DEVELOPMENTAL BIOLOGY

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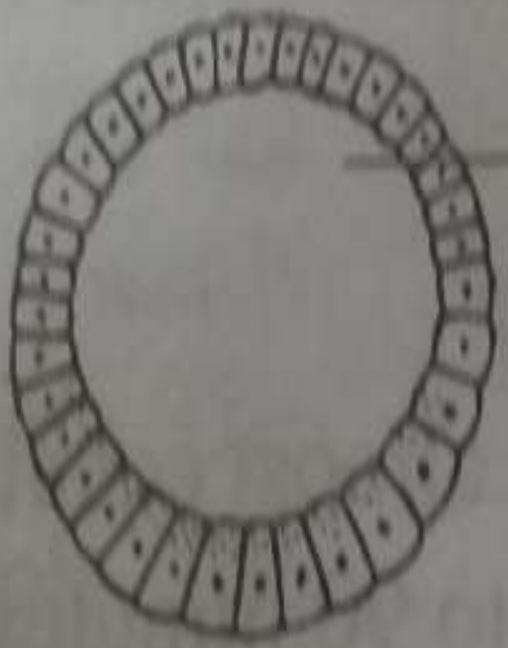
DEVELOPMENT OF AMPHIOXUS

- Eggs- 0.02mm in diameter, microlecithal, isolecithal

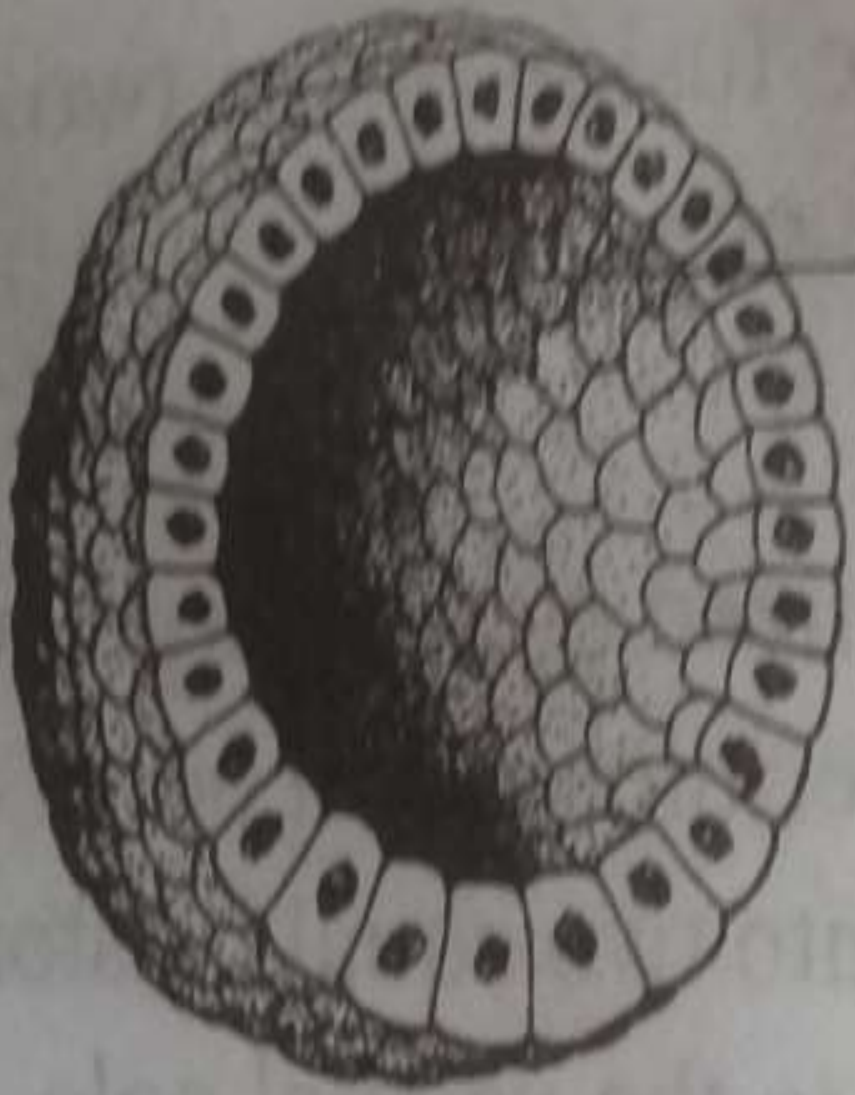
  Cleavage- Holoblastic equal
- 1st & 2nd Cleavage- Meridional
- 3rd Cleavage-lattitudinal- 4 micromeres& 4 macromeres are produced
- 4th Cleavage-Meridional & double
- 5th Cleavage- lattitudinal & double
- 6th Cleavage onwards irregular

BLASTULATION

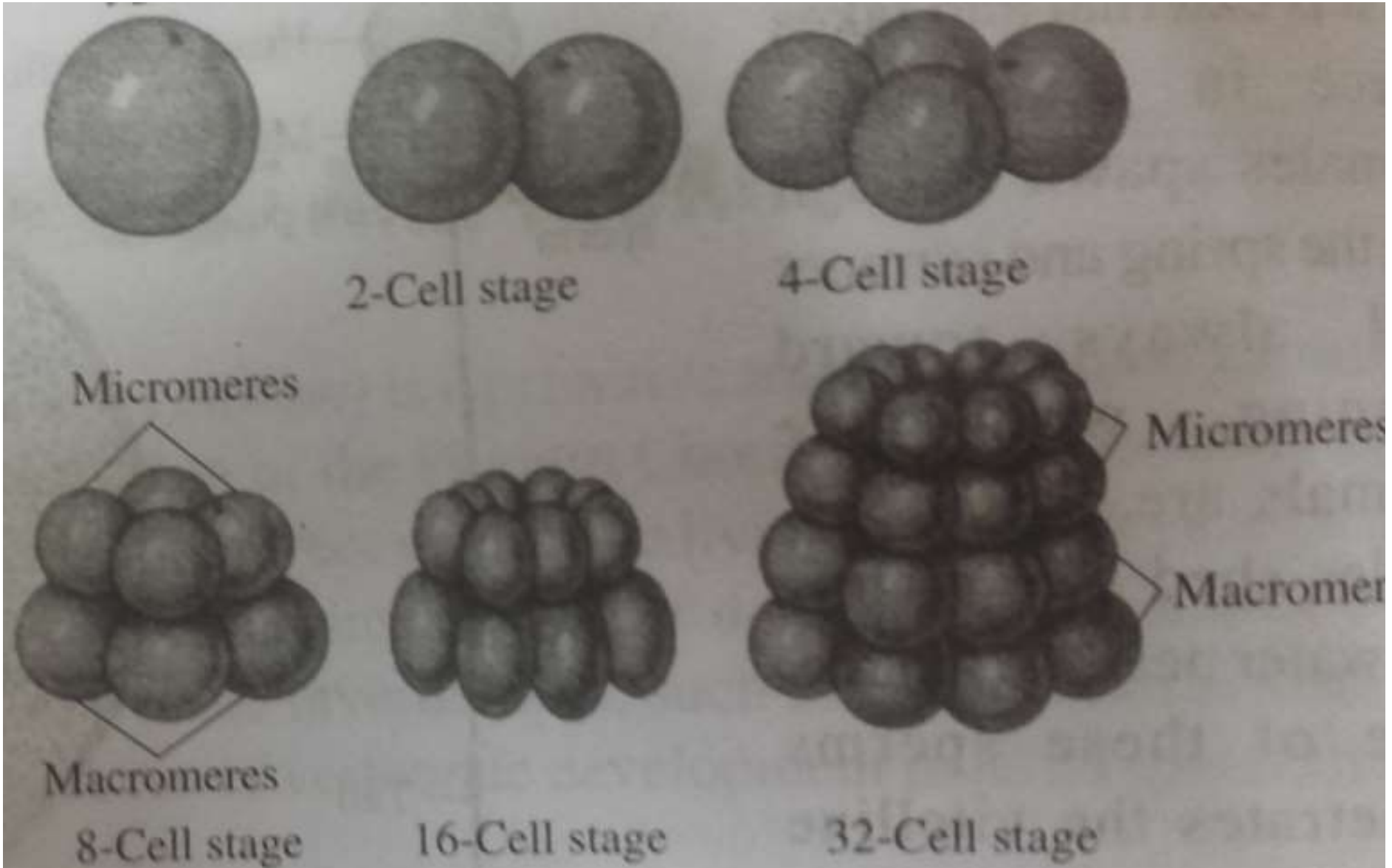
- Blastocoel is filled with jelly like subtance which exerts pressure on blastomeres to become blastoderm
- Blastula – equal coeloblastula but contains micromeres in animal hemisphere & macromeres in vegetal hemisphere



