

Table of Contents

Introduction	1
1 What is Myopia?	4
1.1 How does it Feel being Myopic?	4
1.2 Basic Terminology of the Anatomy of the Eye	5
1.3 Accommodation	5
1.3.1 Myopia and Emmetropia	5
1.3.2 Theory of Accommodation	7
1.3.2.1 The Helmholtz Model	7
1.3.2.2 The Schachar Model	7
1.3.2.3 The Two-Phase-Model	8
1.3.2.4 Two other, Controversial Hypotheses	8
1.4 Refractive Myopia	9
1.4.1 Tonic Accommodation and Night Myopia	10
1.4.2 Pseudomyopia	11
1.4.3 Other Types of Myopia	12
1.5 Axial Myopia	13
1.6 "What Type of Myopia Do I Have?"	13
1.7 Consequences and Risks of Higher Myopia	14
1.8 Myopia and Age	18
1.9 Accommodation and Age / Presbyopia	18
1.10 Age Related Geometrical Changes of the Eye	20
1.11 The Refraction	21
1.11.1 Basic Procedure	21
1.11.2 A Method for Refraction: Fogging	25
1.11.3 The Range of Clarity	26
2 What Causes Myopia in General?	27
2.1 Is Myopia Inherited?	27
2.2 Connective Tissue Disorders	30
2.3 Active Growth by Imaging Effects	31
2.4 Mechanical Effects	31
2.5 General Overview of the Causes of Myopia	32
3 Myopia – Observations and Experimental Results	33
3.1 Distribution of Myopia by Region, Age, Gender and Ethnicity	33
3.2 Accommodation and Near Work	37
3.2.1 Experiences and Results	37
3.2.1.1 General Experiences and Results	37
3.2.1.2 The Effect of Accommodation on Axial Length	40
3.2.1.3 The Effect of Accommodation on Image Quality	41

3.2.1.4	Timing- and Hysteresis- Effects of Accommodation	42
3.2.1.5	Dark Focus and Accommodative Hysteresis	44
3.2.1.6	The Strength of Accommodation.....	44
3.2.1.7	Accommodation Spasm	46
3.2.1.8	Myopia caused by Hyperopia	47
3.2.1.9	"Screen sightedness" by SmartPhones and Tablet-PCs	48
3.2.1.10	Aniso-Accommodation	48
3.2.1.11	Is there a Connection between Blur Sensitivity and Accommodation Deficits?.....	49
3.2.1.12	Accommodation and the Nervous System	49
3.2.1.13	Accommodation and Biochemistry.....	50
3.2.1.14	"Emmetropization" towards Myopia via Accommodation?	50
3.2.1.15	Myopia before modern Times	51
3.2.1.16	Summary of Results about Accommodation	52
3.2.2	Proposed Therapies Based on the Accommodation Issue.....	53
3.2.2.1	Relaxing and Exercising.....	53
3.2.2.2	Biofeedback	55
3.2.2.3	Undercorrection for Near Work, Plus-, Bifocal- and Progressive- Glasses	56
3.2.2.3.1	General Results	56
3.2.2.3.2	Plus Addition, Bifocals and their Prismatic Effects.....	61
3.2.2.3.3	Bifocal and Multifocal Contact Lenses.....	61
3.2.2.3.4	Summary.....	62
3.2.2.4	Why is there no Agreement about the Usefulness of Plus-Glasses?	65
3.2.2.5	Intermittent, Short Term Wearing of Plus Glasses	66
3.2.2.6	Plus glasses – are they Effective via Reduced Accommodation or via Modified Vergence?	67
3.2.2.7	Comparison of the Various Optical Methods	68
3.2.2.8	Psychological Problems with Special Glasses for Near Work	69
3.2.2.9	Permanent Undercorrection instead of Undercorrection for Near Work only	70
3.2.2.10	Plus-Glasses to Reverse Myopia?	72
3.2.2.11	Is the Accommodation System Getting too Lazy by the Plus-Glasses?.....	73
3.2.2.12	How to Break an Accommodation Spasm?.....	73
3.2.2.13	Summary of the Accommodation Based Therapies.....	74
3.3	The Effects of Image Quality and Light-Exposure	76
3.3.1	Basic Results	76
3.3.2	Connective Tissue Related Results	79
3.3.3	Dopamine and Light Exposure.....	83
3.3.4	Remarks on the Image Quality Model	85
3.3.5	"Emmetropization" towards Myopia via Image Quality?	86
3.3.6	Intermittent, Short Term Wearing of Plus Glasses	89
3.3.7	Contrast and Spatial Frequency.....	91
3.3.8	Monochromatic Aberrations and other Optical Deficiencies	92

