**Eastern and Greater Southern Surgical Skills Network**

**Generic Surgical Sciences Examination Physiology Education Sessions 2021**

Important Instructions for Teaching Sessions:

* This curriculum is based on the major topics in *Ganong’s Review of Medical Physiology, 25th Edition* *– Barrett, K.E., Barman, S.M., Boitana, S., Brooks, H.L.*
* This curriculum is designed to overlap with core concepts in the main Pathology reference text *Robbins and Cotran Pathologic Basis of Disease, 9th Edition – Kumar, Abbas, AK; Fausto, N., Elsevier Saunders International*
* Preparation for these sessions should take a few hours and include putting together images taken directly from the reading text and reading through more difficult sections of the curriculum within the respective textbooks.
* Preparation of the Respiratory Physiology session should be guided by *Respiratory Physiology: The Essentials, 10th Edition West J.B., Lipincott, Williams and Wilkins*
* This curriculum was compiled with input from Dr Guy Henry, Senior Paediatric General Surgeon Sydney Children’s Hospital and Dr Matthew Smith, Network Surgical SRMO.

We would like to acknowledge and thank them both for their valued contributions.

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| **Tutorial Date** | **Physiology Session** | **Topics** | **Presenter** |
| **Tue 23 March**  5.30pm - 7.00pm | **Introductory Tips**  **GENERAL CELLULAR PHYSIOLOGY** | **GSSE Study Tips, Resources, High Yield Topics**   1. Composition of intra- and extra-cellular fluid 2. Henderson-Hasselbalch equation 3. Donnan effect/Gibbs-Donnan equation 4. Nernst equation 5. Organelles 6. Cellular membrane and intercellular connections 7. Exocytosis and endocytosis 8. Forms of transport across membranes 9. Receptor physiology 10. Major intra-cellular messaging pathways (IP3/DAG and cAMP) 11. DNA structure, transcription, and translation 12. Mitosis |  |
| **Tue 30 March**  5.30pm - 7.00pm | **IMMUNOLOGY AND INFLAMMATION** | 1. Immune cells and haematopoiesis 2. Primary and secondary lymphoid centres (structure of lymph nodes, spleen, and thymus) 3. Antigen/MHC and receptor interactions 4. Immunoglobulins (regions, structure, class switching, honing) 5. Important cytokines (IL-1, IL-2, IL-6, IL-13, TNF-a, TGF-b) 6. Complement system and activation pathways 7. Phases/stages of inflammation, important mediators (prostaglandin/eicosanoids) 8. Stages of chemotaxis |  |
| **Tue 6 April** | **NEUROPHYSIOLOGY AND MUSCLE PHYSIOLOGY** | 1. Structure of nerves 2. Resting membrane potential, and its maintenance with Na/K ATPase 3. Generation and conduction of action potentials (including EPSPs, IPSPs) 4. Types of nerve fibres 5. Synaptic transmission and neurotransmitters 6. Muscle fibre, myofibril, and sarcomere structure 7. Actin-myosin interactions, including latch action in smooth muscle 8. Conduction through sarcolemma/t-tubule system, including types of calcium transporters 9. Differences in types of muscle (skeletal, cardiac, and smooth), including mechanisms of their innervation 10. Energy sources in muscle (creatinine, glycogen) 11. Types of muscle contraction, output as a form of work and heat, relationship between length and tension 12. Reflex arcs, alpha and gamma-motor neurons, muscle spindle and Golgi tendon organ 13. Principle motor and sensory pathways 14. Cutaneous sensory receptors; brief review of hearing, vision, and balance |  |
| **Tue 13 April** | **ENDOCRINE AND REPRODUCTIVE PHYSIOLOGY** | 1. Overview of HPA, differences between anterior and posterior pituitary structure and function, percentage volume of different anterior pituitary cell types 2. Growth hormone: structure, stimuli for release, receptors (including intra-cellular signalling mechanism [e.g. PLC vs adenylate cyclase]), and function (metabolic/tissue effects, additional downstream hormones) – should include important negatives (e.g. what doesn’t GH do when compared with insulin or androgens) 3. Prolactin: as for GH, brief mention of the role of prolactin vs oxytocin in breast development 4. TSH/T3/T4: as for GH; in addition to this, an overview of thyroid hormone synthesis, plasma binding proteins, and deiodinase activity (including different isotypes) 5. Calcium/phosphate metabolism, summary of PTH, vitamin D, and calcitonin as for GH 6. Adrenal hormones: summary of layers of the adrenal cortex and medulla, simplified steroidogenesis; following this summary of aldosterone, cortisol, and epinephrine/norepinephrine, as for GH 7. FSH and LH: activity in men vs women on distinct cells in the gonads, control of release, cycle of FSH/LH/progesterone/oestrogen levels in the menstrual cycle 8. Progesterone and oestrogen, as for GH 9. Androgens: general function and relative affinity for androgen receptor 10. Vasopressin: via V1 and V2 receptors; should specify intracellular signalling pathways for different receptors. |  |