Blastula



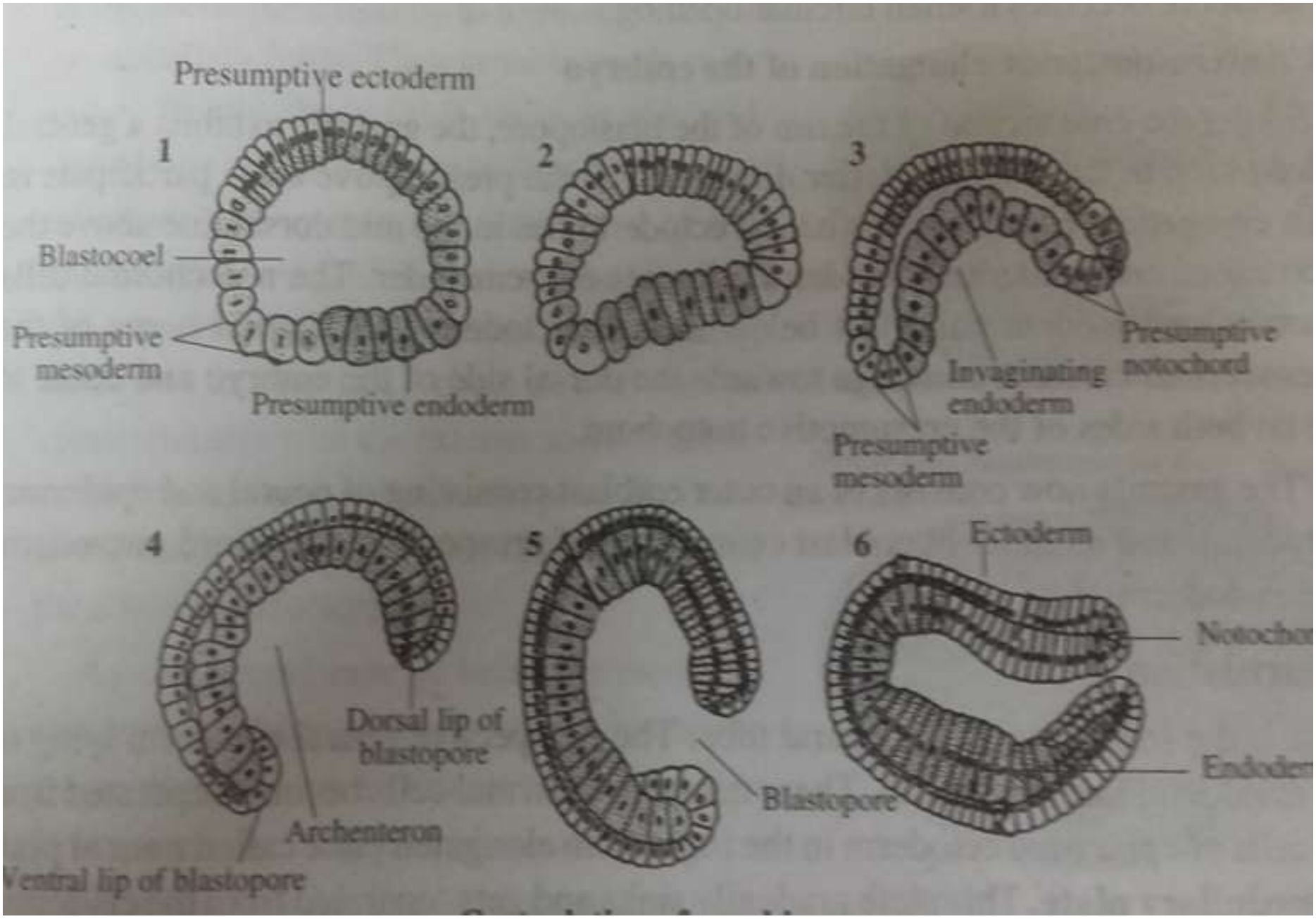
Blastula hemisection



Radial cleavage in amphioxus

GASTRULATION

- The process of formation of double layered gastrula.
- The outer layer- ectoderm& inner layer- median notochord flanked by mesoderm. The remaining cells are endodermal cells.
- Begin after 6 hrs with flattening of prospective endodermal area.
- Characterized by morphogenetic movements & antero posterior elongation


Presumptive ectoderm
1
Blastocoel
Presumptive mesoderm
Presumptive endoderm
2
3
Presumptive notochord
Invaginating endoderm
Presumptive mesoderm
4
Dorsal lip of blastopore
Archenteron
Ventral lip of blastopore
5
Blastopore
6
Ectoderm
Notochor
Endoder

Morphogenetic movements

- *1. Invagination* of P.endodermal cells into blastocoel reducing the cavity and a new cavity is produced- gastrocoel or archenteron which opens to outside through blastopore
- Blastopore has a circular rim - lip
- P.notochord lie in the dorsal lip
- P.mesoderm lie in the ventro lateral lip

- *2. Involution – rolling in* of notochord
- *3.Covergence-* mesoderm converge towards ventro lateral lip and involute in
- *4.Epiboly-* Proliferation of ectodermal cell over the entire gastrula

Antero posterior elongation

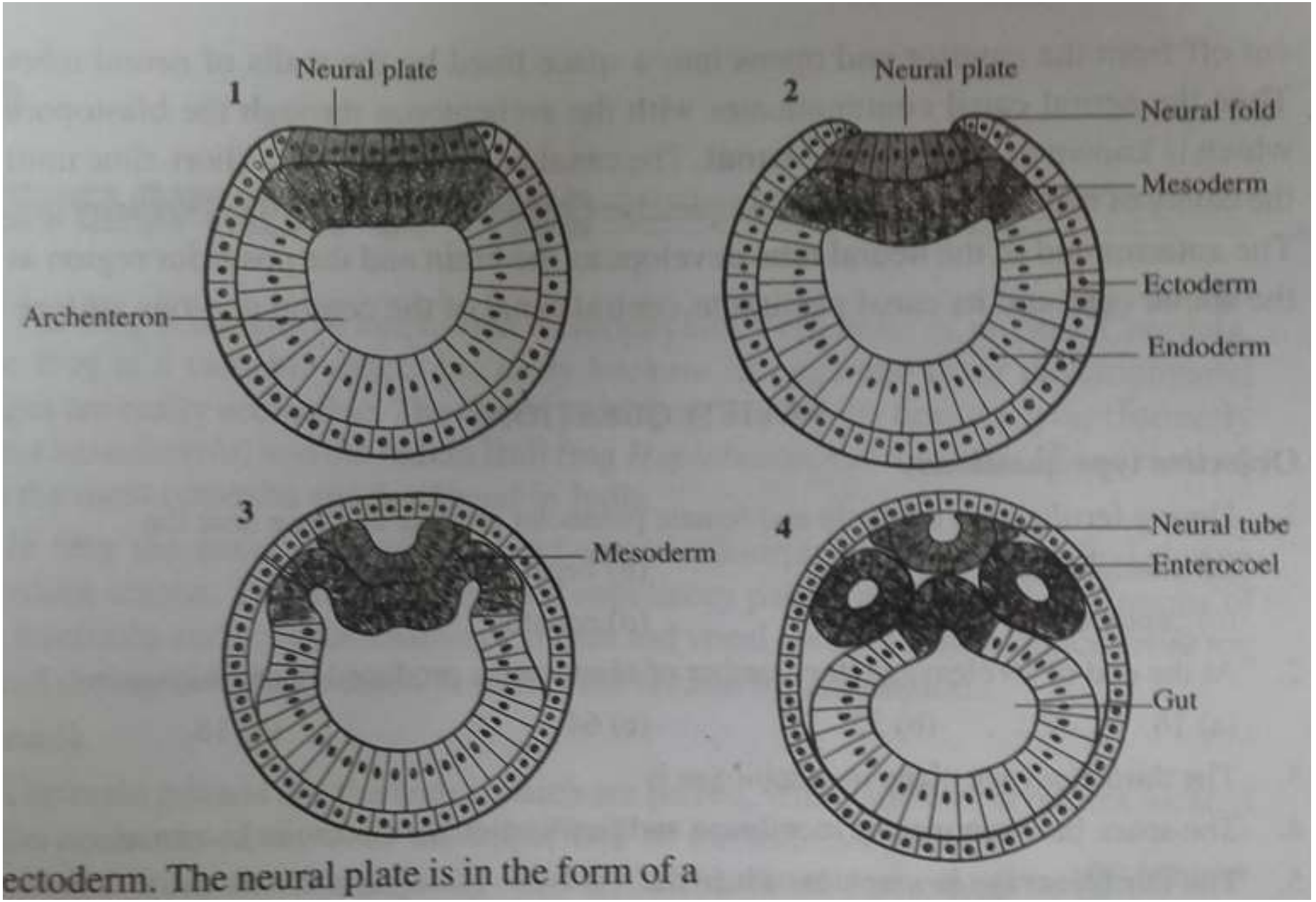
- Notochord – long median band
- Mesoderm- two horns on either sides of notochord

Ectoderm

- ***Neurectoderm*** -elongate into a median band above notochord
- ***Epidermal ectoderm -*** cover the rest of the gastrula

NEURULATION

- 1.Neurectoderm thickens to form neural plate.
- 2. Neural plate sinks down
- 3. Edges of neural plate rise up as neural folds
- 4.Neural folds meet and fuse in the mid line
- 5. Neural tube transformed into neural tube
- 6. The opening of the neural tube at the anterior end is called neuropore.



ectoderm. The neural plate is in the form of a

Neurulation Contnd--

- The ectoderm spread over the blastopore and cuts off the blastopore from exterior and open into a space lined by neural tube
- The canal which connects the archenteron with the neural tube is called neurentric canal. This canal persists till neural tube is completely separated from archenteron.

Notogenesis

- P. Notochord separated from mesoderm
- Edges of P. notochord bent down to form cylindrical rod like notochord
- Cells of notochord –disc shaped, vacuolated surrounded by fibrous sheath

FORMATION OF MESODERM AND COELOM

- Longitudinal groove appear on the mesoderm on either sides
- Groove deepen and the edges meet to produce mesodermal pouches
- Transverse constrictions appear in the mesodermal pouches dividing them into series of enterocoelic pouches. These are later called mesodermal somites

DEVELOPMENT OF FROG

- Eggs- 1.75-2 mm in diameter, mesolecithal, moderatly telolecithal.
- The egg is surrounded by vitelline membrane and 3 layers of jelly coat.
- The egg cytoplasm has 2 regions- cortex & endoplasm
- Cortex is viscous & contain cortical granules close to plasma membrane
- The egg has definite polarity with dark coloured pigments at animal hemisphere & whitish vegetal hemisphere
- Endoplasm contain mostly mitochondria, ribosomes& Yolk platelets

Fertilization

- External
- Egg at metaphase II of secondary oocyte state
- At the point of contact at animal pole –cortical granules burst
- vitelline membrane is lifted to form fertilization membrane/fertilization cone which engulf the sperm head with middle piece

Events during fertilization

- Swelling of jelly coat
- Activation of egg & release of 2nd polar body
- The initial course of sperm – penetration path with pigment trail
- Copulation path- ends up with amphimixis
- Establishment of bilateral symmetry & formation of gray crescent

Establishment of bilateral symmetry

- Radial symmetry changed to bilateral symmetry
- At the equator region cortical layer rise to animal pole (future dorsal region) and move down in the vegetal pole region(future ventral region) .
- This results in the exposure of a crescent shaped light coloured marginal cytoplasm-gray crescent

Gray crescent- significance

- gray crescent- at the opposite point of sperm entry
- This becomes the median plane of symmetry and changes radial symmetry to bilateral symmetry
- Represents future side of formation of dorsal lip of blastopore.
- This region becomes the posterior side of the embryo.

