

# EMBRYOLOGY

## COURSE CONTENT

### COMPETENCIES

The first year medical student should be able to understand and explain the principles of fertilization, contraception, stages of early development of the embryo, development of various organ systems; developmental basis of congenital defects, twinning and teratology.

## GENERAL EMBRYOLOGY

### INTRODUCTION

Stages of human life

**Prenatal** – Zygote, pre-embryonic, embryonic, foetal, birth events

**Postnatal** – Neonatal, infancy, childhood, prepubertal, pubertal, adolescent, adult - young, middle age, old age, death events

Ontogeny, trimester, viability, abortion, miscarriage, medical termination of pregnancy, conceptus, abortus

Terms of reference – Cranial, rostral, caudal, dorsal, ventral, lateral, medial, median, planes of section

**Level 3:** Ontogeny in relation to phylogeny – The law of recapitulation; “Critical period”; Congenital *vs.* hereditary malformations; Investigations - USG, amniocentesis, chorionic villus biopsy, fetoscopy, teratology and its significance with respect to obstetrics, paediatrics; Intrauterine surgery; History of embryology

### GAMETOGENESIS AND FERTILISATION

Menstrual cycle with reference to other reproductive cycles, concept of “first day of last menstrual period”, germ cell transport and fertilisation, sperm capacitation, acrosome reaction, zona reaction, methods of contraception, sex determination

**Level 2:** Reference to genetics, abnormal gametogenesis, abnormal germ cells – morphology, abnormal chromosomal contents, biological significance, conception, assisted reproductive techniques (ARTs), medical termination of pregnancy (MTP)

**Level 3:** Abnormalities which may occur during mitosis and meiosis due to natural or teratogenic influences; Fertility and sterility and investigations thereof up to sex selection, surrogate motherhood; Social significance of “sex-ratio”, ethics and responsibility

### FIRST WEEK

Cleavage, compaction, morula, blastocyst; Implantation - normal sites, abnormal sites - placenta praevia

### SECOND WEEK

Cytotrophoblast, syncytiotrophoblast; Foetal membranes - chorionic villi, amnion, yolk sac; Extra-embryonic mesoderm and coelom; Bilaminar disc - prochordal plate

**Level 2:** Mosaicism, chimera; Spontaneous “abortion”; Tubal transport and block

Consequences of abnormal implantation; Decidual reaction, chorionic gonadotropins - pregnancy test, inhibition of implantation

**Level 3:** Pregnancy wastage, appreciating dangers of abnormal implantation, corrective methods; Pregnancy tests - false positive, false negative and reasons for the same

### **THIRD WEEK**

Gastrulation - Primitive streak - formation and significance; Notochord; Neurulation – neural tube and its fate, neural crest cells - their fate; Development of somites; Intra-embryonic coelom, CVS; Allantois; Inductive significance of structures

**Level 2:** Congenital malformations - Sacrococcygeal teratomas, neural tube defects, spina bifida, meningocoele, anencephaly

**Level 3:** Signs of pregnancy in the first trimester; “Frame of body” - poles, axis, symmetry; Role of teratogens in first trimester; Dilatation and curettage procedure, suction curettage, alpha fetoprotein levels

### **FOLDING OF THE EMBRYO**

Derivatives of germ layers, concept of critical period, pharyngeal arches (pharyngula stage)

**Level 2:** Dysmorphism, histologic significance, tissue organisation in terms of germ layers

**Level 3:** Thalidomide tragedy- historical significance, role of “testing of drug or agent” as teratogen, animal experiments; Estimation of embryonic age - crown-rump length (CRL), somites; Superfoetation & superfecundation

### **FETAL MEMBRANES**

Features, formation, functions, fate of: Chorion; Amnion; Yolk sac; Allantois; Decidua; Umbilical cord; Placenta - Physiological functions; Fetomaternal circulation, Placental barrier, Twinning - monozygotic, dizygotic

**Level 2:** Role of placental hormones, uterine growth, parturition, multiple pregnancy.

**Level 3:** Details of placenta, post-labour examination - information available, types; Types of cord attachments, abnormal multiple pregnancy, incretions; Variety of uses of amniotic membranes, trophoblastic tumours - benign and malignant; Rh incompatibility, haemolytic disease of newborn, erythroblastosis fetalis, teratogenic influences

### **FETAL PERIOD**

The growth of the fetus in general in terms of weight and major features; maternal-fetal correlation during pregnancy (pregnancy changes in mother)

