

## Supplementary files

### Integration of Biochemistry into an organ system based medical curriculum using problem based learning

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Table 1: The time sequence of organ system blocks (OSB) in the undergraduate basic science medical curriculum at Patan Academy of Health Sciences (PAHS)

Basic Sciences			
First year blocks	Time period	Second year blocks	Time period
Principle of Human Biology I	11 Weeks	Gastrointestinal and Hepatobiliary System	6 Weeks
Principle of Human Biology II	8 Weeks	Renal and Electrolytes	4 Weeks
Haemopoetic System	4 Weeks	Endocrine, Metabolism and Reproductive	8 Weeks
Respiratory System	5 Weeks	Musculoskeletal and Skin	5 Weeks
Cardiovascular System	5 Weeks	Nervous System and Special Senses	8 Weeks

Table 2: Distribution of biochemistry curricular content in the principle of human biology (PHB) I and II with the teaching-learning (T-L) methods used to deliver the content

OSB	T-L method	Content Covered
PHB I	PBL	<b>Fever:</b> Prostaglandin <b>Osteogenesis Imperfecta:</b> Structural organization of proteins <b>Alcohol Induced Fatty Liver:</b> Fatty acid synthesis, $\beta$ -oxidation <b>Malnutrition:</b> Macronutrients and micronutrients, metabolism during starvation and feeding.
	Seminar	Integration of Metabolic pathways with case scenario.
	Lab	Qualitative test of Biomolecules (Carbohydrate, Protein and Lipid), Introduction to colorimeter and spectrophotometer, Determination of maximum wavelength ( $\lambda$ max) of the given colored solution, Verification of Beers law of photometry Estimation of protein.
	Lecture	Amino acid chemistry, protein and structural organization, carbohydrate chemistry, lipid chemistry, nucleic acid chemistry, enzymes, vitamins and minerals, basic metabolism and its regulation (glycolysis, Krebs's cycle, gluconeogenesis, glycogenesis, glycogenolysis, ketone body synthesis), integration of metabolism: Metabolism during starvation and feeding.
PHB II	PBL	<b>Cervical Cancer:</b> Human proto-oncogenes and oncogenes, and human tumor suppressor genes. Role of mutations in tumor suppressor genes and oncogenes causing cancer. <b>Breast Cancer:</b> Mechanisms of DNA repair and how these are involved in the development of cancer, role of tumor suppressor genes in the development of familial cancer, patterns of inheritance, genetic counseling. <b>Myasthenia Gravis:</b> Biosynthesis of acetylcholine and its mechanism of action.
	Seminar	Recombinant DNA technology, recent molecular techniques Understanding and application of concepts on central Dogma Pedigree analysis and Risk Calculation Karyotype and Chromosome Behavior
	Lab	DNA extraction, demonstration of electrophoresis techniques
	Lecture	DNA Replication and repair, central dogma (replication, transcription and translation), regulation of gene expression, cell cycle, oncogenetics, multifactorial inheritance and population genetics, neurotransmitters.

Table 3: Distribution of biochemistry curricular content in the Hemopoietic, Respiratory, Cardiovascular, Gastrointestinal and Renal blocks with the T-L methods used for its delivery

Organ	T-L method	Content Covered
Haemopoietic	PBL	<b>Anaemia:</b> Haem biosynthesis, metabolism of iron, HMP shunt pathway <b>Malaria:</b> G6PD deficiency, oxidative stress. <b>Deep Vein Thrombosis:</b> Vitamin K.
	Lecture	Haemoglobinopathies, Haem synthesis, porphyria, RBC metabolism: Role of folic acid and Vit. B <sub>12</sub> .
Respiratory	PBL	<b>COPD:</b> Role of hemoglobin gas transport, arterial blood gas analysis and its interpretation, buffers
	Seminar	The role of respiratory system in pH regulation; its imbalance leading to respiratory acidosis/alkalosis, arterial blood gas analysis and its interpretation.
	Lecture	<b>Electron transport chain (ETC):</b> Uncouplers and inhibitors, structural difference in hemoglobin and myoglobin and its importance in their function as oxygen carrier and oxygen storage, oxidants, antioxidant and oxidative Stress.
Cardiovascular	PBL	<b>Coronary artery disease:</b> Cardiac markers and its application in detecting cardiac injury, dyslipidemia and interpret lipid profile test <b>Hypertension:</b> Lipid profile and its interpretation
	Lab	Estimation of serum total cholesterol and interpretation of lipid profile tests
	Lecture	Cardiac muscle metabolism, cholesterol biosynthesis and its degradation into bile acid, lipid metabolism and lipoproteins
Gastrointestinal	PBL	<b>Gastritis:</b> Digestive enzymes <b>Viral diarrhea:</b> Indigestion and malabsorption <b>Hepatitis:</b> Plasma proteins, bilirubin metabolism, liver function tests and biliary secretion. <b>Liver cirrhosis:</b> Plasma proteins, bilirubin metabolism, liver function tests and biliary secretion. <b>Protein Energy Malnutrition:</b> Revisit of integration of metabolism: starvation
	Seminar	Interpretation of liver function test
	Lab	Perform bilirubin estimation and detection of urine urobilinogen, bile pigment and bile salt. Interpret the liver function test
	Lecture	Liver functions and Xenobiotic metabolism
Renal	PBL	<b>Post-streptococcal glomerulonephritis:</b> Nitrogen balance and urea biosynthesis. <b>Acute Renal Failure:</b> Renal function tests (urea, creatinine and creatinine clearance) and electrolyte balance. <b>Hypertensive Nephropathy:</b> Renal function tests (urea, creatinine and creatinine clearance) and electrolyte balance. Role of kidney in acid base balance and metabolic acidosis / alkalosis
	Seminar	Interpretation of ABG analysis and differentiate metabolic/ respiratory and acidosis/ alkalosis
	Lab	Estimation of blood urea and calculation of creatinine clearance and urea clearance. Detection of urinary protein.
	Lecture	Nitrogen balance and urea cycle, amino acid metabolism, electrolyte balance, role of kidney in acid-base balance