Cleavage

Holoblastic unequal

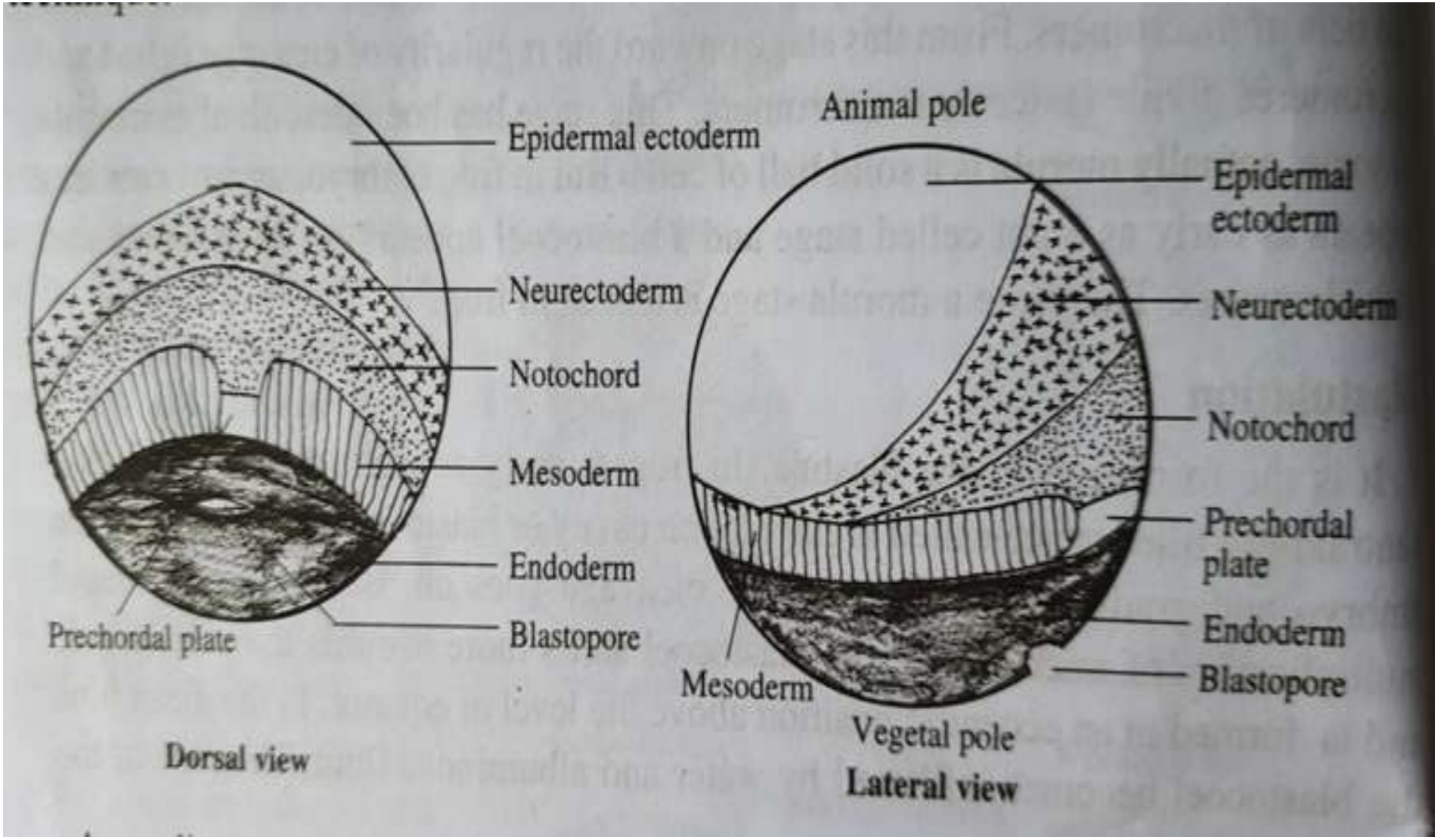
- 1st Cleavage- Meridional with equal distribution of gray crescent and takes about 30 minutes to complete
- 2nd cleavage- Meridional , right angles but unequal distribution of gray crescent
- 3rd Cleavage-lattitudinal- 4 micromeres& 4 macromeres are produced
- 4th Cleavage-Meridional & double
- 5th Cleavage- lattitudinal & double
- 6th Cleavage onwards irregular micromere divide faster than macromeres

BLASTULATION

- Blastocoel appear in 8 celled stage and shifted to animal pole due to rapid dividing of micromeres.
- Blastula – unequal coeloblastula with eccentric blatocoel , roof occupied by micromeres and floor by macromeres

FATE MAP

- Chart showing the fate of each part in the blastula with the help of vital stains
- Proposed by Vogt
- 3 areas
- 1.Prospective ectoderm area
- 2.P. Notochord & mesoderm area
- 3. P.endoderm area


Epidermal ectoderm
Neurectoderm
Notochord
Mesoderm
Endoderm
Blastopore
Prechordal plate
Dorsal view
Animal pole
Epidermal ectoderm
Neurectoderm
Notochord
Prechordal plate
Endoderm
Blastopore
Mesoderm
Vegetal pole
Lateral view

P. ECTODERM AREA

- Pigmented area on and around the animal hemisphere , also called zone of expansion
- Contain Epidermal and Neuro ectoderm
- Both contain sub areas also for nose, ear etc.

P. NOTOCHORD & MEODERM AREA

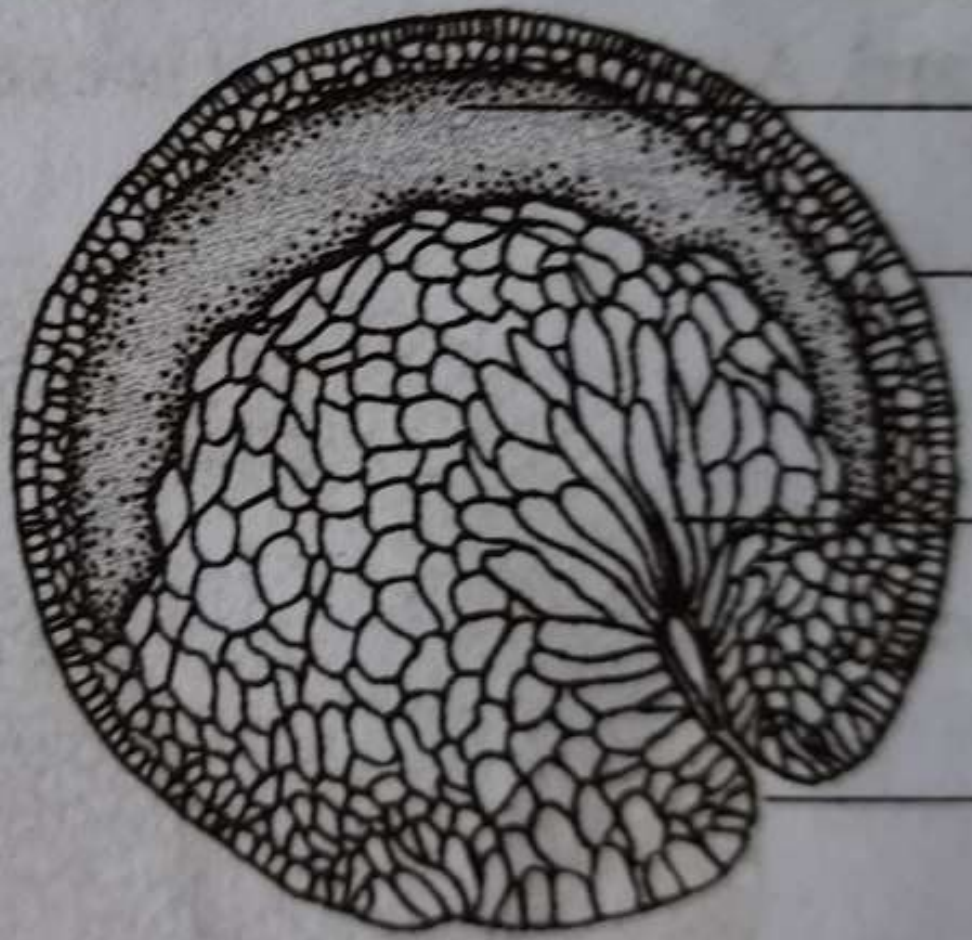
- Crescentic area below ectoderm also called zone of involution
- Notochordal cells occupy dorsal surface of the crescent
- Below it a strip of prechordal cells- give rise to head mesoderm
- Venreo-lateral sides- mesoderm
- Area on both sides of notochord give rise to somites

P.ENDODERM AREA

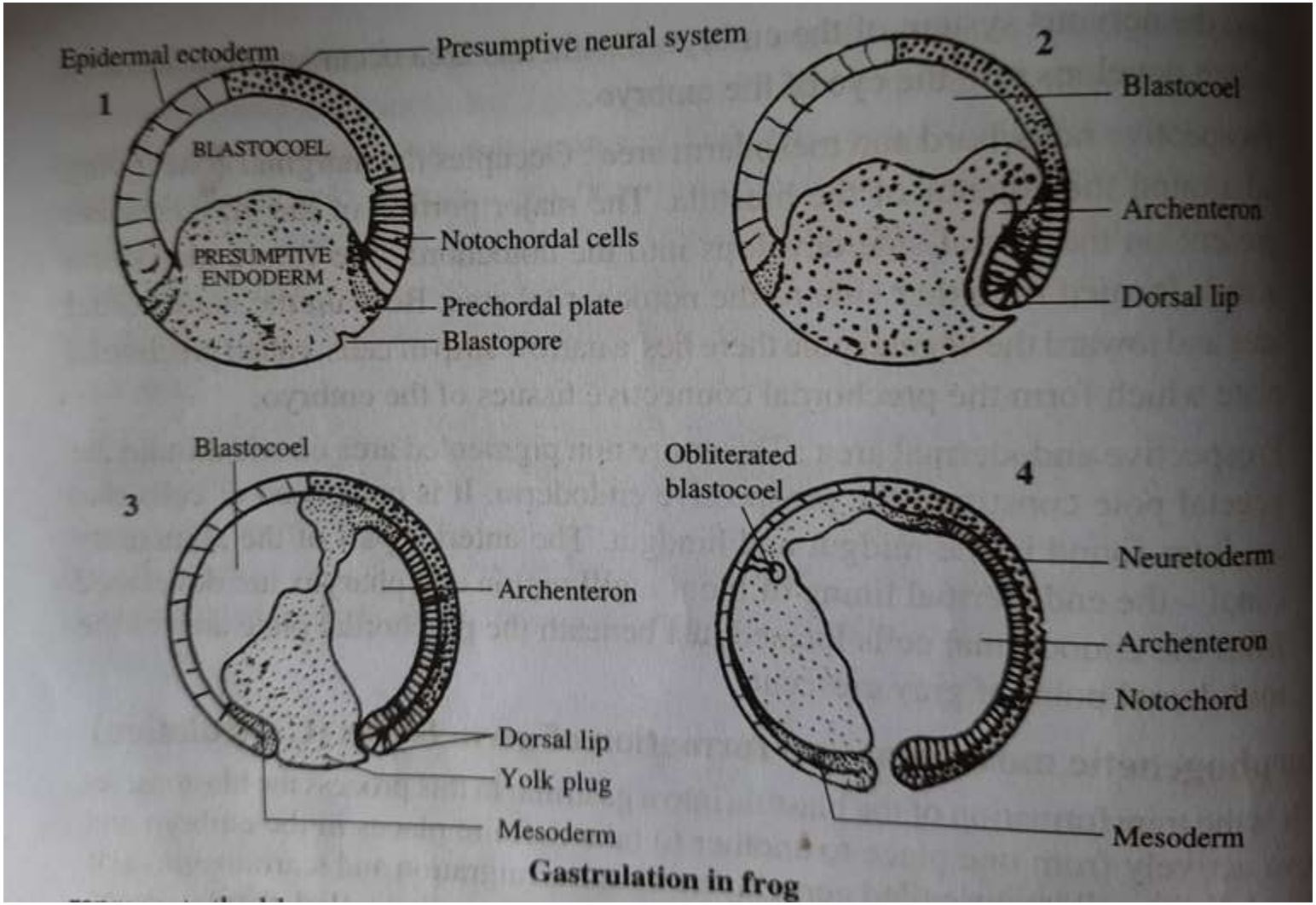
- Non pigmented area around vegetal pole
- Also called zone of invagination
- Develop into dig.sytem, liver, pancreas, urinary bladder etc.

