, 240–241
 practical considerations on using, 241–243
 spatial, 243–246
 linearity, 243
 receptive fields, 246
 spatial frequency, 244
 time vs. space, 243–244
- square wave (*see* Square wave)**
- standard periodic signals, 238
 test signals, 240
- Fourier integral**, 238–240
- Fourier, Joseph**, 237
- Fourier spectrum**: of periodic impulses, 239
- Fovea**
 atrophy
 centralis, in cone dystrophy, 540
 after chloroquine, 595
 development of, 56
 light micrograph of (in monkey), 57
 midget pathways in, 43–44
 neural connections in, 44
 neuropil, electron micrograph of, 35
 radial section through, 28
- Full-field dome**, 372
- Fundus**
 abnormalities in night blindness, congenital stationary, 715–719
 alipunctatus, 717–719, 730–736
 clinical findings, 730–732
 dark adaptation in, 718
 dark adaptation curves from, 733
 electro-oculography in, 734–735
 electroretinography in, 718, 733–734
 psychophysical test results in, 732
 reflectometry in, fundus, 732–733
 visual pigment regeneration in, 733
- in Best's disease, 693
- in chorioretinitis, birdshot, 641
- in diabetic retinopathy, 625, 626, 628, 629, 631, 632
- dystrophy**, Sorsby's, 705
- flavimaculatus**
(See also Stargardt's disease)
 advanced, 677
 case studies, 676–681
 diagnosis, differential, 676
 electrophysiological findings in, 681
 -like diseases, 675–682
 -like diseases, differential diagnosis, 675–682
 -like diseases, splitting vs. lumping, 675–682
- in Leber's hereditary optic atrophy, 763
 in night blindness, incomplete-type, 722
 reflectometry, 264–267
 in Stargardt's disease, 670–671
- G**
- Gain**
 of amplifiers, 185
 calibration of, 194–195
- Ganglion cell**
 firing of (in cat), 82
 on/off, antion potentials from, 367
 properties of, summary of (in cat), 83
 types in retina (in monkey), 37
- Ganzfeld**
 dome, 372
 electro-oculography in cone dystrophy, X-linked, 759
 electroretinography in Bietti's crystalline dystrophy, 688
 in cone dystrophy, X-linked, 758
- fields**
 relationship to b-wave amplitude reduction, 393
 relationship to cone b-wave implicit time, 393
 rod b-wave amplitude change in dark after, 394
 stimulation, 214–215, 332
 stimulator, 371–372
- Gaussian noise**, 247
- Gender**
 difference in P100 peak latency, 420
 in retinitis pigmentosa, 516
- Genetic carriers**: rapid off-response in, 344
- Genetics**
 hereditary forms of cone dysfunction, 537
 hereditary transmission of night blindness, incomplete-type, 724
 inheritance
 in Leber's hereditary optic atrophy, 763
 pattern in retinitis pigmentosa, 516, 517
 of Stargardt's disease, 669
 inherited drusen, 668
- molecular, of gyrate atrophy, 655–656
- Genotype**: in albinism, 774
- Geometric relationships**
 in extended primary and secondary sources, 199
 with point source, 198
- Glaucoma**
 chronic open-angle, diagnosis, 767
 electroretinography in, pattern, 549–556, 766–772
- Glial cell**
 K^+ spatial buffer process in, 88
 of retina, 38–39
- Glioma**: optic nerve, surgery of, flash VEP during, 609
- Global field power**, 268
- Glutamate**: depolarization of rod horizontal cell by pulses of, 81
- L-Glutamate**: conductance changes mediated by, 79–81
- Gold foil lid-hook electrodes**, 179
- Goldmann**
 perimetry in gyrate atrophy, 653
 visual fields, for Bietti's crystalline dystrophy, 685, 686, 687
- Goldmann-Weekers dark adaptometry**: in cone dystrophy, X-linked, 759
- Grating(s)**, 465–466
 acuity
 in infant, 408–409
 tests, 462
- sinusoidal, 466
- stimuli, comparison with checkerboard stimuli, 409
- Ground loop**, 386
- Gunshot wound**: orbit in, 569
- H**
- Halothane**: electroretinography of children under, 378
- Handicapped patients**: visual acuity of multihandicapped patients, 463
- Head injury**, 570
- Hemianopia**
 bitemporal, 558

Hemianopia (*cont.*)
macular-sparing,
homonymous, 560,
561
Hemisphere: responses to
two spatial
frequencies, 149
Hemorrhage: vitreous, effect
on
electroretinography,
379
Histograms
log (bp/ba), 529–530
of photopic ERG
amplitudes, 290
History
of electro-oculography,
14–16
of electroretinography,
5–13
of visual
electrophysiology,
1–22
of visual evoked cortical
testing, 17–22
Hormones: and visual
nervous system,
169–170
Hydroxychloroquine: causing
retinal toxicity,
594–599
Hyperosmolarity responses,
163–166
Hypertension: ocular,
pattern
electroretinography in,
550, 766–772
Hypopigmentation: in
chloroquine toxicity,
595
Hysteria: electrodiagnostic
testing in, 573–577

