RANZCO The Royal Australian and New Zealand College of Ophthalmologists

THE MEDICAL EYE SPECIALISTS

PHYSIOLOGY
Curriculum Standard

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Purpose

The purpose of the curriculum standard in Physiology is to provide an overview of the specific topics in basic and applied physiology, of special relevance to a clinical ophthalmologist, that are expected to be learnt during training, and examinable in the Physiology examination.

The learning outcomes and their associated performance criteria in this standard are concerned with the physiology of the eye as an organ, the neurophysiology of vision, and basic core physiological principles.

This subject is the basic science which underpins the understanding of ophthalmic disease. While its clinical relevance may not always be immediately obvious to Basic Trainees, a good grasp and solid knowledge of the basic principles and concepts of ocular physiology are essential for every ophthalmologist.

Structure

This standard comprises seven elements, each with several topics and their associated learning outcomes.

References

Core Reading

1. Levin LA, Nilsson FE, Ver Hoeve J, Wu S, Kaufman PL and Alm A. *Adler's Physiology of the Eye*. 11th Edition, 2011. Mosby. (ISBN: 978-0-323-05714-1)

2. Study Guides:
   - PH1.1 –*Cornea and Ocular Surface* (Dr Vivek Chowdury)
   - PH1.2 – *Eyelids* (Dr Jean-Louis De Sousa)
   - PH2 – *Lens, Accommodation and Emmetropisation* (Dr Vivek Chowdury)
   - PH3 – *Tonometry Through the Ages* (Kniestedt *et al*. Surv Ophthalmol 53:568–591, 2008)
   - PH4.1 – *Structure and Function of the Vitreous* (Drs James Leong and Peter Hadden)
   - PH4.2 – *Electrical Responses of the Visual Pathways* (Dr Peter Hadden)
   - PH6.1 – *Binocular Vision and Stereopsis* (Drs Con Petsoglou and John Dickson)
   - PH6.2 – *Extra-ocular Muscle Actions* (Dr John Dickson)
   - PH6.3 – *Extra-ocular Muscles: Structure and Functions* (Dr John Dickson)
   - PH6.4.1 – *Functional Organisation of Eye Movements* (Dr John Dickson)
   - PH6.4.2 – *Control of Eye Movements : Anatomical Aspects* (Dr John Dickson)
   - PH7.1 – *Psychophysical Laws of Visual Perception* (Dr Peter Wellings)
   - PH7.2 – *Entoptic Phenomena* (Chapter 16, Adler 10th Ed)

   These Study Guides are available for download from the College Learning Management System, Moodle.

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Teaching and Learning

For each of the elements in this standard, Trainees are encouraged to study the relevant chapters in *Adler*, as well as refer to the Study Guides or other suggested readings as outlined in the Study Guides.

The Study Guides are intended to supplement the text book, as well as to assist Trainees by emphasising or summarising some of the most important information.

Assessment

Physiology is assessed through a written 2.5 hour examination conducted twice per year at major training centres in Australia and New Zealand.

The exam paper typically contains a combination of shorter answer and essay type questions.

The required pass mark is 60%.

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Elements and Learning Outcomes

PH1 LIDS, CORNEA, SCLERA AND OCULAR SURFACE	
TOPIC	**LEARNING OUTCOMES**
1.1 The physiology of the cornea and sclera *(Adler Chapter 4 pp.78–112, & Chapter 16 pp.375–377, Study Guide PH1.1)*	Describe: • Light transmission • Stromal components of the cornea – Collagen – Keratocytes – Proteoglycans – Nerves • Corneal innervation • Corneal maintenance and healing • Trophic effects of ocular sensory nerves • Corneal epithelial physiology • Corneal endothelial physiology • Mechanical properties • Drug delivery • UV light transmission • Limbal stem cells • Function and properties of the sclera
1.2 The formation and function of the tear film *(Adler Chapter 15 pp.350–361)*	Describe: • Tear film – production, structure, composition and function • Maintenance of the tear film • Regulation of tear film production
1.3 Eyelid and lacrimal drainage physiology *(Study Guide PH1.2)*	Describe each of the following: • Blinking and the blink reflex • The elimination of tears from the ocular surface

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PH2 LENS, ACCOMMODATION AND EMMETROPISATION	
TOPIC	**LEARNING OUTCOMES**
2.1 The structure, function and ageing of the lens *(Adler Chapter 5)*	• Describe the structure of the: – Lens – Lens capsule – Lens zonules • Explain the basis of lens refraction and transparency • Briefly describe lens fibre cell differentiation • Discuss each of the following: – Composition of the lens – Lens proteins – Lens lipids – Water and electrolyte balance – Non-electrolyte transport mechanism – Optical transparency and accommodation – Protective mechanisms in the lens • Discuss the physiology of ageing of the lens
2.2 Accommodation and presbyopia *(Adler Chapter 3)*	Describe: • The mechanism of accommodation • The stimulus to accommodation • The pharmacology of accommodation • Measurement of accommodation • Presbyopia and its contributing factors
2.3 Emmetropisation of the eye *(Adler Chapter 1 pp.2–3 & Chapter 4 pp.115–119; Study Guide PH2)*	• Define emmetropisation • Describe the mechanisms involved in emmetropisation