GASTRULATION

- Initiated at grey crecent region just below the equator
- Begin with invagination of prospective endodermal area to form a slit like blastopore.
- During invagination the endodermal cells attain a bottle shape



Invagination of endodermal cells



Gastrulation in frog

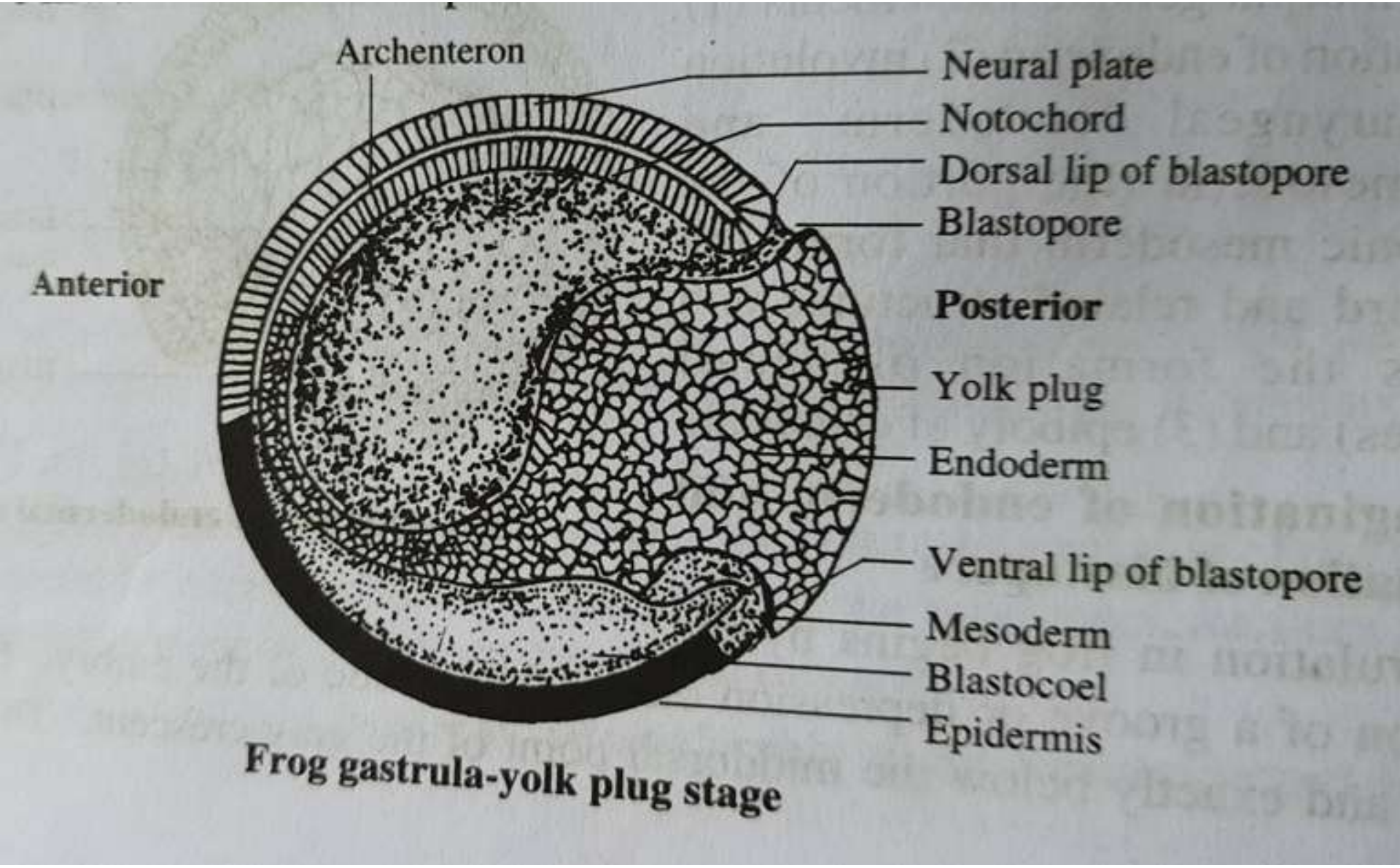
Involution

- *1.*some endoderm cells involute through the dorsal surface of blastopore which later become pharyngeal cells of the foregut.
- 2. Then Head mesoderm & chorda mesodermal cells through the dorsal lip of the blastopore
- Blastopore attains lateral and ventral lips and assumes a circular shape.
- It enclose yolky endoderm and this endoderm projecting out through the circular rim of blastopore is called yolk plug.

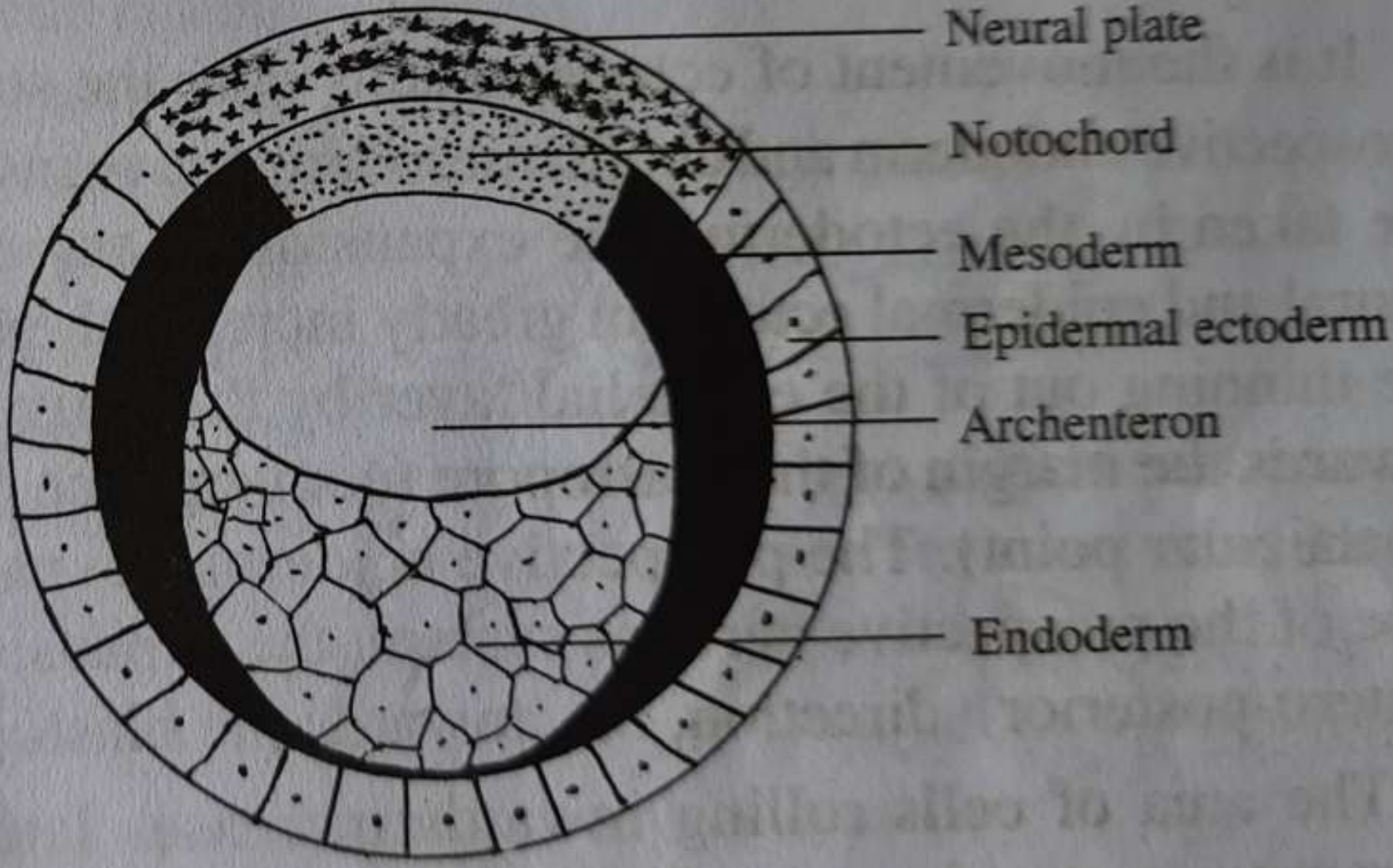
Epiboly

- Rapid proliferation of ectodermal cell over the entire gastrula shifting blastopore to ventral side.
- Neurectoderm expands in longitudinal direction towards blastopore
- Epidermal ectoderm spreads all around and converge towards blastopore
- Yolk plug is withdrawn by contraction of the lips of the blastopore and it gets closed.