**Level 2:** Estimation of fetal age, concept of prematurity; Relative proportion of body segments; Some details of tissue differentiation and development of function

**Level 3:** Cytogenetics, chorion villus biopsy and amniocentesis; Causes of “small” and “large” babies; Concept of small for date (age) growth; Factors influencing fetal growth; Older methods of fetal monitoring, their hazards; Estimation of fetal age - crown-heel length (CHL)

### **TERATOGENESIS**

Enumeration of factors causing congenital malformations with examples

**Level 2:** Brief clinical manifestations and details with genetic basis

**Level 3:** Concept of critical period, teratogens; Multifactorial inheritance; Methods available to correct or palliate e.g. In Utero Surgery; Genetic engineering; Stem cell transplants

## **BODY CAVITIES, PRIMITIVE MESENTERIES AND DIAPHRAGM**

Coelomic cavity; its subdivisions; Related parts i.e., cardiogenic area, septum transversum, somatopleure, splanchnopleure, mesenteries formation, Functions and fate; Development of diaphragm

**Level 2:** Enumeration of congenital malformations; Diaphragmatic hernias

**Level 3:** Clinical presentation; Neonatology; Respiratory distress; Herniations; Attempts at intrauterine surgery to correct malformations

### **General Embryology Models**

- Gametogenesis - Oogenesis; Spermatogenesis; Structure of spermatozoon
- Cell division - Mitosis; Meiosis
- Germ disc showing - Primitive streak; Notochordal process and Prochordal plate
- Folding of the embryo and somites
- Placenta and foetal membranes

## **SYSTEMIC EMBRYOLOGY**

### **CARDIOVASCULAR SYSTEM**

General principles of angiogenesis; Sinus venosus - venous system; Heart - chambers, septa; Truncus - formation and fate; Aortic arches - arterial system; Fetal circulation - changes at birth; Lymphatic system; Anomalies - ASDs, VSDs, PDA, Fallot's tetralogy

**Level 2:** Development of major veins, Correlation with gross anatomy and commonly occurring anomalies; Anomalies of the lymphatic system

**Level 3:** Clinical features; Latest developments including prosthetic valves, graftings, transplantation; Surgical corrections

### **RESPIRATORY SYSTEM**

Development of larynx, trachea, bronchi, lungs; tracheo-oesophageal fistula

**Level 2:** Other anomalies

**Level 3:** Respiratory distress syndrome; Premature births and consequent necessary care with respect to respiratory system

### **ALIMENTARY SYSTEM**

**Foregut** - Oesophagus, stomach, mesenteries and omental bursa (lesser sac); duodenum, hepatobiliary apparatus, pancreas, spleen

**Midgut** - Rotation and fixation, caecum and appendix, Meckel's diverticulum

**Hindgut** - Cloaca; Digestive tract / urogenital tract derivatives; Rectum and anal canal  
Arteries of Foregut, Midgut, Hindgut

**Level 2:** Malformation - review; Tracheo-oesophageal fistula; Congenital hypertrophic pyloric stenosis; Atresia; Omphalocele; Hernia; Situs inversus; Nonrotation; Mixed rotation

**Level 3:** Clinical presentation in premature births and neonatal period

## **PHARYNGEAL ARCHES AND FACE**

Ectodermal clefts - cervical sinus, auricle; Mesodermal derivatives - skeletal, muscle mass, arterial arches; Endodermal pouches - tongue, thyroid, parathyroid, thymus, tubotympanic recess; Pre and posttrematic nerves

Mandibular process, maxillary process, frontonasal process; Cleft lip, cleft palate

**Level 2:** Branchial cyst, sinus, fistula; Other congenital anomalies of the glands; Oblique facial cleft; Other congenital anomalies of the face

**Level 3:** Treacher Collins syndrome; Genetic basis of teratology

## **UROGENITAL SYSTEM**

Along with vascular pattern and development; Development of kidneys and ureters; Cloaca - urinary bladder and urethra; Genital system - testis and ovary; Ducts and associated glands; External genital organs; Mesonephric and paramesonephric ducts; Uterine tube, uterus and vagina

**Level 2:** Enumeration of congenital malformations with their explanations; Ambiguous genitalia and hermaphroditism; Remnants and vestiges of ducts and tubules

**Level 3:** Clinical presentation and visualisation in the living; Hernia, hydrocoele; Relevance to forensic medicine

## **ENDOCRINE GLANDS**

Pituitary - Rathke's pouch, neural tube extension; Thyroid & parathyroid - pharyngeal pouches; Suprarenal - intermediate mesoderm, neural crest