| **Tue 20 April** | **GASTROINTESTINAL AND METABOLIC PHYSOIOLOGY** | 1. Secretion volumes across the gastrointestinal tract 2. Control of salivary function and predominant components (i.e. mucinous versus serous secreting salivary glands; additional products such as salivary amylase) 3. Physiology of gastric acid secretion, via intercellular communication between parietal, ECL, and G cells; important transporters and “alkaline tide” 4. Major enteric hormones and their functions (gastrin, secretin, CCK, somatostatin) 5. Digestive enzymes of the gastrointestinal tract, their substrate and source (and relationship of trypsin as chief activator) 6. Reabsorption across the gastrointestinal tract, including: water, electrolytes macronutrients, vitamins, and minerals. Mechanisms and conditions of solute transport to be discussed (e.g. mechanisms meaning SGLT-1 and GLUT5 for monosaccharides, condition meaning iron being in ferrous not ferric form) 7. Bile constituents; circulation of bile acids/salts and bilirubin 8. Gastrointestinal motility, including peristalsis and segmentation; basic electrical rhythm generated by ICC and migrating motor complex; special motor activities in the stomach and rectum 9. Introduction to metabolism, explanation of calories (and available calories in each major macronutrient), respiratory quotient, oxygen debt 10. Macronutrients and relevant cycles/pathways (glycolysis, TCA cycle) 11. Insulin and glucagon: structure, stimuli for release, receptors, and function |  |
| **Tue 27 April** | **CARDIOVASCULAR PHYSIOLOGY** | 1. Cardiac electrical physiology: generation of pacemaker potentials, anatomical details, conduction speeds, ventricular action potentials 2. Electrocardiography: mechanism of recording, leads 3. Mechanical events in the cardiac cycle, pressure-volume loops, normal pressures in cardiac chambers 4. Fick’s principle of diffusion, and its relationship to calculating cardiac output 5. Factors controlling cardiac output (preload, afterload, and contractility), Frank-Starling law 6. Anatomical/histological differences throughout the vasculature (arteries, veins, and in between), including relative contribution to contained blood volume and contribution to peripheral resistance (i.e. resistance and capacitance vessels) 7. Principles of laminar flow; Poiseuille formula for calculation of flow through a tube; critical closing pressure within capillaries 8. Bernoulli principle: kinetic and potential energy 9. Starling forces and movement of fluid across small vessels 10. Law of Laplace, as it relates to capillaries (and can then be extrapolated to heart failure, caecal perforation in bowel obstruction) 11. Venous pressures, and changes with position; mechanism of venous return from dependent areas; mechanism of air embolism 12. Circulating and regional control of vascular resistance/arteriole calibre – including feedback mechanisms (baroreceptors) and autonomic innervation 13. Haemostasis: formation of platelet plug and coagulation cascade, important anticoagulant/fibrinolytic mechanisms (thrombomodulin, antithrombin III) |  |
| **Tue 4 May** | **RENAL PHYSIOLOGY** | 1. Nephron structure and major absorptive roles across the nephron (PCT, loop of Henle, DCT, and cortical collecting ducts) 2. Glomerulus structure and major barrier structures (fenestrated endothelium, basement membrane, podocyte foot process) 3. Renal blood flow, renal plasma flow, and glomerular filtration rate; and their estimation using para-amino hippuric acid and creatinine/inulin respectively. 4. Mechanisms of autoregulation of renal blood flow, including important hormones (angiotensin, atrial natriuretic peptide, nor/adrenaline) and autonomic innervation; myogenic and tubuloglomerular reflexes 5. Starling equation as it relates to glomerular filtration, and how this changes across the glomerular capillary (i.e. plasma oncotic pressure increasing) 6. Calculation of renal clearance of a substance, and building on this how net tubular reabsorption versus secretion of that substance can be defined 7. Revisit mechanisms of transport (passive, secondary active, active) as it pertains to solute reabsorption in the nephron 8. Glucose reabsorption in the nephron, and introducing the concept of transport maximum (Tm) and splay 9. Reabsorption of common solutes across the nephron (see figure 37-8 in ***Ganongs 25th ed.***) 10. Countercurrent mechanism for concentrating the ultrafiltrate 11. Water and sodium regulation, therefore the renin-angiotensin system, antidiuretic hormone, and aquaporins 12. The kidneys role in acid-base balance |  |
| **Tue 11 May** | **RESPIRATORY PHYSIOLOGY**  **(information should be taken from *West’s*)** | 1. Overview of respiratory tree structure and respiratory circulation 2. Commonly used lung volumes (FVC, TV, FRC, RV), and what systems are required to calculate them (simple spirometry versus total body plethysmography) 3. Definition of ventilation and dead space (both anatomical and physiological) 4. Fick’s law of diffusion, perfusion versus diffusion limitation of a molecule, and why carbon monoxide can be used to measure diffusion capacity (DLCO) 5. Pressures across the pulmonary circulation, mechanism of recruitment and distension in modifying pulmonary vascular resistance, mechanism of hypoxic pulmonary vasoconstriction 6. Differences in ventilation and perfusion, and therefore V/Q ratio from the upper and lower lung, and how this changes with position and in pathological states. 7. A-a gradient and causes of hypoxaemia and causes of hypercapnia 8. Shunting: anatomical, physiological, and pathological 9. Oxygen carriage in the blood, the oxygen dissociation curve, and modifiers of this curve. 10. CO2 carriage within and outside of the red blood cell 11. Acid-base balance, and defining respiratory acidosis/alkalosis versus respiratory compensation to metabolic acidosis/alkalosis 12. Mechanisms of breathing: quiet versus active 13. Compliance, as a function of surface tension and elastic properties of the alveoli and chest wall 14. Airway resistance and dynamic compression of the airways 15. Control of respiration – peripheral and central 16. Adjustments to oxygen carrying at altitude |  |
| **Wed June 16 & Thu June 17** | **Generic Surgical Sciences Examination** | | |