I

I-ERG analysis, 7
Illuminance
measurement problems,
200–202
of red flickering test
stimulus, 470
retinal, 201
of sinusoidally flickered
test stimulus, 470
units, conversion factors
for, 199
Illumination
background
effect on cone
electroretinography,
392–394
in electroretinography,
372
results of, 392

flash, in
electroretinography,
372
Impedance
electrode, measurement of,
194
source, measurement of,
193
Infant
electroretinography in, 410
high visual evoked
potential sensitivity,
clinical implications of,
414–415
management for testing,
279–280
stereopsis in, 410
vernier acuity in, 409–410
visual acuity estimation by
visual evoked cortical
potentials, 408–416
contrast sensitivity, 409
measurement methods,
410–412
philosophy of, 408
visual evoked potential
latency, 410–411
steady-state, 411
sweep technique,
411–412
transient, 410
visual performance tasks,
408–410
Inflammatory states:
electrophysiological
evaluation, 611–645
Inheritance (*see* Genetics,
inheritance)
Instrumentation: for rod and
cone perimetry, 476
Intensity relations, 260–263
significance of, 260–263
Intensive care unit:
monitoring with visual
evoked potentials and
ERG, 607–610
International ten-twenty
system, 400
Interphotoreceptor
matrix
composition, 57–63
embryological origins,
53–55
function, 57–63
morphology, 57–63
relationships in central
retina, light
micrograph of (in
monkey), 54
structure, 61–63
space, development of,
56–57
Interplexiform cell: in retina
(in cat), 46

Intraocular pressure:
elevation, scotopic
threshold response in,
360

Intraoperative monitoring:
with visual evoked
potentials and ERG,
607–610

Ion
channels, Müller cell,
106–107
movements across surface
membrane of rod, 70
recordings in
electroretinography
origins, 88–89
Iron chelators: and retina,
159
Ischemia: vascular,
electroretinographic
ratios in, 613–618
Ischemic optic neuropathy,
636–639
Isodensity maps: of cone
photoreceptor density,
49

J

Jansky-Bielchowsky
lipofuscinosis,
786–789
Juvenile (*see* Children)

K

K^+ changes: source of, and
b-wave generation,
105
 K^+ concentration:
extracellular,
light-evoked
variations, 105
 K^+ conductance, 105–106
distribution over Müller
cells, 106
 K^+ /Müller cell hypothesis
(*see* Müller cell/ K^+
hypothesis)
 K^+ -Müller cell mechanism:
for scotopic threshold
response, 122–123
 K^+ spatial
buffer process in glial cell,
88
buffering, 87–88
 K^+ variations: in b-wave
generation, 104–105
Kernel
analysis, 254–259
linear approximations of
nonlinear system, 256
stimuli for, 256–258
first-order, 255–256

second-order, 255, 256
systems, 255–256
Kufs lipofuscinosis, 789

L

Lake-Cavanagh
lipofuscinosis,
787–789
Lamp, xenon flash, 213
time course of light output
from, 214
L-dopa: and visual nervous
system, 168
Leber's hereditary optic
atrophy, 763–765
associated neurological
findings, 764
color vision in, 763
diagnosis, differential, 764
electrophysiology, 764
electroretinography in,
pattern, 764
fundus in, 763
inheritance, 763
in Japan, 764
pathogenesis, 764
retinal function in,
763–764
treatment, 764
visual acuity in, 763
visual evoked cortical
potentials in, 764
visual fields in, 763–764
Lens (*see* Contact lens)

L-glutamate: conductance
changes mediated by,
79–80

Light
adaptation, 73–75
cone electroretinography
growth during,
391–392
early receptor potential
and, 318–319
in electroretinography,
375
adjustment, standard in
ERG, 286
background calibration,
standard in ERG, 286
background illumination,
standard in ERG, 286
background intensity,
standard in ERG, 286
calibration in
electroretinography,
373–374
standard, 286
concentration in
light-emitting diodes,
222
diffusion, standard in
ERG, 285