**Level 2:** Histogenesis; Congenital anomalies

## **NERVOUS SYSTEM**

Neural tube - spinal cord and brain i.e., forebrain, midbrain and hindbrain, ventricular system, hypophysis cerebri; Neural crest - peripheral nervous system, i.e., somatic and autonomic; Principle of neurobiotaxis - correlation with gross and histogenetic neuroanatomy; Functional components - correlation spina bifida; Anencephaly, hydrocephalus, functional components of peripheral nerves

**Level 3:** Sequence of myelination of tracts T3-T4; Relative shortening of spinal cord vis-à-vis vertebral column - therefore longer nerve roots, more liable to compression; Genetic and teratologic factors in neural tube defects

## **ORGANS OF THE SPECIAL SENSES**

**Eye** - General organization; Enumeration of each component starting from its development; Include reference to adnexa

**Level 2:** Common anomalies; Retinal detachment; Congenital glaucoma; Coloboma iris; Congenital cataract and aphakia

**Level 3:** Genetics and teratology especially rubella, toxoplasmosis; "TORCH" Test; Clinical detection of small functional problems related to the eye

**Ear** - Internal ear - Membranous and bony labyrinth; External and middle ear - Review common anomalies of the ear

## **SKELETAL SYSTEM**

Bones and joints; General development of cartilage and bone ossification; Joints; Axial and Appendicular skeleton, vertebrae, ribs

**Level 2:** Abnormalities of development; Gross and microanatomy correlations

**Level 3:** Neural tube defects - Related consequences; Genetics and endocrinology;  
Radiological and forensic significance of ossification

## **MUSCULAR SYSTEM**

Myotomes; Local differentiation of muscles, myotomic fusions; Splits and migrations;  
Correlation with motor innervation

**Level 2:** Common anomalies; anatomic variations

**Level 3:** Rare syndromes of muscular defects and deficiencies - Genetics

## **LIMBS**

General principles; Rotations - dermatomal distribution; Review vascular pattern

**Level 2:** Congenital malformations

**Level 3:** Genetic and Teratologic influence in limb; development and anomalies

## **INTEGUMENTARY SYSTEM**

Skin - Non-hairy; Hair (Pilo-sebaceous unit); Nails; Sweat glands; Mammary glands;  
Tooth as a modified dermal papilla

**Level 2:** Congenital anomalies, especially with respect to pigment, sweat glands,  
vessels, nerves, lymphatics; Mammary gland anomalies

**Level 3:** Genetics and teratology; Clinical syndromes

## **Systemic Embryology Models**

- Alimentary System
  - Rotation of gut
  - Development of stomach, pancreas and liver
- Circulatory System
  - Chambers of the heart
  - Development of interatrial septum
  - Development of interventricular septum
- Urogenital System
  - Septation of hindgut
  - Development of kidney
  - Derivatives of paramesonephric duct
  - Derivatives of mesonephric duct
- Alimentary System
  - The Branchial apparatus & tongue
  - Development of face & palate
- Nervous System
  - Brain vesicles and their development
  - Neural crest cells and their derivatives

## LECTURES

- Male gametogenesis
- Female gametogenesis
- 1<sup>st</sup> week of development
- 2<sup>nd</sup> week of development
- 3<sup>rd</sup> week of development
- 4<sup>th</sup> to 8<sup>h</sup> week of development
- Placenta & membranes
- Twinning and teratogenesis
- Heart - Exterior
- Heart - Interior
- Arteries
- Veins
- Foetal circulation; Lymphatics
- Anomalies
- Respiratory system
- Foregut - caudal part
- Midgut
- Hindgut
- Anomalies
- Upper urinary tract - Kidney & ureters
- Lower urinary tract - Urinary bladder & urethra
- Male reproductive system
- Female reproductive system
- Anomalies
- Integumentary system
- Development of endocrine glands
- Pharyngeal arches
- Development of face
- Muscular system
- Skeletal system
- Development of spinal cord & histogenesis
- Development of brain
- Anomalies of nervous system
- Development of eye & ear
- Postnatal growth & development

### Topics for integration

- Paediatric anatomy
- Assisted Reproductive Techniques (ARTs)

**Karl Ernst Von Baer**  
(1792-1876)



He was an Estonian zoologist.

He is referred to as the “Father of Modern Embryology” and the founder of comparative embryology.

He described the development of many vertebrate types.