Table 4: Distribution of biochemistry curricular content in Endocrinology-Reproductive, Musculoskeletal-Skin and Neurosensory blocks with T-L methods used for its delivery

Organ System	T-L method	Content Covered
Endocrinology and Reproductive	PBL	<p><b>Pituitary Tumor:</b> Nature, synthesis, secretion and mechanism of action of pituitary hormones.</p> <p><b>Thyroid follicular adenoma:</b> nature, synthesis, secretion and mechanism of action of parathyroid hormone and calcitonin, calcium homeostasis.</p> <p><b>Type 1 Diabetes Mellitus:</b> Diabetes mellitus, types, glucose homeostasis, metabolic changes that occurs in diabetes and biochemical basis of diabetic complication.</p> <p><b>Type 2 Diabetes Mellitus:</b> Hormones and body weight, dyslipidemia in diabetes, insulin and glucagon.</p> <p><b>Pregnancy:</b> Nature, synthesis, secretion and mechanism of action of ovarian hormones.</p> <p><b>Polycystic Ovarian Syndrome:</b> Ovarian hormones and androgen.</p> <p><b>Male infertility:</b> Nature, synthesis, secretion and mechanism of action of testicular Hormones.</p>
	Seminar	Interpretation of thyroid function test
	Lab	Glucose estimation and interpretation, Interpretation of OGTT and HbA1c. Detection of urinary glucose.
	Lecture	Role of hormones in the control of body weight, Regulation and mechanism of action of different types of hormones in general. Nature, synthesis, secretion and mechanism of action of parathyroid hormone and calcitonin, corticosteroid hormones, testicular hormones, ovarian hormones, pancreatic hormones and glucose homeostasis
Musculoskeletal and Skin	PBL	<p><b>Leprosy (Hypopigmented Patch):</b> Melanin biosynthesis.</p> <p><b>Neck Pain:</b> Bone metabolism (integrated role of parathyroid hormone, calcitonin and vitamin D in bone mineralization) calcium homeostasis, vitamin D.</p> <p><b>Poliomyelitis:</b> Muscle marker in diagnosing muscle injury.</p>
	Lecture	Bone metabolism, muscle metabolism and differentiation of type I and type II muscle fiber on biochemical basis.
Neurosensory	PBL	<p><b>Parkinson Disease:</b> Synthesis neurotransmitter dopamine.</p> <p><b>Night blindness:</b> Vitamin A and its role in protecting from night blindness.</p> <p><b>Meningitis:</b> Biochemical analysis of CSF.</p>
	Seminar	Interpretation of biochemical analysis of CSF.

Table 5: PBL case prototype: Hepatitis in the Gastrointestinal and Hepatobiliary Block

<b>Clinical presentations (learning triggers)</b>	<b>Biochemistry learning objectives</b>
Yellow eyes and skin Analysis of stool and urine	Describe bilirubin synthesis and metabolism
Itchy skin	Bile synthesis
Liver function test report, urine and stool examination	Differentiate different types of jaundice (pre-hepatic, hepatic and post-hepatic)
Edema	Explain the function of albumin

Table 6: Curricular contents dealing with Vitamins and minerals

<b>Block</b>	<b>Vitamins and minerals</b>	<b>Clinical scenario</b>
Haemopoetic Block	Vitamin B12, folic acid and iron	Anemia
Respiratory Block	Vitamin A and E, Selenium	Antioxidants
Gastrointestinal and Hepatobiliary Block	Vitamin K	Bleeding in liver disease
Endocrine, Metabolism and Reproductive Block	Iodine	Thyroid disorder
Musculoskeletal and integumentary Block	Calcium, phosphorus and vitamin D	Osteoporosis
Neurosensory Block	Vitamin A	Night-blindness