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PH3 AQUEOUS PHYSIOLOGY AND OCULAR BLOOD SUPPLY	
TOPIC	**LEARNING OUTCOMES**
3.1 Aqueous humor composition and formation *(Adler Chapter 11 pp.274–283; Table 11.2)*	Describe each of the following: • The physiological processes involved in aqueous humor formation • The biochemistry of aqueous humor formation • The composition of aqueous humor, the role of the blood aqueous barrier and active transport • The physiological basis of diurnal variation in intraocular pressure (IOP) • The pharmacology and regulation of aqueous humor formation
3.2 Aqueous humor drainage *(Adler Chapter 11 pp.274–297; Figs 11.1, 11.4, 11.5, 11.7, 11.8, 11.9 and 11.10)*	• Describe the fluid mechanics of aqueous humor drainage and the concept of outflow facility • Explain the classic and modified Goldmann equations • Describe aqueous drainage through the trabecular meshwork • Describe aqueous drainage through the uveoscleral route • Describe the effect of cholinergic mechanisms on trabecular and uveoscleral outflow • Describe the effect of adrenergic mechanisms on trabecular and uveoscleral outflow • Describe the cytoskeletal and cell-junctional mechanisms that may influence aqueous outflow • Describe how glucocorticoids are involved in regulation of IOP • Describe how prostaglandin analogues affect aqueous humor drainage
3.3 Intraocular pressure measurement *(Study Guide PH3 – Tonometry Through the Ages)*	• Describe manometry for measurement of IOP • Describe applanation, indentation, contour and rebound tonometry, and factors which affect these measurements • Describe the instruments used for IOP measurements

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3.4 Physiology of the ocular circulation *(Adler Chapter 10 pp.243–266; Figs 10.6, 10.10, 10.19, 10.20 and 10.21; Chapter 11 pp.278–279)*	• Describe the functional differences between blood vessels in different parts of the eye • Describe the blood-ocular barriers • Describe blood flow in the retina, choroid and ciliary body • Explain the regulation of ocular blood flow, autoregulation and the mechanisms involved

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PH4 VITREOUS AND RETINA	
TOPIC	**LEARNING OUTCOMES**
4.1 Structure and function of the vitreous *(Study Guide PH4.1 – Vitreous Physiology)*	Discuss each of the following: • Vitreous structure and composition • Functions of the vitreous • Vitreous ageing
4.2 Biochemistry and physiology of sensory retinal transduction *(Adler Chapters 18 and 19, Figs 18.11, 18.12, 18.14, 19.2, 19.10 and 19.11)*	Describe each of the following: • The visual pigments – including their biochemistry and metabolism • Photo transduction
4.3 Electrical responses of the visual pathways *(Study Guide PH4.2 – Electrical Responses of the Visual Pathways)*	Discuss each of the following: • Electrical phenomena in retina • Nature and origins of electroretinogram (ERG) wave components • Nature and origins of visual evoked response (VER) components • Nature and origins of the electro-oculogram (EOG)
4.4 Retinal metabolism and nutrition *(Adler Chapter 12 pp.308–315 and 319–322, Figs 12.1 and 12.13)*	• Discuss retinal metabolism and nutrition
4.5 Retinal Pigment Epithelium (RPE) and retinal adhesion *(All of Adler Chapter 13, Figs 13.1, 13.2 and 13.3)*	• Explain the functions of the RPE • Describe all the mechanisms of retinal adhesion

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PH5 PUPILLARY REFLEXES AND VISUAL PATHWAYS	
TOPIC	**LEARNING OUTCOMES**
5.1 Visual processing in the retina *(Adler pp.452–455, 465–469, 471, 473, 476–478)*	• Explain centre-surround organisation • Describe each of the following: – Bipolar cell pathways – Amacrine cell activity – Ganglion cell pathways
5.2 The pupillary reflexes *(Adler pp.502–515)*	• Describe each of the following: – Functions of the pupil – Neuronal pathways for the pupillary light reflex – Neuronal pathways for the pupillary near reflex • Describe the sympathetic system control of the pupil and the pathways involved • Describe how the properties of the light affect the pupillary light reflex • Explain physiologic anisocoria
5.3 Non-image forming vision *(Adler pp.538–541)*	• Explain the physiological significance of ganglion cell photoreceptors
5.4 The physiology of the optic nerve *(Adler pp.553, 555–556, 558–560)*	Describe each of the following: • Axon counts in the optic nerve • Blood supply to the optic nerve • Optic nerve conduction and axonal transport
5.5 Visual processing in the lateral geniculate nucleus *(Adler pp.580–584)*	• Describe the receptive field properties and parallel processing in the lateral geniculate nucleus • Describe the extra-retinal input
5.6 Visual processing in the primary visual cortex *(Adler pp.591–597)*	Describe each of the following in relation to the primary visual cortex: • Functional properties • Functional organisation • Parallel processing • Dynamic activity
5.7 Visual processing in the extra-striate visual cortex *(Adler pp.605–609)*	• Describe the functional attributes of areas associated with the dorsal and ventral streams in humans