- electrical changes
produced by, 69–72
- emitting diodes, 221–227
applications, 224
arrays, 224
connections of, series
and parallel, 224
construction of, 222
feedback loop of current
drive to enhance, 223
light concentration in, 222
relationship between
current and light
output, 223
- measurement (*see*
Photometry)
- micrograph
fluorescence, of cone
matrix sheath, 62
of fovea (in monkey), 57
of interplexiform cell in
retina (in cat), 46
of midget bipolar cell, 33
of Müller cells in retina
(in monkey), 38
- of peanut
agglutinin-binding
molecules (in
monkey), 58
- of relationships in
central retina (in
monkey), 54
- peak, 96–97, 546–547
in electro-oculography,
303–305
- recalibration standard in
ERG, 286
- sensitivity of postsynaptic
cells, 80–81
- sources, standard in ERG,
285–286
- stimulation in
electroretinography,
371–376
- stimulus
adjustment, standard in
ERG, 286
calibration in ERG, 286
duration, standard in
ERG, 285–286
strength, standard in
ERG, 286
wavelength, standard in
ERG, 286
- Linear approximations: of
nonlinear system, 256
- Linearity: of amplifiers, 185
- Lipofuscinosis
Jansky-Bielchowsky,
786–789
- Kufs, 789
- Lake-Cavanagh, 787–789
- neuronal ceroid, 786–792
adult, 789
- animal models, 790
atypical forms, 789
b-wave in, 790
clinical findings,
786–789
electrophysiology,
786–789
findings in
heterozygotes,
789–790
- infantile, 786
- infantile, late, 786–787
- juvenile, 788–789
- juvenile, cataract in, 788
- juvenile, early, 787–789
- juvenile, early,
electroretinography in,
788
- juvenile, electron
microscopy in, 789
- prenatal diagnosis,
789–790
- treatments,
experimental, 790
- types, tabular data, 789
- ultrastructure in, 789
- Santavuori-Haltia, 786
- Stengel-Spielmeyer-Vogt,
788–789
- Log (bp/bst)
histograms, 529–530
in retinitis pigmentosa,
528–530
- Loop: ground, 386
- Luminance, 201
along elements of
checkerboard, 245
- in ERG, pattern, 296–298
- flash
in albinism, 432
calibration with
subjective photometer,
202
- illuminance (*see*
Illuminance)
measurement problems,
200–202
- of square-wave flickering
test probe, 471
- units of, conversion table,
200
- visual acuity as function
of, 460
- in visual acuity testing,
459–460
- M**
- Macula
in cone dystrophy, 540
X-linked recessive, 757
- degeneration with
nyctalopia, 679
- edema, 496–497, 524
- holes: focal ERG in, 337
normal, in night blindness,
incomplete-type, 724
- in retinitis pigmentosa,
523, 524
- schisis vs. edema,
fluorescein
angiography in,
496–497
- Maculopathy
angiography of,
fluorescein, 672
- focal ERG in, 336
- Magnetic fields: in
environment,
phosphene related,
364–365
- Magnetically evoked retinal
responses, 363–368
- Magnetophosphenes
comparison with
electrophosphenes,
365–366
- generation of, possible site
of, 366–367
- sensitivity maxima,
363–364
- threshold values, 364, 365,
366
- thresholds of, 363–364
- Mains
hum reduction and
double-sided
amplifiers, 386–387
- interference
entering recording
situation, 385
theory of, 385–386
- Malingering:
electrodiagnostic
testing in, 573–577
- Management of patient,
277–280
children, 279–280
infants, 279–280
- Mapping topographical
evoked potential
component latency, 268
- global field power, 268
- potential map series, 273
- potential profiles
enhanced display of, 272
series of, 271
- topographical potential
profile construction,
270
- Melanoma, malignant,
643–645
- electro-oculography in,
644–645
- Membrane potential
rod, 77
- transmitter release control
by, 76–77
- Memoir: personal, 3–4
- Mesoridazine, 604
- Microelectrodes, 8–9
- Micrograph
electron (*see* Electron
micrograph)
light (*see* Light micrograph)
- Microscopy
electron, in neuronal
ceroid lipofuscinosis,
juvenile, 789
- fluorescence, of retinal
radial section (in
dogfish), 79
- Minimum-phase rule: in
signal analysis,
234–235
- Miosis: effect on
electroretinography,
379
- Model(s)
in lipofuscinosis, neuronal
ceroid, animal, 790
- mathematical, in
electro-oculography,
305–306
- Molecular genetics: of gyrate
atrophy, 655–656
- Monitoring
equipment, 193–204
- ERG (*see*
Electroretinography,
monitoring)
- eye position with
electro-oculography,
303
- of intensive care unit with
visual evoked
potentials and ERG,
607–610
- intraoperative, with visual
evoked potentials and
ERG, 607–610
- for retinal toxicity,
596–598
- Monoamines: retinal effects
of, 156–157
- Monochromatism: blue cone,
753–755
- Monocular
acuity measurement, 413
latency variation, mean,
normal values, 438
- Monosodium aspartate: and
ERG intensity series,
357
- Mucopolysaccharidosis VI,
63–64
- Müller cell
cytology, 61
- electroretinographic
component, 92–93
- electroretinography of, 103
- function, 61

