Primary Physiology 2008.1 THURSDAY Morning Session **Candidate No.**

Topic	Questions	Core Knowledge	Score
1.1 VP inequality (West pp 67-72)	Describe the relationship between ventilation and perfusion of the lung in a person while standing? What are the effects of V/Q inequality on gas exchange? What effect does increasing ventilation to the lungs have on arterial PO2 and PCO2	• Max ventilation 3-4x greater at apex • PO_2 40mmHg higher at lung apex • Max perfusion basally Q nearly 20x greater at base • Prompt: are there regional variations in either • V/Q inequality impairs uptake or elimination of all gases • Majority of blood returns from lung bases where the oxygen saturation is low • Results in blood PO2 being lower than that of mixed alveolar PO2 • PCO2 reduces much more than PO2 increases	/2
1.2 Renal regulation K^+ (Ganong pp 724)	How does the kidney handle potassium? How do other ions affect potassium transport across the membranes in the nephron? Prompt: ***How is potassium transported into and out of the tubules?***	• K+ filtered ~600meq/24hrs • Active K+ reabsorption in prox tubules ~560meq/24hrs • K+ secretion ~502meq/24hrs at distal tubule – amount proportionate to flow rate through distal tubules • Secretion - Electrical coupling to Na+ reab, thus H+ also • Collecting tubules Na reab'd, K excreted, electrical coupling and passive K movement • Na reab'd in association with H secretion, K excretion decreased if Na low in distal tubule • Na/K 2Cl apical transporter/transport protein • 3Na/2K ATPase	/2
1.3 Pressure, flow & resistance (Guyton pp 164-170)	What are the basic factors which determine the rate of flow of blood through a blood vessel? What factors cause turbulent flow in a blood vessel?	Poiseulle's Law and formula describe these factors; **(Radius to 4th power + 2 others)** Where: F is the rate of flow; $P_A - P_B$ is the pressure differential; $\mathbf{F = \frac{P_A - P_B}{R}}$ R is the resistance: r is the radius of the tube; $\mathbf{R = \frac{8 \eta L}{\pi r^4}}$ η is the viscosity of the fluid L is the length of the tube $\mathbf{F = P_A - P_B \times \frac{\pi r^4}{8 \eta L}}$ Expressed by Reynold's number; **(3 out of 4)** Where: ρ is the fluid density; D is the diameter of the tube; $\mathbf{Re = \frac{\rho D V}{\eta}}$ V is the velocity of flow; η is the viscosity of the fluid. The higher the value of Reynold's number the greater the probability of turbulence' which usually occurs when Reynold's number is between 2000-3000.	/2

1.4 Thyroid hormones Ganong pp 319-328	What are the effects of thyroid hormones?	**(4 out of 7)** • Widespread actions • Metabolically active tissues • Heart - increased rate • Brain - development reticular Act. Sys. • Gut - increased carbohydrate absorbtion. • Muskuloskeletal growth • Adipose – lipolysis	
	What is the mechanism of action?	**(4 out of 8)** Intracellular--- • At the nuclear level • O2 consumption regulator. • T3 binds better than T4 to receptor • Hormone/receptor binds to DNA • Affects gene expression • Two genesites • Alpha Chromosome 17 • Beta Chromosome 3	/2
1.5 Vitamin D Ganong pp 387-388	What are the actions of vitamin D?	**(3 of 4)** • Increased absorption of calcium from the intestine by induction of calbindin-D proteins. • Increased resorption of calcium in the kidneys. • Increased osteoblast activity. • Aids calcification of bone matrix.	
	How is the synthesis of vitamin D regulated?	**(3 of 5)** • Not closely regulated. • Low calcium leads to increased PTH secretion and increased vitamin D is produced. • High calcium inhibits PTH and the kidneys produce inactive metabolites. • Low phosphate increases vitamin D production (and high phosphate inhibits it). • Vitamin D inhibits the enzyme involved in its synthesis.	/2
			Final Score