- Archenteron expands in all directions
- Blastocoel is shifted antero ventrally and reduces into gastrular slit .
- Gastrula
- Outer layer of ectoderm
- Inner layer of chordamesodermal cells and endoderm

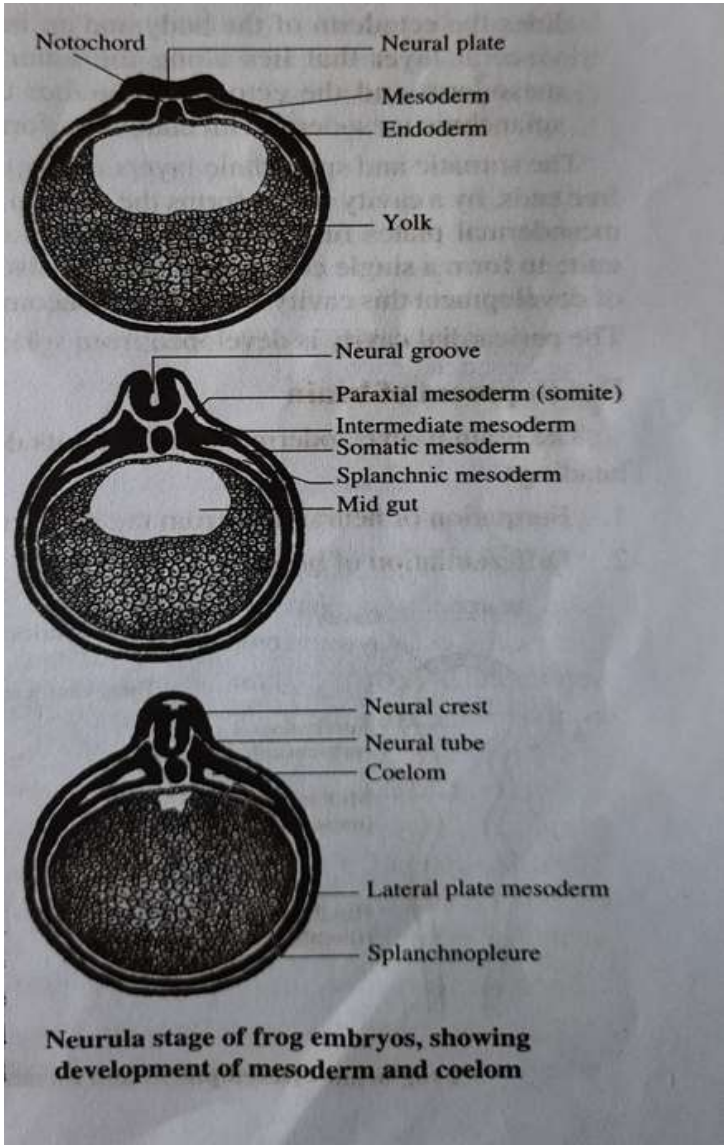


Frog gastrula-yolk plug stage

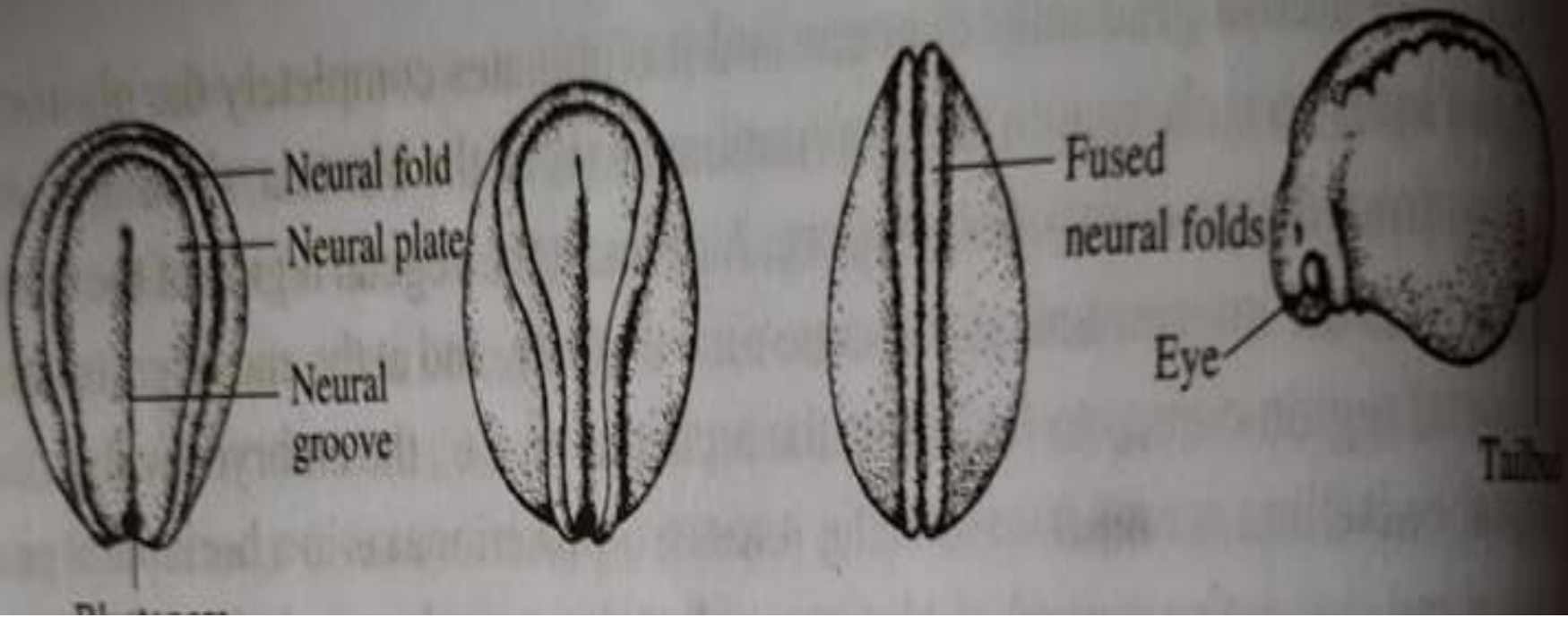


Frog - C.S. of gastrula

Neurulation



Neurula stage of frog embryos, showing development of mesoderm and coelom


Neural fold
Neural plate
Neural groove
Fused neural folds
Eye

Chordagenesis

- Notochord develops from chordamesoderm which lie as a long median chordamesoderm mantle in the roof of the archenteron
- Later the chordamesodermal mantle delaminates into the prechordal plate in the middle with the somatic mesoderm on the sides. The prechordal plate cells expands and arrange themselves into a cylindrical rod.
- Later become vacuolated, elastic with a fibrous sheath around it called notochordal sheath.
- Lengthening occurs by the swelling of the notochord cells in the long axis within the fibrous sheath .

FORMATION OF MESODERM AND COELOM

- The mesoderm on either side of the notochord will grow downwards between ectoderm & endoderm and meet together below the gut.Later it subdivided into somites
- Each somite has three parts

1. Epimere/dorsal mesoderm
2. Intermediate mesoderm/nephrotome
3. Ventral & lateral plate mesodem

Epimere/dorsal mesoderm

- lie on either side of notochord
- Outer layer thin dermatome – develop into dermis
- Inner layer thick myotome- develop into skeletal muscles
- Space between these two- myocoel
- Mesenchyme cells separates from somite lying next to the notochord form sclerotome which later become the part of the vertebral column.

Nephrotome

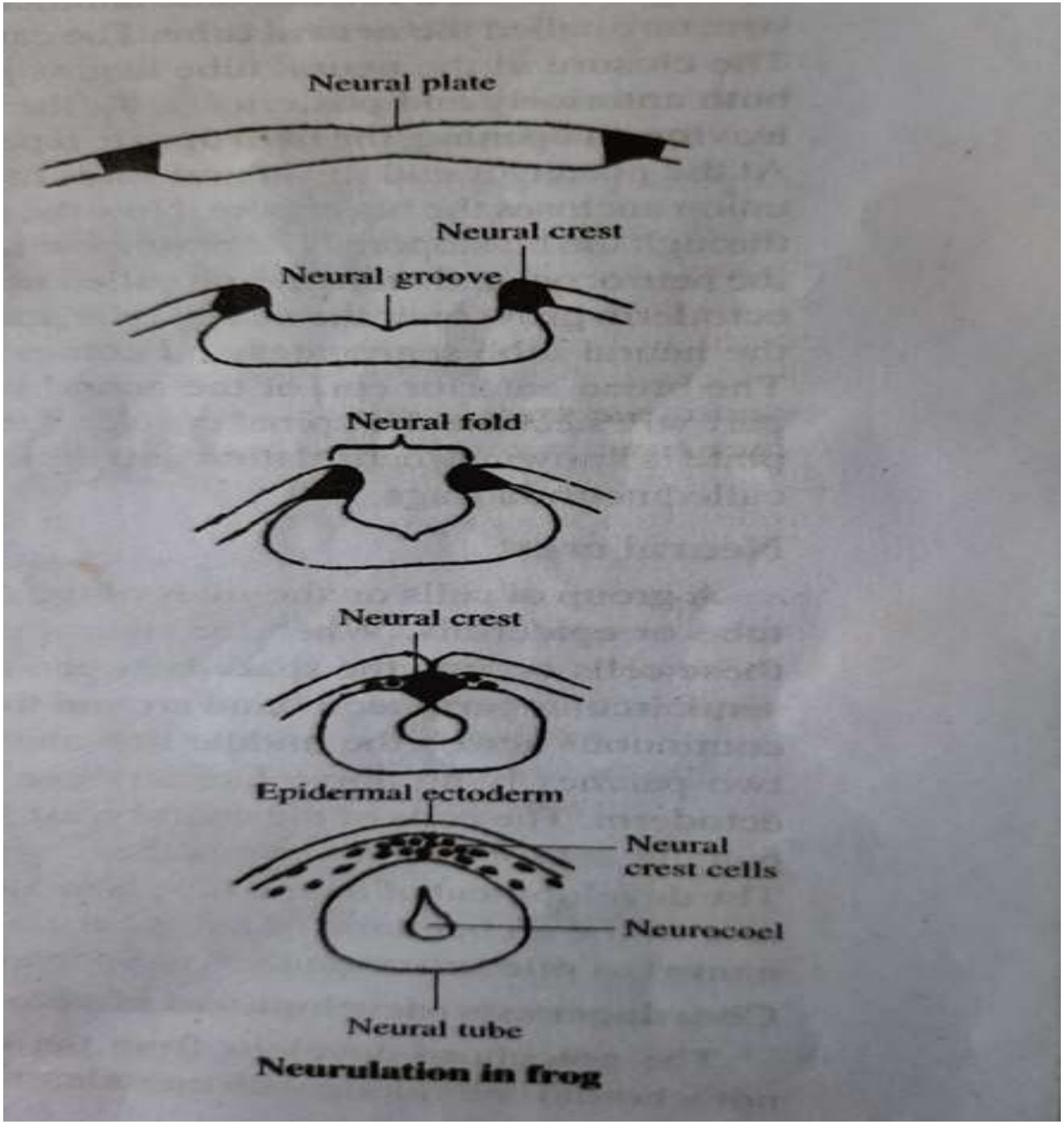
.