- Müller cell (*cont.*)
 intracellular responses, 103
 ion channels, 106–107
 K^+ conductance
 distribution over, 106
 $/K^+$ hypothesis
 challenges of, 107–108
 summary of, 107
 membrane properties,
 105–107
 origin of b-wave (*see*
 b-wave, Müller cell
 origin of)
 of retina (in monkey), 38
 Multiple sclerosis, 797–805
 color sense abnormality in,
 807–808
 electroretinography in,
 pattern, 800
 with optic nerve
 demyelination, 552
 paraplegia due to,
 progressive spastic,
 799
 P100 and, 807–808
 PVEP in, abnormal,
 incidence of, 798
 visual acuity decrease in,
 806–807
 visual dysfunction in,
 806–809
 visual evoked cortical
 potential in
 delayed, 806–809
 pattern, 806–810
 pattern, delayed,
 underlying
 mechanism, 809
 visual evoked potentials
 in, flash, 799
 visual field defects in,
 808–809
- Muscle
 artifacts, 388–389
 biopsy in gyrate atrophy,
 655
- M-wave, 118–120
 generation, summary of
 events underlying, 116
- N**
- Nerve(s)
 connections in fovea, 44
 optic (*see* Optic nerve)
 organization of retina,
 25–52
- Nervous system
 central, dysfunction,
 761–813
 visual
 anesthetics and, 169
 anticholinergics and, 169
 antiepileptics and, 169
- cholinergics and, 169
 drugs of abuse and, 170
 hormones and, 169–170
 L-dopa and, 168
 neuropsychiatric drug
 effects on, 167–173
 tranquilizers and, minor,
 169
- Neural (*see* Nerve)
- Neuritis
 of eye, 800
 optic, 807
 retrobulbar, 553, 554
- Neuromodulators: in retina,
 48
- Neuron(s)
 intracellular responses
 from, and oscillatory
 potentials, 126–128
 in rod pathways through
 retina, 40
- Neuronal ceroid
 lipofuscinosis (*see*
 Lipofuscinosis,
 neuronal ceroid)
- Neuropathy: optic, ischemic,
 636–639
- Neuropeptides: in retina, 48
- Neuropharmacology:
 experimental, of
 retina, 153–157
- Neuropil: of fovea, electron
 micrograph of, 35
- Neuropsychiatric drugs:
 effects on visual
 nervous system,
 167–173
- Neurotransmitters: in retina,
 47–50, 83–84
- Night blindness, 521
 congenital stationary,
 713–720
 with abnormal fundi,
 715–719
 carrier state of, 711–712
- congenital stationary,
 incomplete-type,
 721–725
 angiography in,
 fluorescein, 722, 724
 clinical findings,
 721–724
 dark adaptation in,
 psychophysical, 721
 diagnosis, differential,
 724–725
 electro-oculography in,
 722
 electroretinography in,
 723
 electroretinography in,
 photopic, 722
 electroretinography in,
 scotopic, 722
- electroretinography,
 single-bright-flash, 722
 fundus in, 722
 hereditary transmission,
 724
- macula in, normal, 724
 refractive error in,
 721–722
 visual acuity in, 721, 724
 visual field in, 721
- congenital stationary, with
 normal fundi, 713–715
- congenital stationary,
 X-linked recessive, 711
- dark adaptation curve in,
 454
- rod-cone interaction and,
 suppressive, 471–472
- Noise
 analytic techniques and,
 246–249
 electronic sources, 184
 Gaussian, 247
 physiological, and visual
 signals, 184
 signal-noise ratio
 improvement with
 averaging, 249–250
- Nonlinear system: linear
 approximations of, 256
- Nonphotic standing potential
 responses, 163–166
- NP207 (*see* Thioridazine,
 NP207 and)
- Nucleotide, cyclic
 cascade, 72–73
 retina and, 154–155
- NVI, 614, 615
- Nystagmus
 with macular
 degeneration, 679
 in retinitis pigmentosa,
 520–521
- O**
- Ocular
 (*See also* Eye)
- hypertension, pattern
 electroretinography in,
 550, 766–772
- media changes in
 electroretinography,
 379–381
- pigmentation, effect of, in
 electroretinography,
 377–378
- trauma, evaluation,
 opaque media,
 567–572
- Off-response: rapid (*see*
 Rapid off-response)
- Oguchi's disease, 715–717
 dark adaptation curve, 716
- Ophthalmoscope: hand-held,
 dual-beam,
 maxwellian-view
 stimulator, 373
- Optic
 atrophy
 with disc telangiectasia,
 499
 of Leber (*see* Leber's
 hereditary optic
 atrophy)
 temporal, in cone
 degeneration, 541
 temporal, and retinitis
 pigmentosa, 521–524
- nerve
 damage, 571
 demyelination with
 multiple sclerosis, 552
 demyelination, pattern
 electroretinography in,
 551–552
 disease and early
 receptor potential, 320
 dysfunction, 761–813
 dysfunction, pattern
 electroretinography in,
 550–553
 function, pattern
 electroretinography in,
 549–556
- glioma surgery, flash
 VEP during, 609
- pallor, 522
- pallor after chloroquine,
 595
- response, and
 beta-adrenergic
 agents, 156
- stimulation, retinal
 potentials evoked by,
 129
- neuritis, 807
- neuropathy, ischemic,
 636–639
- Optotype tests, 460–462
- Orbit: in gunshot wound, 569
- Ornithine: metabolism,
 biochemical pathways
 in, 655
- Oscillations
 fast, 546–547
 slow, 546–547
- Oscillatory potentials,
 125–128
 amplitude measurements,
 327
 calculated energy of, 324,
 326
- cells generating, 125–126
 depth profile in retina (in
 animals), 126
- in diabetic retinopathy,
 620–622

- drugs affecting, 168
energy density spectrum, 323
ERG responses and, 288
intracellular responses from neurons and, 126–128
normal, 325–327
origin of, 125
recording, 322–327
adaptational conditions, 324–325
filtering technique, 322
with short time constant, 325
stimulus light, 322–324
- P**
- Paraplegia, spastic progressive electroretinography in, pattern, 800
multiple sclerosis causing, 799
Parkinsonism, 811–813
electroretinography in, 811–812
psychophysics in, 812
visual evoked potentials in, 811
Pattern dystrophy (*see* Dystrophy, pattern)
electroretinography (*see* Electroretinography, pattern)
visual evoked potentials (*see* Visual evoked potentials, pattern)
Peanut agglutinin-binding molecules, 58
Pediatric (*see* Children)
Pedigree
in albinism, 777, 778
in blue cone monochromatism, 754
in X-linked retinoschisis, 750
Perimetry
Goldmann, in atrophy, gyrate, 653
rod and cone, 475–482 analyses, 475–482 computerized testing, 475–482 data processing steps, 477 instrumentation for, 476
Pharmacologic effects: in retinal electrophysiology, 151–162
- Pharmacology
of retina (*see* Retina, pharmacology of)
of scotopic threshold response, 357–358
Phenothiazine
chemical structure, 601
retinal toxicity of, 600–606
Phenotype: in albinism, 774
Phosphene-related magnetic fields: in environment, 364–365
Phosphodiesterase inhibitors: and retina, 154–155
Phosphors: typical screen, for cathode ray tubes, 218
Photometry, 195–200
digital, for flash calibration, 202
measures and their relationships, 198
subjective, calibration of flash luminance with, 202
units, common, 197–200
Photopic/scotopic equivalence, 202–203
Photoreceptors, 28–31
cells
cytology, 59–61
development of, 55–57
function, 59–61
pathologies, 64
density
cone, isodensity maps of, 49
cone and rod, 49
interphotoreceptor (*see* Interphotoreceptor) mediation, 478, 480, 481
-retinal pigmented epithelium interface, 53–68
Phototransduction
cGMP cascade of, 74
in rods and cones, 69–75
Pigment
deposition in retinitis pigmentosa, 521
epithelium
diseases of, c-wave in, 545–546
responses, slow, in electroretinography, 328–329
epithelium, retinal
cell cytology and function, 59
characteristics of responses, 164
in chloroquine toxicity, 595
composition, 57–63
- development of, 56
diseases, 647–706
electroretinographic component, 93–95
embryological origins, 53–55
function, 57–63
morphology, 57–63
pathologies, 63–64
with pattern dystrophy, 497
-photoreceptor interface, 53–68
relationships in central retina, light micrograph of (in monkey), 54
and visual system testing, 486–487
visual, regeneration in fundus albipunctatus, 733
Pigmentation
in dystrophy, pattern, 703
ocular, effect of, in electroretinography, 377–378
Pituitary syndromes, 783–785
diagnostic aspects, 783
electrophysiology in, 783–785
Plexiform layer
inner, 34–37
outer, 32–34
PI: relationship to electroretinography, 7
P100
latency in developmental delay, 583
multiple sclerosis and, 807–808
peak latency
and age, 420
gender differences in, 420
topographical distribution, 436
Postsynaptic cell
circuit of, equivalent, 81
light sensitivity of, 80–81
synaptic gain of, 80–81
responses, 77–79
Potential(s)
evoked (*see* Evoked potentials)
membrane (*see* Membrane potential)
nonphotic standing potential responses, 163–166
oscillatory (*see* Oscillatory potentials)
- receptor (*see* Receptor potentials)
retina (*see* Retina, potentials)
Prader-Willi syndrome, 781
Preamplifiers, 183–185
Prematurity, 586, 587
Prenatal diagnosis: of neuronal ceroid lipofuscinosis, 789–790
Protan(s)
carriers, spectral sensitivity of rapid off-response in, 343
patients, early receptor potential in, 344–346
rapid off-response in, 339–344
Proximal negative response, 115–116, 119
generation, summary of events underlying, 116
Pseudo-Foster-Kennedy syndrome, 638
Psychiatric conditions: drugs for, 167–168
Psychophysical techniques relevant to electrophysiological testing, 445
test results in fundus albipunctatus, 732 testing, 443–482, 445–458
Psychophysics
of drusen, dominant, 665–668
light-emitting diodes in (*see* Light-emitting diodes)
in parkinsonism, 812
PII
proximal, 99–100
relationship to electroretinography, 7
slow, electroretinographic component, 92–93
PII
relationship to electroretinography, 7
scotopic threshold response waveform interaction with, 355
Pupil
area vs. contrast threshold, 422
diameters, 201
dilatation for ERG, 287
size
aging and, 423
in pattern electroretinography, 294