Topic	Questions	Core Knowledge	Score
2.1 Airway Resistance West pp 106-112	What factors impact on resistance in airways?	• Size of airway: R highest in medium sized bronchi, low in very small airways. • Lung volume: R decreases with expansion as airways pulled open • Bronchial smooth muscle tone: controlled by B sympathetics • Gas density: eg heliox -> low R • Forced expiration: intrathoracic pressure compresses airways = 'dynamic compression'	
	What factors cause turbulent flow in airways	Expressed by Reynold's number; **(3 out of 4)** Where: ρ is the fluid density; D is the diameter of the tube; V is the velocity of flow; η is the viscosity of the fluid. $\mathbf{Re} = \frac{\rho D V}{\eta}$ Laminar flow only in small airways, transitional most areas, turbulent in trachea (rapid breathing)	/2
2.2 Renal blood flow Ganong pp 702-705	What is a typical value for renal blood flow in an adult at rest?	**~25% of cardiac output or 1250 ml/min**	
	What factors regulate renal blood flow?	**Chemical**: Noradrenaline constricts interlobular and afferent arterioles. **(3 of 5)** Dopamine causes renal vasodilation. Angiotensin II constricts efferent arterioles to a greater extent than the afferent arterioles. Prostaglandins increase blood flow in the cortex and decrease blood flow in the medulla. Acetylcholine produces renal vasodilation. **Neural**: Strong stimulation of the sympathetic nervous system produces renal vasoconstriction. **Autoregulation**: Direct contractile response of smooth muscle of afferent arteriole to stretch. NO may be involved. **At low perfusion pressures angiotensin II plays a role in constricting efferent arterioles.**	/2
2.3 Factors controlling cardiac output & O_2 consumption Ganong pp 571-576	What factors control cardiac output?	**Cardiac Output = Heart Rate x Stroke Volume** **Heart rate** controlled by cardiac innervation – symp. / parasymp. **Stroke Volume:** • **Afterload** • **Preload** - Starling Curve (Fibre length-tension) **(2 out of 5):** Pericardial pressure Ventricular compliance Atrial filling Blood volume Intrathoracic pressure • **Contractile state (3 out of 7):** Cardiac innervations Hypoxia; hypercapnia; acidosis Drugs +ve & -ve inotropes Circulating catecholamines Loss of myocardium Intrinsic depression (Heart failure) Force-frequency relationship	
	What are the major factors which determine myocardial oxygen consumption?	**(2 out of 3)** Intramyocardial tension Contractile state of myocardium Heart rate (= Ventricular work/beat = SV x MAP)	/2

2.4 Glucocorticoids Ganong pp 372-380	What are the physiological effects of glucocorticoids?	• **Metabolic;** increased protein catabolism, increased hepatic glycogenesis and gluconeogenesis (raised plasma glucose). Raise peripheral tissue insulin resistance • Permissive effects on other reactions • Are required for catecholamines to produce **calorigenic and lipolytic** effects, **pressor responses** (vascular reactivity) and vasodilatation • Inhibit ACTH secretion (feedback) • Impair water excretion (mechanism unclear) • Reduce circulating basophils and eosinophils and increase other elements • Required for stress response • Affect EEG waveforms (mild personality changes in insufficiency)	
	How is glucocorticoid secretion regulated?	• Basal secretion and stress response both dependent on **ACTH** • (Other substances may stimulate adrenal directly but no evidence of role in physiologic regulation) • Free glucocorticoids produce negative feedback on ACTH secretion at both hypothalamic and pituitary levels. Effect mediated by action on DNA • Stress response ACTH secretion mediated almost exclusively via hypothalamic release of corticotrophin releasing hormone • **Circadian rhythm.** ACTH released in irregular bursts throughout day but much more common in early morning. 75% of cortisol secreted at this time	/2
2.5 Iron Ganong pp 474-478	Please describe how ingested iron is absorbed.	• Most ingested iron is ferric (3+) but the ferrous (2+) form is absorbed. • Minimal absorption in stomach but gastric secretions dissolve iron and aid conversion to the ferrous form. • Almost all absorption in duodenum. Iron is transported into enterocytes via DMT1. • Some stored as ferritin. • Remainder transported out via ferroportin 1 (basolateral transporter) in the presence of hephaestin. Then converted to ferric form and bound to transferrin. • Dietary heme is absorbed by an apical transporter andiron is removed from the porphyrin in cytoplasm.	
	What are the mechanisms that regulate iron absorption?	Precise mechanisms uncertain, probably related to: • Recent dietary intake of iron. • State of body iron stores. • State of erythropoiesis in bone marrow. • The regulatory mechanisms are unclear.	/2
			Final Score