- Seen on either side of the somites –develop into kidney

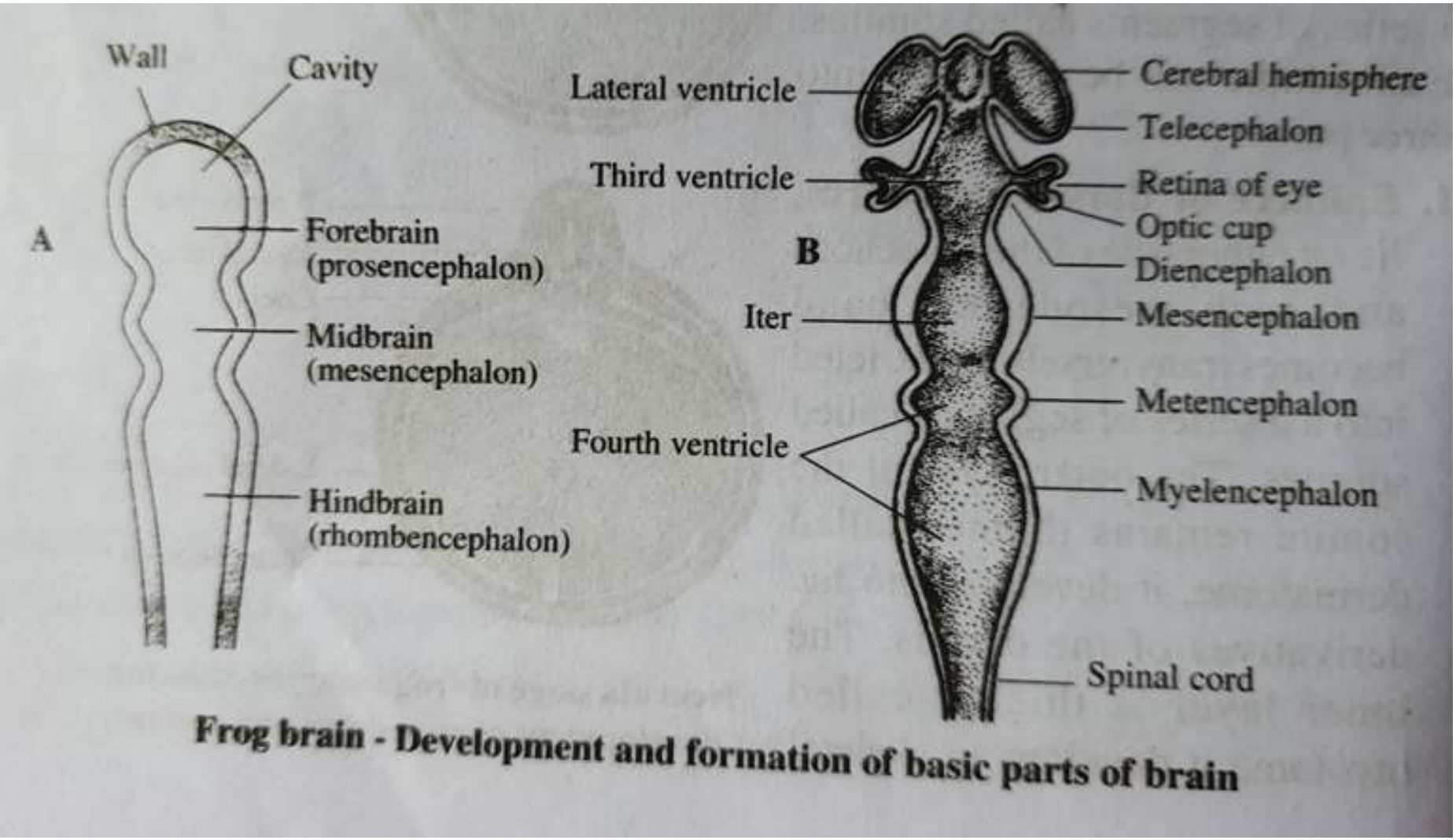
Ventral & Lateral plate mesoderm/ Hypomere

- Lie lateral to nephrotome.
- Two layers- Outer layer adjacent to ectoderm- somatic mesoderm/Parietal layer
- Inner wall adjacent to endoderm- splanchnic mesoderm/visceral layer
- Ectoderm+ somatic mesoderm- somatopleure
- Endoderm+ splanchnic mesoderm- splanchno pleure

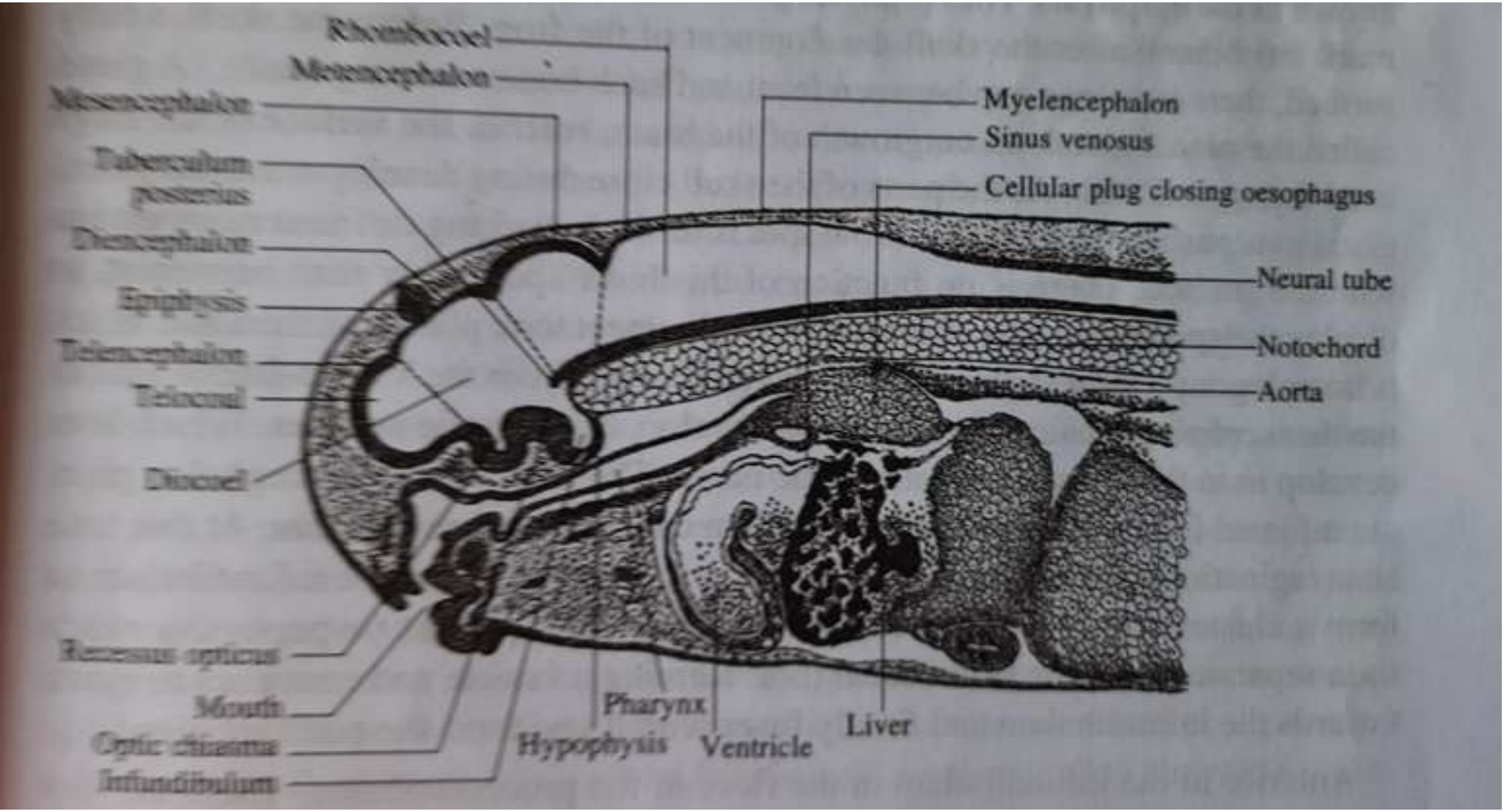
- The cavity within the somatic & splanchnic layers unite to form a single continuous cavity /coelom/splanchnocoel. with the fusion of two lateral mesodermal plates below the gut. The coelom becomes the body cavity of the adult animal & the pericardial cavity is developed from this.



Neurulation in frog



Frog brain - Development and formation of basic parts of brain


Rhombocoel
Metencephalon
Mesencephalon
Tuberculum posterius
Diencephalon
Epiphysis
Telencephalon
Telocoel
Diocoel
Recessus opticus
Mouth
Optic chiasma
Infundibulum
Pharynx
Hypophysis
Ventricle
Liver
Myelencephalon
Sinus venosus
Cellular plug closing oesophagus
Neural tube
Notochord
Aorta

DEVELOPMENT OF BRAIN

1. Formation of neural tube
2. Differentiation of brain

Differentiation of brain- Takes place from the anterior end of the neural tube.At the anterior end, the floor of the brain undergoes bending called cranial flexure.

Floor - tuberculum posterius –posterior limit of forebrain

Roof- Dorsal thickening-

- Brain is differentiated into Forebrain, mid brain & hind brain

Forebrain (Procencephalon)

Lamina Terminalis - anterior limit of forebrain

Tuberculum posterius –Posterior limit of forebrain

1.Telencephalon

2.Diencephalon

Telencephalon

- Lateral pouches – Telencephalic pouches- cerebral hemisphere
- Cavity- Toelocoel/lateral ventricle
- Toelocoel communicate with diocoel below through foramen of Monro and communicate with olfactory ventricles/rhinocoel
- Roof & Dorso lateral walls –coretx/pallium
- Floor& ventro lateral sides- Corpora Striata

Diencephalon

- Cavity- Diocoel/Third ventricle
- Roof– Non nervous forms folded finger like processes –anterior choroid plexus
- Behind it another finger like evagination- Epiphysis- which grow into browspot
- Ventro lateral walls- Optic vesicles develop- retina & optic nerve
- Floor- Infundibulam . To it later fuses hypophysis which develop as a cluster of cells (Rathke's Pocket) from stomodaeum

- Two thickenings in front of the infundibulam
- Anteroir – Torus Transversus
- Posterior- Optic Chiasma within it optic nerves cross
- Ridge between these two thickenings- Optic recess

Mid brain(Mesencephalon)

- Cavity- Mesocoel- narrowed to form Iter/aqueduct of sylvius. Connects 3rd & 4th ventricles
- Dorso lateral walls-optic lobes/corpora bigeminata
- Floor & sides – tract of gray matter- Crura cerebri

Hind brain (Rhombencephalon)

- Demarcated by a constriction
- Cavity- 4th ventricle/rhombocoel
- Roof-Transverse thickening -cerebellum
- Behind it non nervous & vascular area- Posterior choroid plexus
- Ventro lateral walls- medulla oblongata

DEVELOPMENT OF EYE

- Develops as a pair of ventro lateral evaginations (Optic vesicles) from diencephalon
- Cavity of Optic vesicles-optocoel
- Stalk of optic vesicles-optic stalk
- Optic vesicles pushes the lateral Head epidermis and induces it to form lens placode
- Optic vesicles invaginate to form double walled optic cup/secondary optic vesicle and finally converted into a double walled groove- choroid fissure through which blood vessels enter.