Pyridoxine-responsive gyrate atrophy, 650–651, 652

R

Radiation: visible, sources of, 212

Rapid off-response amplitude in normal subjects, 341 in deutans, 339–344 in genetic carriers, 344 in protans, 339–344 mean sensitivity of, 343 relationship to early receptor potential, 346

sensitivity of

log ratio of, 341, 342 spectral, 340 spectral, in protan carriers, 343

RCS rat, 63

Receptor potential, early, 317–321, 488

amplitude

log ratio of, 345 mean and standard deviation, 345

applications, clinical,

317–321

in color blindness, 319

cone dystrophy in, 319

disease and, 319–320

in duetan patients,

344–346

light adaptation in normal response, 318–319

nature of, 317–318

optic nerve disease and,

320

origin of, 317–318

in protan patients,

344–346

relationship to rapid off-response, 346

retinal disease and, 320

in retinitis pigmentosa,

319–320

spectral sensitivity curve of, 344

Receptor potential: late, 318

Reflectometry, fundus,

264–267

in fundus albipunctatus, 732–733

Refraction

effect of, in

electroretinography, 377

error in night blindness, incomplete-type, 721–722

linear regression of b-wave amplitude on, 378

Refsum's disease: electroretinography in, 507

Reticular dystrophy, 701

Retina

artery occlusion, 532–533

central, 545

electroretinography in, 617–618

astrocyte in (in cat), 39

atrophy, gyrate (*see* Atrophy, gyrate, of choroid and retina)

beta-adrenergic

mechanisms in, 155–156

Bietti's dystrophy (*see* Bietti's crystalline dystrophy of cornea and retina)

cell(s)

amacrine (in monkey), 36

biology, principles of, 23–84

bipolar, 32

bipolar, receptive field of, center-surround organization, 80

ganglion (*see* Ganglion cell)

glial (*see* Glial cell)

horizontal, 34

interplexiform (in cat), 46

midget, light micrograph of, 33

Müller (*see* Müller cell)

circuits, scheme of, 152

composition, 57–63

cone (*see* Cone of retina)

damage, inner, a-wave

and b-wave in, 534

dark-adapted responses in, amplitudes of, 122, 123

-degenerative mice, 64

development of, 53–55

disease

early receptor potential and, 320

hereditary, with

distinctive fluorescein angiography, 494–500

effects

of adenosine on,

156–157

of monoamines on,

156–157

electrophysiology

drugs and (*see* Drugs and retinal electrophysiology)

pharmacological effects in, 151–162

electroretinographic

components arising in (*see*

Electroretinography, components arising in retina)

embryological origins,

53–55

facts and figures

concerning, 48

feedback loops in, 45–47

function, 57–63

in Leber's hereditary optic atrophy, 763–764

in Sorsby's fundus dystrophy, 705

gain in scotopic threshold response, 358–359

illuminance, 201

image size, calculation of, 203

inner signals in, 81–83

iron chelators and, 159

magnetically evoked responses, 363–368

midretina, diseases,

707–760

morphology, 57–63

neural organization of, 25–52

neuromodulators in, 48

neuropeptides in, 48

neuropharmacology, experimental, 153–157

neurotransmitters in, 47–50, 83–84

nucleotides and, cyclic, 154–155

in origins of scotopic threshold response, 356–357

outer, diseases, 707–760

pharmacology of, 157–160

topical application, 157–158

phosphodiesterase inhibitors and,

154–155

physiological mechanisms, 145–176

physiology, 69–84

pigment epithelium (*see* Pigment epithelium, retinal)