3.3.9	Peripheral Defocus and Dual-Focus Lenses	95
3.3.10	Summary of the Effects of the Image Quality	98
3.4	Basic Question – what Elongates the Eye	99
3.4.1	Image Quality and Accommodation	99
3.4.2	Myopia by Accommodation or Myopia by Degraded Image Quality?	101
3.4.3	Emmetropization by Growth or Mechanical Stretching or Biochemical Thinning?	103
3.5	Phoria, Convergence, Astigmatism and Anisometropia	104
3.5.1	Phoria	104
3.5.2	The AC/A Ratio	105
3.5.3	The CA/C Ratio, and some more Types of Vergence	107
3.5.4	Hysteresis of Vergence	108
3.5.5	Glasses, Contact Lenses and Vergence	109
3.5.6	Prescription of Prisms	109
3.5.7	The Impact of Vergence on the Axial Length	111
3.5.8	Astigmatism	111
3.5.9	Anisometropia	111
3.5.10	Summary of the Vergence Related Effects	112
3.6	Saccades and Focusing	113
3.7	Mechanical Properties, Stress, Strain and Pressure	114
3.7.1	Impact of Mechanics on Biochemistry	114
3.7.2	Intraocular Pressure (IOP)	114
3.7.3	The Ciliary and other Muscles	117
3.7.4	The Lens	119
3.7.5	The Ocular Shape	119
3.7.6	The Zonular Fibers	121
3.8	Relations between the Dimensions of the Cornea, the Crystalline Lens and the Ciliary Muscle	121
3.9	Growth or Stretching and Thinning or Biochemical Thinning of the Sclera in Myopic Eyes?	122
3.10	Outdoor Activities	124
3.11	Sun Exposure	127
3.12	Seasonal Impact	127
3.13	Physical Exercises	128
3.14	Illumination / Light / Day- and Night-Rhythm	129
3.14.1	Day- and Night-Rhythm	129
3.14.2	Level of Illumination	131
3.14.3	Color of Illumination – Wavelength of the Light	138
3.14.4	Flickering Light and Flashing Light	141
3.15	Vision Training / Vision Therapy / Behavioral Optometry	141
3.16	Temperature	142
3.17	Blood Circulation	143
3.18	Some Specific Biochemical Issues	145
3.18.1	The Immune System	145

3.18.2	Oxidative Damage and Antioxidant Defense in General	147
3.18.3	Enzymes Glutathione, Glutathione Peroxidase, Superoxide Dismutase, G6PD.....	148
3.18.4	The Blood-Retinal Barrier	149
3.18.5	The Vitreous Body.....	149
3.18.6	Nitric Oxide (NO).....	150
3.18.7	Cross-Linking of the Collagen of the Sklera by UV-Radiation and Roboflavin	152
3.18.8	More Biochemical and Biomechanical Effects.....	152
3.19	Mental Issues.....	154
3.19.1	Stress	154
3.19.2	Personality and Mentality.....	157
3.20	Why are some People not becoming Myopic, Independent from the Circumstances?	158
3.21	A Study: Factors Associated with Myopia in School Children.....	160
3.22	Recommendations from Optical and Biomechanical Results.....	161
3.23	Myopic Changes in Pregnancy.....	162
3.24	Impact of Nutritional Components.....	162
3.24.1	Carbohydrates, Blood Sugar Level, Insulin Metabolism	163
3.24.2	Is there a Connection between the Blood Sugar Level and Negative-Lens-Induced Myopia?.....	166
3.24.3	Calcium, Vitamin D and Sunlight.....	167
3.24.4	Vitamin D and Dopamine.....	170
3.24.5	Magnesium	170
3.24.6	Copper and Zinc.....	170
3.24.7	Chromium	172
3.24.8	Manganese	173
3.24.9	Potassium	173
3.24.10	Iodine / the Thyroid Gland.....	173
3.24.11	Fluoride.....	173
3.24.12	Fat and Cholesterol.....	174
3.24.13	Vitamin A	174
3.24.14	B-Vitamins.....	174
3.24.15	Some More Antioxidants	175
3.24.15.1	Selenium	175
3.24.15.2	Flavonoids and Related Compounds, and Vitamin E	176
3.24.16	Folic Acid and Homocysteine.....	177
3.24.16.1	Observations.....	177
3.24.16.2	An Explanation.....	178
3.24.17	Other Components of the Diet	179
3.24.18	Overall Nutritional Status and Myopia	179
3.25	Pharmaceuticals.....	180
3.25.1	Atropine.....	180
3.25.2	7-Methylxanthine	182
3.25.3	Other Pharmazeutical Agents.....	183