- Inner & outer walls of optic cup develops into edges of pupil- Iris.
- The pigment granules develop in the external thin layer of optic cup forms pigmented layer of retina.
- Inner thick layer becomes nervous layer of retina and fibres of the nerve cells come out of the eye ball as optic nerve

- Lens placode- invaginate to form a cup like structure- later pinched off to form lens vesicle and lie within the ring of the optic cup supported by suspensory ligaments. The free edges of ectoderm extends over the lens vesicle and in association with head mesoderm form cornea
- Cell of this undergo cytodifferentiation to form solid lens.

- Mesenchyme cells form the middle layer – choroid coat of eye ball and a tough scleroid coat around the eye.

Chambers

- 1.Aqueous chamber- between Iris & cornea filled with Aqueous humour(which is actaully produced in V.chamber)
- 2.Vitreous chamber- between Iris & lens filled with Vitreous humour- maintains shape of the eye.

- Eyelids and nictitating membrane develops later
- Inner epithelial layer of eyelid form conjuctiva which fuse with cornea.

Hormonal Control of Amphibian Metamorphosis

- It is a genetically determined programme and include 4 processes
- Growth, Death of certain tissues, remodelling & respecification
- Initiated by Thyroxine (T4) and Triiodo Thyronine (T3) reaches larval organs through blood increases the synthesis of RNA & protein to increase the tissue response.
- Experimental observation of the influence of the hormones on metamorphosis was done by Gundernatsch (1912)

Experiments

- 1, Fed the tadpoles with dried and powdered thyroid glands- showed precautious development
- 2.Thyroid gland rudiment was removed in embryos- failed to metamorphose but became large larvae
- 3.supplied Thyroid hormone to thyroidless larvae –metamorphosed normally.

Hormonal Regulation

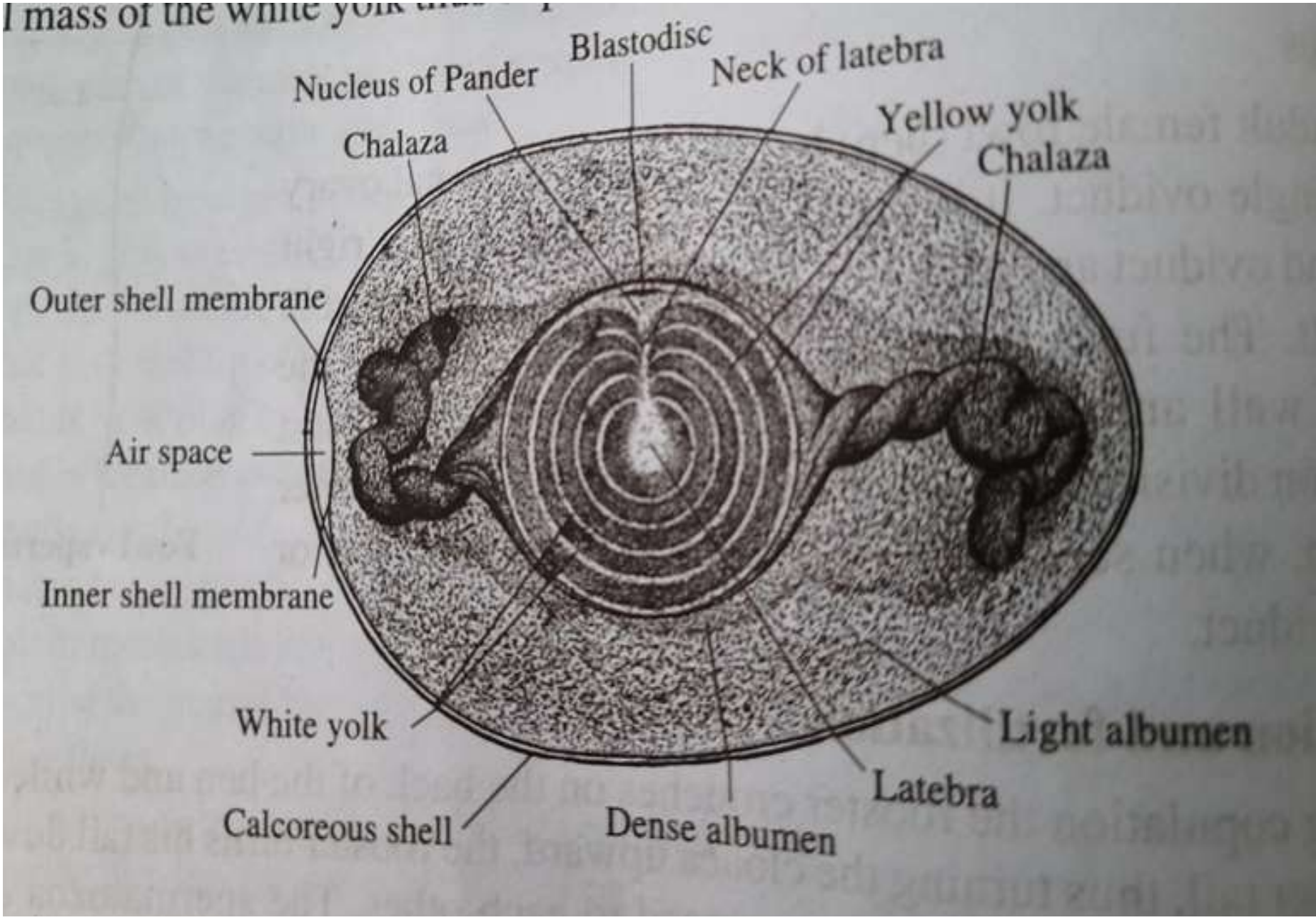
- 3 endocrine glands are involved
- 1 Thyroid
- 2. Hypophysis
- 3.Hypothalamus
- Neurosecretory cells of hypothalamus secrete Thyrotropic hormone Releasing Hormone (TRH)/TRF/Thyrotropin
  TRF stimulate ant. Pituitary gland to release Thyroid Stimulating Hormone (TSH) and inhibits Prolactin secretion by prolactin releasing inhibiting hormone
  TSH act on thyroid gland to stimulate secretion of thyroid hormones to bring about metamorphosis.

DEVELOPMENT OF CHICK

Structure of Egg

- 3-5cm broad , 5-7cm long. Macrolecithal & Extremely telolecithal.
- Definite Polarity.
- The egg cytoplasm with nucleus seen in animal pole & is called blastodisc.
- Other regions are filled with yolk.

White yolk is formed first in the cytoplasm around the nucleus & it is called latebra


Blastodisc
Nucleus of Pander
Neck of latebra
Chalaza
Yellow yolk
Chalaza
Outer shell membrane
Air space
Inner shell membrane
White yolk
Light albumen
Latebra
Calcoreous shell
Dense albumen

- Yellow yolk is formed in concentric & alternate rings around latebra
- Later nucleus moves to periphery leaving a path of white yolk- neck of latebra which form plate like area called Nucleus of Pander.
- The other egg membranes seen surrounding the egg are
- 1. Vitelline Membrane
- 2. Albumen
- 3.Shell membrane-s eparated by air space at the broad end –help embryo to breath
- 4. Shell-porous-helps in exchange of gases

albumin

- 85%Water & 15%Proteins
- Inner layer- viscous, thick & spirally twisted – Chalazae- keep blastodisc always up
- Middle layer –thick ,secreted by oviduct
- Outer layer –thin , secreted by uterus