potentials

evoked by electrical current, transretinal, 129–130

evoked by optic nerve stimulation, 129

extracellular, responses not evoked by light, 129–131

radial section of, 27

fluorescence microscopy

of (in dogfish), 79

retinoids and, 158–159

rods (*see* Rods of retina)

toxicity (*see* Toxicity, retinal)

vein occlusion, 533–536

branch, 617

vein occlusion, central, 568

electroretinographic amplitudes, 613–615

electroretinographic ratios in, 613–617

intensity-response analysis, 616–617

temporal factors, 615–616

vessel

after chloroquine, 595

disease, b/a-wave

amplitude ratios in, 531–536

vinca alkaloids and, 159–160

Retinitis pigmentosa, 501–530

age of onset and duration, 519–520

clinical characteristics, 515

cone-rod degenerations in, 510–527

course, 501–509

natural, of common forms, 504–506

dark adaptation in, 520

diagnosis, differential, 512–513

early receptor potential in, 319–320

electrophysiological parameters vs. clinical findings, 510–527

electroretinography in, 516–519

for early detection, 501–503

full-field, computer-averaged, 504

full-field responses, 502, 503

specialized recording techniques, 503–504

gender in, 516

historical background, 511–512

inheritance pattern, 516, 517

inversa

adult-onset, 678

juvenile-onset, 677

log (bp/ba) in, 528–530

macula in, 523, 524

- nyctalopia in, 520–521
optic atrophy and,
 temporal, 521–524
patients and methods,
 513–515
pigment deposition in, 521
rare treatable forms,
 506–507
results, 515–524
retinal pigment epithelial,
 preserved
 para-arteriolar, 497
scatterplots in, 519, 520
sector, 497
signs and symptoms, 501
simplex, Coats's reaction
 in, 499
visual acuity in, 520
visual function change in,
 505–506
X-linked, 504
 recessive, female
 carriers, ERG
 detection, 741–743
Retinitis punctata albescens:
 atypical, 678
Retinoids: and retina,
 158–159
Retinopathy
 diabetic, 619–635
 angiography in,
 fluorescein, 626, 628,
 629, 632
 b-wave in, scotopic,
 622–623
 case examples, 625–634
 DRS-HRC, 621, 622
 electro-oculography in
 625
 electroretinography in,
 620–625
 electroretinography in,
 progression
 prediction, 621–622
 electroretinography in,
 protocol, 624–625
 electroretinography in,
 severity, 620–621
 electroretinography in,
 temporal aspects, 623
 flicker implicit time in,
 623
 fundus in, 625, 626, 628,
 629, 631, 632
 high-risk characteristics,
 622
 oscillatory potentials in,
 620–622
 VECPs in, 625
thioridazine (*see*
 Thioridazine
 retinopathy)
Retinoschisis
 reticular peripheral, 727
- X-linked, carrier state
 detection, 748–752
 method, 748–750
 results, 750–751
X-linked juvenile, 496,
 726–729
 dark adaptation in, 728
 electroretinography in,
 728
 macula in, 727
 X-linked, pedigrees, 750
 X-linked, rod-cone
 interactions in, 750
Retrobulbar neuritis, 553, 554
Retrochiasmal lesions,
 560–562
 bilateral dysfunction, 562
 unilateral dysfunction,
 560–562
Rhodopsin: in vitamin A
 deficiency, 739
Riggs contact lens electrode,
 10
Ring scotoma, 518
Rod(s)
 -cone
 degenerations in retinitis
 pigmentosa, 510–527
 dystrophy, 512
 dystrophy, atypical, 679
 dystrophy, progressive,
 variation, 678
 interaction in normal
 subjects, 749
 interaction in
 retinoschisis, X-linked
 carriers, 750
 -cone interaction,
 suppressive, 469–474
 background, 469–470
 clinical perspective,
 470–471
 color vision disorders
 and, 472
 newer developments,
 472–473
 night blindness and,
 471–472
 X-linked inherited
 conditions and, 472
-cone sensitivity loss maps,
 480, 481
electroretinography, dark
 adaptation of, 394–395
membrane potential, 77
pathway in starlight and
 scotopic threshold
 response, 358
perimetry (*see* Perimetry,
 rod and cone)
of retina
 cells, horizontal,
 depolarization by
 glutamate, 81
- cells, responses of, 78
circulating current
 reduction through,
 produced by light
 flashes (in monkey),
 71
degeneration,
 progressive, 64
desensitization of (in
 monkey), 75
electron micrograph of
 (in monkey), 29
functional
 interconnections of,
 75–76
ion movements across
 surface membrane of,
 70
pathways, neurons in,
 40
photocurrent
 fluctuations of, 73
photoreceptor density,
 49
photoresponse spectral
 sensitivity of (in
 monkey), 72
phototransduction in,
 69–75
rod-cone coupling, 76
rod-rod coupling, 75–76
signals, circuitry
 through, 39–41
synaptic terminal,
 calcium concentration
 at, 77
 vs. cone b-wave, 109
spectral sensitivity
 functions, 476
- S**
- Santavuori-Haltia
 lipofuscinosis, 786
Scattergrams: for scotopic
 responses, 377
Scatterplots: in retinitis
 pigmentosa, 519, 520
Schisis: macular, vs. edema,
 fluorescein
 angiography in,
 496–497
Sclerosis (*see* Multiple
 sclerosis)
S-cone syndrome, 680
Scotoma
 with cone degeneration
 and familial drusen,
 680
 ring, 518
Scotopic b-wave: in diabetic
 retinopathy, 622–623
Scotopic/photopic
 equivalence, 202–203
- Scotopic responses:
 scattergrams for, 377
Scotopic threshold response,
 121–124
 characteristics of, 353–355
 clinical applications, 360
 comparison between
 species, 355–356
 contribution to ERG, 122
 dominating intraretinal
 recordings, 122
 of electroretinography,
 352–362
 history of, 352–353
 intraretinal recordings (in
 cat), 356
 K⁺-Müller cell mechanism
 for, 122–123
 latency decreasing, 354
 pharmacology of,
 357–358
 physiology, 358–359
 quantal sensitivity of, 358
 recording tips for clinical
 patients, 359–360
 retinal gain in, 358–359
 retinal origins of, 356–357
 rod pathway in starlight,
 358
 as separate response,
 121–122
 depth distribution,
 121–122
 intensity, 122
 in vision loss and
 intraocular pressure
 elevation, 360
 V-log I curve of, 353
 waveform interaction with
 PII, 355
Scotopic vision: lacking
 spatial sensitivity, 359
Senile dementia: of
 Alzheimer's type,
 pattern
 electroretinography in,
 795
Sex: effect of, in
 electroretinography,
 377
Signal analysis, 232–237
 delay, 234–235
 distortion, 235–237
 frequencies, two
 harmonically related,
 234
 frequency dependence,
 232–234
 latency, 234–235
 linearity, 232
 minimum-phase rule,
 234–235
 phase shifts, 234
 square wave pattern, 236