3.26	Other Means to Slow Down or Stop Progression of Myopia	184
3.26.1	Contact Lenses	184
3.26.2	Orthokeratology / Overnight Corneal Reshaping (OCR)	186
3.26.3	Orthocology	189
3.26.4	Reinforcement of the Sclera	189
3.26.5	Acupuncture and Acupressure	190
3.26.6	Electrostimulation	191
3.27	Summary of Randomized Trials to Slow Progression of Myopia	191
3.27.1	Single Trials	191
3.27.2	Comparisons of the Efficacy of the Various Measures to Slow the Progression of Myopia....	191
3.28	Correction of Myopia by Surgery.....	193
3.28.1	Manipulation of the Cornea	193
3.28.1.1	Radial Keratotomy RK	193
3.28.1.2	Photorefractive Keratectomy (PRK).....	193
3.28.1.3	Laser In Situ Keratomileusis (LASIK, Epi-LASIK), Laser Epithelial Keratomileusis (LASEK), Femto-LASIK.....	194
3.28.1.4	Small Incision Lenticule Extraction (SMILE).....	194
3.28.1.5	Intrastromal Corneal Ring.....	195
3.28.1.6	Artificial Cornea	195
3.28.2	Manipulation of the Lens System inside the Eye.....	195
3.28.2.1	Exchange of the biological lens:.....	196
3.28.2.2	Adding an additional lens:	196
3.28.2.3	Risk-comparison between LASIK and implantable contact lenses (ICL):	197
3.29	Summary: What Causes Myopia?.....	197
3.29.1	School and Myopia	198
3.29.2	Is Myopia Caused by Mechanical or by Biochemical Processes?.....	199
3.29.3	Prevention of Progression of Myopia or Prevention of Myopia?	199
3.29.4	Working against Myopia or against the Consequences of Myopia?.....	200
3.29.5	Inflammation towards Progressive and Pathologic / Malignant Myopia	200
3.29.6	Functional- versus Structural- Deficits.....	201
3.29.7	Is Myopia Inherited or Acquired?	202
3.29.8	Congenital Myopia, and Inherited Diseases which are related to Myopia.....	203
3.29.9	From Simple to High and Progressive Myopia.....	205
3.29.10	Summary of the Summary: Are the Published Results really Contradictory? Maybe not!.....	206
4	A Synthesis – or how some Pieces might Fit together.....	212
4.1	Some General Remarks about Nutrition and Environment.....	213
4.1.1	Biochemistry versus Mechanical Effects versus Optical Effects?	213
4.1.2	Nutrition and the Environment have Changed Dramatically.....	214
4.1.3	There is a very Large Biochemical Individuality	218
4.1.4	The Impact of "Foreign" Microorganisms.....	218
4.1.5	There are Biochemical Alterations before Clinical Symptoms Arise.....	219