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PH6 PAEDIATRICS, BINOCULAR VISION AND OCULAR MOTILITY	
TOPIC	**LEARNING OUTCOMES**
6.1 The physiological basis, development and features of normal and abnormal binocular vision *(Study Guide PH6.1 – Binocular Vision and Stereopsis)*	• Discuss each of the following in relation to binocular vision: – Motor fusion and fusional vergences – Sensory fusion – Visual direction, binocular correspondence and the horopter – Binocular disparity – Fixation disparity – Panum's fusional area – Dichoptic stimulation – Monocular cues to depth perception • Describe each of the following in relation to stereopsis: – General characteristics – Random dot stereopsis – Magnocellular and parvocellular stream mediated stereopsis – Physiologic basis • Discuss the normal development of binocular vision • Discuss the abnormal development of binocular vision, with specific reference to: – Ocular dominance histograms – The critical period of development – Effects of strabismus – Abnormal retinal correspondence
6.2 The features and frames of reference of extra-ocular muscle (EOM) actions *(Study Guide PH6.2 – Extra-ocular Muscle Actions)*	Explain each of following: • Frames of reference of EOM • Descriptive terms for EOM • Models of EOM action

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6.3 Structure and functions of extra-ocular muscles (EOM) *(Study Guide PH6.3 – Extra-ocular Muscles: Structure and Functions)*	Discuss each of the following in relation to the EOM: • Gross anatomy • Orbital connective tissue • Muscle pulleys • Orbital and global layers • Fibre type classification • Metabolism • Excitation/contraction coupling • Proprioception and proprioceptors • Development • Pharmacology of EOM • Effects of disease
6.4 Functional organisation of eye movement control *(Study Guide PH6.4.1 – Functional Organisation of Eye Movements; Study Guide PH6.4.2 – Control of Eye Movements : Anatomical Aspects)*	• Discuss the features and functional organisation of eye movement control • Discuss the various types of eye movements, their purposes, features and supranuclear control: – Position maintenance – Optokinetic reflex – Vestibulo-ocular reflex – Saccades – Smooth pursuits – Vergences • Describe the characteristics of the neurons of eye movement control • Describe the anatomical correlates of eye movement control

PH7 VISUAL PERCEPTION AND ITS PHYSIOLOGICAL BASIS	
TOPIC	**LEARNING OUTCOMES**
7.1 Luminance threshold *(Adler pp.698–699; Study Guide PH7.1 – Psychophysical Responses)*	Define each of the following: • Temporal summation • Critical duration • Bloch's law • Spatial summation • Ricco's law
7.2 Luminance increment *(Adler pp.12–13, 613–614, 643, 655–661, 667–668)*	• Define Weber's law and describe how this varies throughout the visual field • Describe the physiological principles involved in perimetric testing, including short wavelength automated perimetry (SWAP) and frequency doubling technology (FDT) • Define contrast, contrast sensitivity and contrast sensitivity function and describe their, measurement, values and physiological variation
7.3 Light adaptation *(Adler pp.429–432,440–441)*	• Describe photopic and scotopic adaptation and recovery after bleaching
7.4 Visual acuity *(Adler pp.4–6, 627–645)*	• Describe the features of the different forms of visual acuity • Explain how optical, anatomical and physiological factors limit visual acuity • Describe the clinical testing of visual acuity • Describe the development of spatial vision and visual perception in infancy • Define amblyopia and describe its features • Describe changes in visual acuity with aging

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7.5 Perception of periodic stimuli *(Adler pp.699–702, 706)*	• Define critical fusion frequency (CFF) • Describe how CFF is affected by each of the following: – Luminance (Ferry-Porter law) – Chromaticity – Eccentricity – Stimulus size (Granit-Harper law) • Describe the effects of flicker on perception (Brucke brightness enhancement effect; Talbot-Plateau law)
7.6 Motion perception *(Adler pp.708–710)*	• Describe motion after-effect, apparent motion, neural encoding of motion and the clinical applications
7.7 Colour vision *(Adler pp.454–455, 648–653)*	• Describe trichomacy and its perceptual manifestations • Describe opponency, including the psychophysical formulae and electrophysiological responses • Describe congenital dyschromatopsia including classification, molecular genetics and colour vision testing
7.8 Entoptic images *(Study Guide PH7.2 – Entoptic Phenomena)*	• Briefly describe the nature and sources of entoptic images

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