- Signal-noise ratio:
improvement with averaging, 149–150
- Silent substitution, 202–203
- Sine wave, 233
- Sinusoidal grating, 466
- Sinusoidally flickered test stimulus: illuminance of, 470
- Skin electrodes, 180
- Small signals: averaging, 389–390
- Sorsby's fundus dystrophy, 705
diagnosis, differential, 706
electrophysiology of, 706
histology, 706
pathogenesis, 706
- Spastic paraparesis (*see* Paraparesis, spastic)
- Spatial contrast, 467
sensitivity, 468
- Special-purpose data acquisition systems, 188–192
characteristics of, general, 189–191
questions about, 191–192
- Spreading depression, 130
- Square wave, 238, 240
flickering test probe:
luminance of, 471
infinite, line spectrum of, 242
pattern, 236
- Stargardt's disease, 669–674
(*See also* Fundus flavimaculatus)
age of onset, 669–670
angiography of, fluorescein, 670, 671–672
dark choroid effect in, 498
diagnosis, differential, 674
fundus in, 670–671
history, 669
inheritance of, 669
pathogenesis, 673
pathology, 673
prognosis, 673–674
visual acuity in, 670
visual function in, 672–673
- Stengel-Spielmeyer-Vogt lipofuscinosis, 788–789
- Stereopsis: in infant, 410
- Sternomastoid tremor, 406
- Stimulation
Ganzfeld, 214–215, 332
local, for electroretinography, 215
pattern-onset, and defocusing, 439
- Stimulator(s)
for electrophysiology, 224–226
electroretinography, 224–226
visual evoked response, 224
flash, voltage drive circuit for, 223
Ganzfeld, 371–372
maxwellian-view ophthalmoscope, 373
- Stimulus
color (*see* Color stimuli)
devices, 211–220
/response function, 261
- Sweep (*see* Visual evoked potential, sweep)
- Synapse: first, signal shaping at, 76–81
- Synaptic
gain of postsynaptic cells, 80–81
postsynaptic (*see* Postsynaptic)
terminal of rod, calcium concentration at, 77
- Synchronous amplification, 250–252
- T**
- Telangiectasia: disc, with optic atrophy, 499
- Telodendria: of cone pedicles, gap junction between two, 31
- Temporal contrast, 466–467
- Temporal frequency characteristics: and aging, 420
- Ten-twenty
designated positions, plan view of, 402
designations of electrode position, 402–406
method of measurement, 400–401
system
circumference location of, 401
lateral locations of, 401
- Testing: clinical, principles, 483–569
- Theory: duality, 448–449
- Thioridazine
NP207 and, 600–604
clinical findings, 600–601
physiological testing, 602–603
- retinopathy, 600–606
adaptometry in, dark, 604
- early, 601
ERG in, 603
late, 602
stable vs. progressive, 601–602
toxicity mechanism, 603–604
visual field changes in, 604
- Thorazine, 605
- Threshold
absolute, 445
determination methods critique of, 445–448
visual channels and, 448
- difference, 445–446
- scotopic (*see* Scotopic threshold)
term, discussion of, 445
- Topographical evoked potential mapping (*see* Mapping, topographical evoked potential)
- Toxicity
corneal, 594
drug, pathogenesis, 598
retinal, 565–610
chloroquine causing, 594–599
functional problems, 565–610
hydroxychloroquine causing, 594–599
monitoring for, 596–598
phenothiazine, 600–606
practical problems, 565–610
risk of, 596
- thioridazine (*see* Thioridazine, retinopathy)
- Tranquillizers: minor, and visual nervous system, 169
- Transmitter release: control by membrane potential, 76–77
- Trauma: ocular, evaluation, opaque media, 567–572
- Tremor: sternomastoid, 406
- Tubes
cathode ray, 218
display (*see* Display tubes)
- Tumors:
electrophysiological evaluation, 611–645
- U**
- Ultrastructure
in Bielli's crystalline dystrophy, 689, 690
- in lipofuscinosis, neuronal ceroid, 789
- Usher syndrome: type I, fluorescein angiography in, 496
- V**
- Vein, retinal (*see* Retina, vein)
- VEP (*see* Visual evoked potential)
- Vernier acuity: in infant, 409–410
- Vessels
disease, electrophysiological evaluation, 611–645
retinal (*see* Retina, vessels)
- Vinca alkaloids: and retina, 159–160
- Vision
color (*see* Color vision)
loss
nonorganic, PVEP and PERG in, 574
scotopic threshold response in, 360
scotopic, lacking spatial sensitivity, 359
- Visual acuity
(*See also* Acuity)
charts according to international recommendation, 461
decrease in multiple sclerosis, 806–807
development, and sweep VEP, 411
estimation in infants (*see* Infant, visual acuity estimation in)
as function of luminance, 460
in Leber's hereditary optic atrophy, 763
low-contrast, 462
low-contrast tests, practical value of, 462–463
in multihandicapped patients, 463
in night blindness, incomplete-type, 721, 724
in retinitis pigmentosa, 520
in Sorsby's fundus dystrophy, 705
of Stargardt's disease, 670
testing, luminance in, 459–460