4.1.6	There can be Selective Nutrient Deficiency	219
4.1.7	Nutrition and Environment Can Change even the Genetic Inheritance	219
4.1.8	Summary – the Balance	220
4.2	Some Relevant Biochemical Key Issues	221
4.2.1	The Connective Tissue	221
4.2.1.1	Connective Tissue in General.....	221
4.2.1.2	The Connective Tissues of the Eye.....	223
4.2.2	The Immune System	223
4.2.2.1	Natural (Innate) Immunity	224
4.2.2.2	Acquired Immunity	225
4.2.2.3	Pathologic Immune Responses	225
4.2.2.4	Effects of the Immune System on the Tissue.....	226
4.2.2.5	Turnover of Connective Tissue and the Immune System	226
4.2.2.6	TH1/TH2 Balance	226
4.2.2.7	Neurotransmitters and the Immune System	227
4.2.2.8	Stress and the Immune System	228
4.2.2.9	The Gut and the Immune System	229
4.2.2.10	Acupuncture and the Immune System	229
4.2.2.11	Melatonin and the Immune System, Microcirculation and Homocysteine	229
4.2.2.12	The Eye and the Immune System	230
4.2.2.13	Summary Immune System	230
4.2.3	Miscellaneous issues.....	231
4.2.3.1	The Metabolism of the Feedback Process Leading to Myopia via Degraded Image Quality.....	231
4.2.3.2	Oxidative Processes and Antioxidant Defense	231
4.2.3.3	Cortisol and other Hormones	232
4.2.3.4	The Nitric Oxide (NO) Balance	233
4.2.3.5	"The Nerves": Neurotransmitters, Stress and Personality.....	239
4.2.3.6	Homocysteine	240
4.2.3.7	The Day- / Night-Rhythm, Illumination, and Melatonin Metabolism	242
4.2.3.8	Blood Sugar Level / Insulin Level.....	243
4.2.3.9	The Sodium / Potassium Balance.....	245
4.2.3.10	Hormones	246
4.2.3.11	Physical Exercises and Physical Stress	246
4.2.3.12	G6PD (Glucose-6-Phosphatase Dehydrogenase) Deficiency – an Example.....	248
4.2.3.13	Is there an Analogy between Structural Heart Problems and Progressive Myopia?	251
4.2.3.14	Is there an Analogy between Arthritis and Progressive Myopia?.....	251
4.3	The Impact of Nutritional Components.....	252
4.3.1	Minerals	253
4.3.1.1	Calcium	253
4.3.1.2	Chromium	255

4.3.1.3	Copper	256
4.3.1.4	Magnesium	259
4.3.1.5	Manganese	260
4.3.1.6	Selenium	261
4.3.1.7	Silicon.....	264
4.3.1.8	Zinc.....	265
4.3.2	Vitamins	266
4.3.2.1	Vitamin A	266
4.3.2.2	B-Vitamins.....	267
4.3.2.2.1	Vitamin B2 (Riboflavin)	267
4.3.2.2.2	Vitamin B5 (Pantothenic Acid).....	268
4.3.2.2.3	Vitamin B6 (Pyridoxine, but also Pyridoxal or Pyridoxamine)	268
4.3.2.2.4	Vitamin B12 (Cobalamin)	270
4.3.2.3	Folate / Folic Acid (member of the family of B-vitamins)	270
4.3.2.4	Interactions between B Vitamins.....	271
4.3.2.5	Vitamin C.....	271
4.3.2.6	Vitamin D – or Sunlight.....	272
4.3.2.7	Vitamin E.....	274
4.3.3	Other Components of Nutrition, and some Facts about Nutrition.....	275
4.3.3.1	Flavonoids.....	275
4.3.3.2	Carbohydrates	276
4.3.3.3	Lipids and Fatty Acids	277
4.3.3.4	Amino Acids	278
4.3.3.5	Proteins.....	278
4.3.3.6	Some Other Nutrients.....	279
4.4	Nutrition, some General Facts	280
4.5	Impact of Nutrition and Behavior– Summary.....	282
4.6	The "Right" Supply with Vitamins and Minerals, and the Supply Status	284
4.7	The Speed of Nutritional Effects.....	288
5	Overall Recommendations	289
6	Additional Information.....	293
6.1	Optical Correction.....	293
6.1.1	Glasses	293
6.1.2	The Material of the Glass.....	293
6.1.3	The Coating of the Glass	294
6.2	Contact Lenses.....	294
6.2.1	Basic Types of Lenses – Soft Lenses versus Hard Lenses	295
6.2.2	How about Lenses for Permanent Wear?.....	299
6.2.3	Potential Complications.....	300
6.2.4	Parameters of the Material for Contact Lenses.....	301