Primary Physiology 2008. FRIDAY Morning Session **Candidate No.**

Topic	Questions	Core Knowledge	Score
3.1 Elastic Properties of the Lung West pp 96-106	Define lung compliance?	• Change in volume / change in pressure (Slope of pressure-volume curve) (Lung "stiffness")	
	What factors influence lung compliance?	**(3 out of 6)** • Fibrosis • Alveolar oedema • Elastic tissue • Emphysema / age • Volume / Size of lung • Surface tension in alveoli (Surfactant)	
	What else does surfactant do?	**(2 of 3)** • Reduces WOB Prevents collapse Keeps alveoli dry	/2
3.2 Loop of Henle, structure & function Ganong pp 700, 714-718	Please outline the structure of the Lof H	• Thin/descending, Thick/ascending. Situated mostly in the renal medulla • **Origin from PCT** • Short (cortical) and long (juxta med.)loops • **Macula densa at distal end, where joins DCT**	
	What happens to electrolytes in the loop	• **(Thin) Descending limb water permeable** • **Fluid becomes hypertonic as descends loop** • **(Thick) Asc limb impermeable to water, NaK Cl transported out, hypotonic at end, so K+ diffuses back** • **Active trans. ATPase**	
	Explain the counter-current concentrating mechanism	• Gradient • Exchange (vasa recta)	/2
3.3 Cerebral blood flow. Brain metabolism & O2 requirements Ganong pp 616-620	What factors determine cerebral blood flow?	**(4 of 5)** • Intracranial pressure • Local constriction/dilation of cerebral arterioles, autoregulation etc • MAP at brain level • Blood viscosity • Mean venous press at brain level	
	What substances are important for brain metabolism?	• Oxygen ~49ml/min = 20% body O2 consumption • Glucose (major energy source) ~77mg/min • Glutamate (converted to glutamine as detox mech NH3) ~5.6mg/min	/2

3.4 Insulin & Glucose Ganong pp 336-340	Describe the effects of insulin on various tissues What is the time frame for these effects	• **Adipose:** glucose in, fatty acid + glycerol synthesis, TG deposition, K in • **Muscle:** glucose in, glycogen synthesis, Aas in, protein synthesis, ketones in, K in • **Liver:** glycogen, protein + lipid synthesis, • General: cell growth • **Rapid:** glucose, AAs, K into sensitive cells • **Intermediate:** protein synthesis, glycolysis and synthesis, inhibition gluconeogenesis • **Delayed:** lipogenesis	/2

3.5
Regulation of calcium
Ganong pp 383-395
	What factors influence the level of free calcium in plasma?
	
	How does bone resorption occur?
		• Protein binding - depends on plasma protein level and pH.
		• Total body calcium
		  o bound in bone; bone calcium readily exchangeable or slowly exchangeable (resorption / deposition)
		  o Intake
		  o GI absorption under influence of vitamin D
		  o Renal excretion under vitamin D influence
		  o Parathyroid hormone
		  o Calcitonin
		
		• Osteoclasts are monocytes that develop from stromal cells under influence of RANKL.
		• Attach to bone via integrins in sealing zone of the membrane.
		• Hydrogen dependent proton pumps move into cell and acidify the area.
		• Acid dissolves hydroxyapatite and collagen.
		• Products move across osteoclast into interstitial fluid.
			/2

Final Score