- testing principles, 459–464
 tests, 460–462
 tests, optotype, 460–462
 tests, standardization of situations, 463
 angles, calculation of, 203
 channels and threshold determination methods, 448
 delayed maturation (*see* Developmental delay)
 development control by visual experience, 412–413 results in, recent, 412–414
 dysfunction in multiple sclerosis, 806–809
 electrophysiology (*see* Electrophysiology)
 evoked potential(s) amplitude of, 233 cortical (*see below*)
 drugs decreasing amplitude, 168 drugs increasing amplitude, 168 flash, cutoffs and, 188 flash, in multiple sclerosis, 799 flash, during optic nerve glioma surgery, 609 latency in infant, 410–411 monitoring with, intraoperative and intensive care unit, 607–610 in normal adult, 133 occipital, to sinusoidally modulated light, 236 in parkinsonism, 811 pattern, in multiple sclerosis, 798 pattern reversal, 136–141 pattern reversal, normal, 140 pattern reversal, waveforms, 136–141 phase characteristics of, 233 relation to acuity, 136 source derivations of stimulation and, 137 steady-state, in infant, 411 stylized, to flash stimulation in adults, illustration, 18
- during surgery, 608 sweep contrast sensitivity, 414 sweep technique in infant, 411–412 topography in albinism, 430 transient, in infant, 410 evoked potentials, cortical, 397–441 age changes in, 417–420 aging and, 417–424 in albinism (*see* Albinism) basic recording, 399–407 in blindness, cortical (*see* Blindness, cortical, visual evoked cortical potentials in) with chromatic stimuli, 147–150 with chromatic stimuli, clinical data, 148 color, to appearance, 147–148 color, to reversal and motion, 148 in developmental delay, 581–584 in diabetic retinopathy, 625 electrodes for, 399 electrodes, placement, 399–406 flash, in developmental delay, 585–588 in Leber's hereditary optic atrophy, 764 in multiple sclerosis (*see* Multiple sclerosis, visual evoked cortical potential in) origin of components, 132–144 pattern-reversal, 419 pattern-reversal responses, 418 recording, artifact recognition, 438–439 recording, diurnal patterns, 438 recording, interest variability, 438 recording, normative studies, 437–438 recording, patient compliance, 439–440 recording, stimulus conditions, 435–437
- recording, technical issues in, 435–441 testing, history of, 17–22 for visual acuity estimation in infants (*see* Infant, visual acuity estimation in, by visual evoked cortical potentials) evoked response electrodes, 181 flash, 132–136 flash, distribution of P1 and P2 components, 135 flash, scalp localization, 133–136 flash, waveform, 132–133 stimulators for, 224 experience, visual development control by, 412–413 field(s) changes in thioridazine retinopathy, 604 defects in multiple sclerosis, 808–809 in Leber's hereditary optic atrophy, 763–764 in night blindness, incomplete-type, 721 function change in retinitis pigmentosa, 505–506 in Stargardt's disease, 672–673 tests, 487 tests, diseases where tests are informative, 487 tests, information obtained, 487 loss (*see* Vision loss) nervous system (*see* Nervous system, visual) performance contrast sensitivity in, 413–414 tasks, 408–410 tasks, uses of, 408–410 signals and physiological noise, 184 system, testing levels of, 485 testing in infant (*see* Infant, visual acuity estimation in)
- Vitamin A deficiency, 737–740 adaptometry in, two-color dark, 739 electroretinography in, 738 fundus photograph in, 738 rhodopsin in, 739 Vitreous hemorrhage, effect on electroretinography, 379 humor, electrode in (in cat), 109 substitute, effect on electroretinography, 379–380 V-log intensity curves, of b-wave amplitudes, 154 Voltage calibration, 382
- W**
- Waveform aging and, changes, 417 electroretinographic (*see* Electroretinography, waveform)
- White-dot syndromes, 640–642**
- "multiple evanescent," 641
- X**
- Xenon flash lamp, 213 time course of light output, 214 sources for stimulation, 211–214
- X-linked**
- choroideremia carrier state evaluation, 744–747 inherited conditions and suppressive rod-cone interaction, 472 recessive cone dystrophy (*see* Cone dystrophy, X-linked recessive) congenital stationary night blindness, 711 pedigree in choroideremia, 495 retinitis pigmentosa, female carriers, ERG detection, 741–743 retinitis pigmentosa, 504
- retinoschisis (*see* Retinoschisis, X-linked)**