Functions

- *Nourishment, protection, moisture*

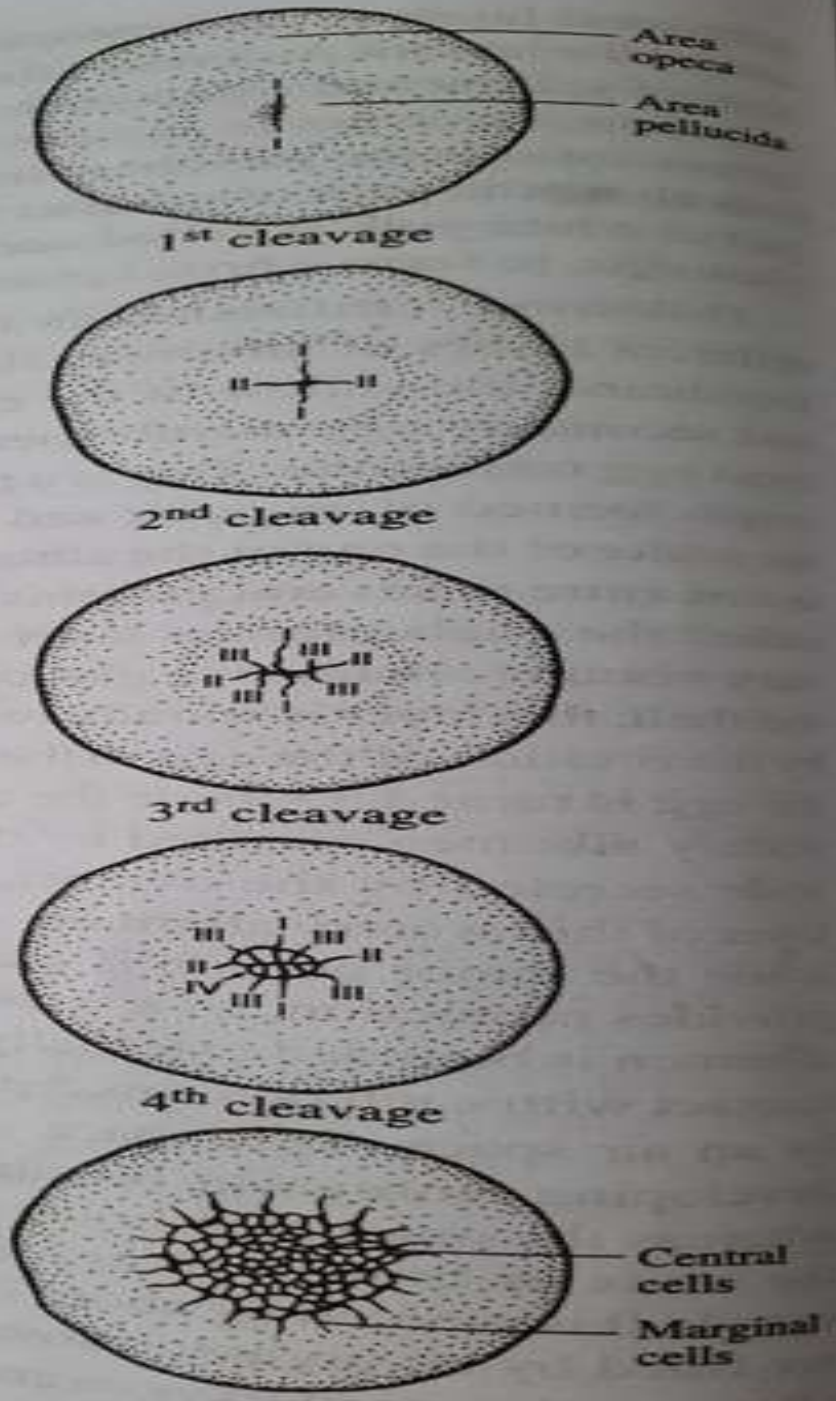
Yolk

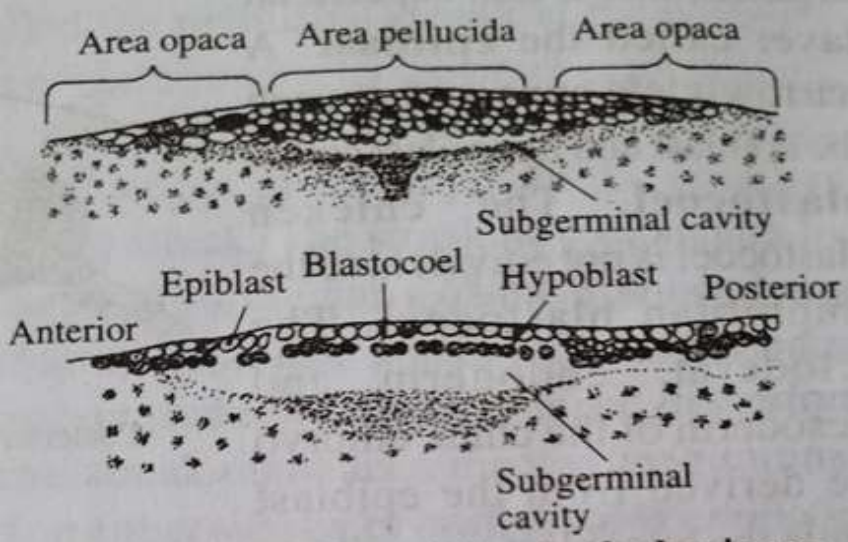
- Carbohydrate- 1%- glucose, polysacharides
- Protein -16.6%- Phosvitin, Lipovitelline
- Fat-32.6%- Phosphatids, Cholesterol
- Water-48.7%
- Vitamins-A,B,B_6,D,E

Cleavage

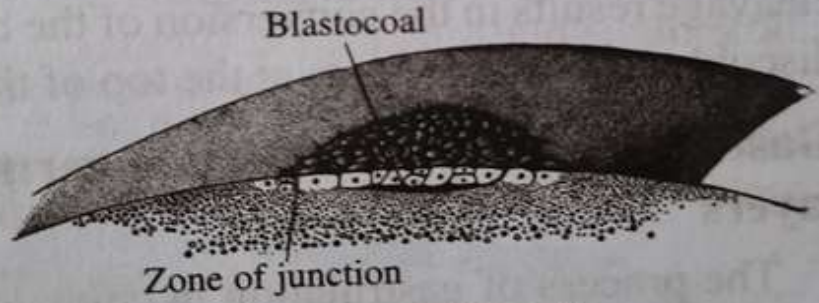
Partial / meroblastic discoidal results in central mass of dividing cells & marginal zone /periblast

- 1st Clevage- Meridional
- 2nd cleavage- Meridional , right angles
- 3rd Cleavage- vertical & parallel
- 4th Cleavage- vertical & circular- central & marginal cells are formed.
- 5th Cleavage- onwards irregular, rapid. Central cells detach from central yolk forming a cavity- blastocoel in between

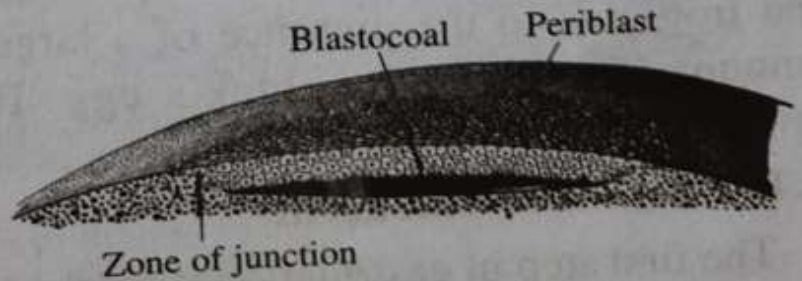




Cleavage and blastulation in the hen's egg



Early blastula



Late blastula

DISCOBLASTULA

- The outer area of the blastula – Area opeca
- The central area- Area pellucida
- Yolk laden large blastomeres form hypoblast which give rise to primordial germ cells & extra embryonic endoderm
- Poorly yolk laden small blastomeres form epiblast which give rise to ectoderm,endoderm& mesoderm
- Blastocoel appear between hypoblast & Epiblast

GASTRULATION

1. *Formation of Endoderm*

   Secondary hypoblast is formed due to the migration of cells from epiblast and gets transformed to endoderm

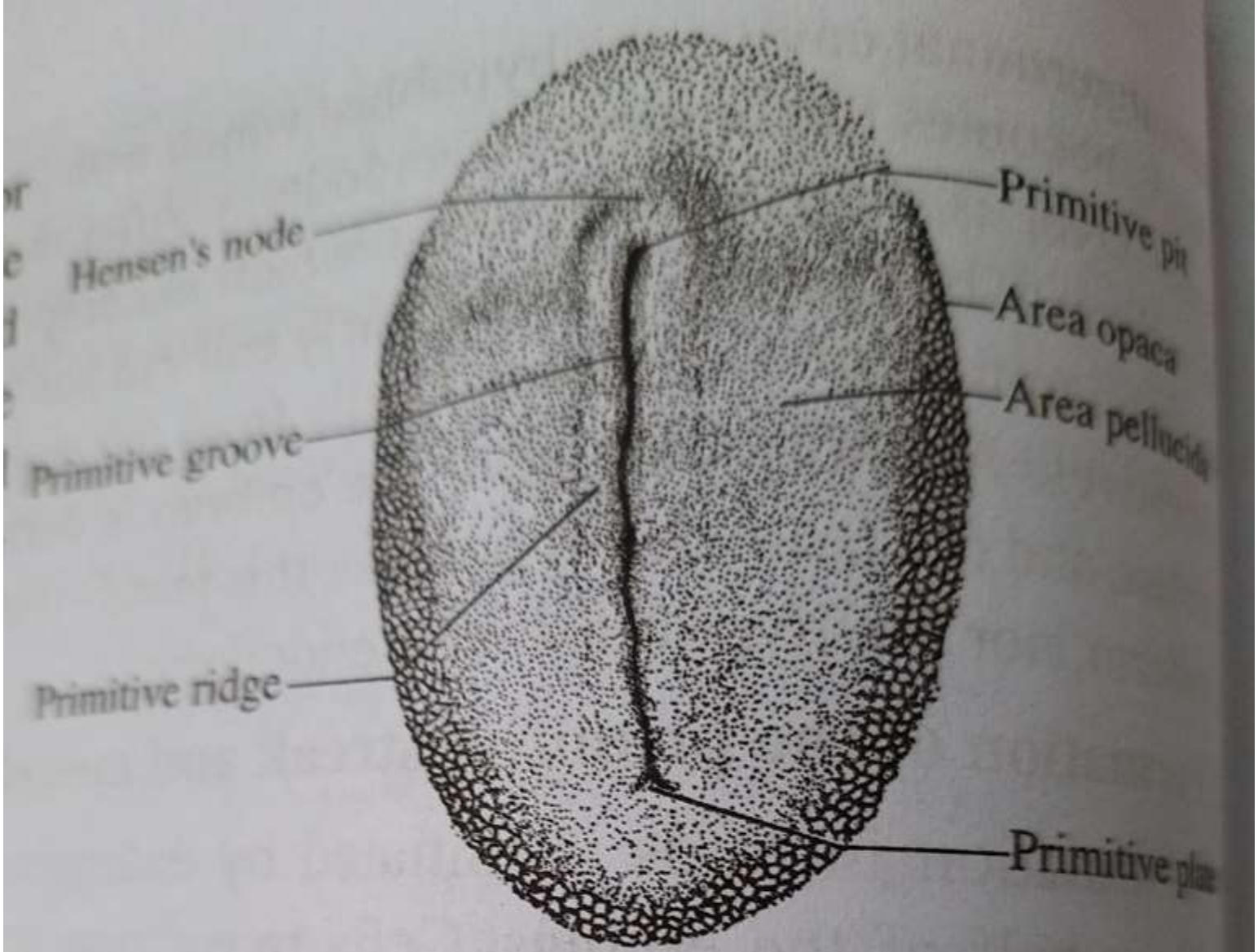
2. *Formation of Primitive streak & mesoderm*

   Takes place after 7-8hrs of incubation at the posterior end of the area pellucida of epiblast Initiated by the formation of solid ridge like P.S

   Short P.S → Definite/mature P.S (after 18-19hrs of incubation)

Structure of Primitive streak

- Primitive groove
- Primitive folds
- Hensen’s node/primitive knot embryo develops from infront of this
- Primitive pit
- Primitive plate



Chick embryo 18 hours of incubation

- The notochordal cells move forward from Hensen's node as a massive band - called Head process (also somatic mesoderm on either sides)– give rise to definitive notochord. By the time elongation of the primitive streak is completed.
- The involuted mesoderm cells lie between epibalst & hypoblast.
- The mesoderm free area anterior to primitive streak is called proamnion- Head is developed from this site.
- P.ectodermal cells undergo Epiboly.

- The primitive streak regress to a fragment in the tail bud after 22 hrs of incubation.
- The disappearance of P. streak indicates

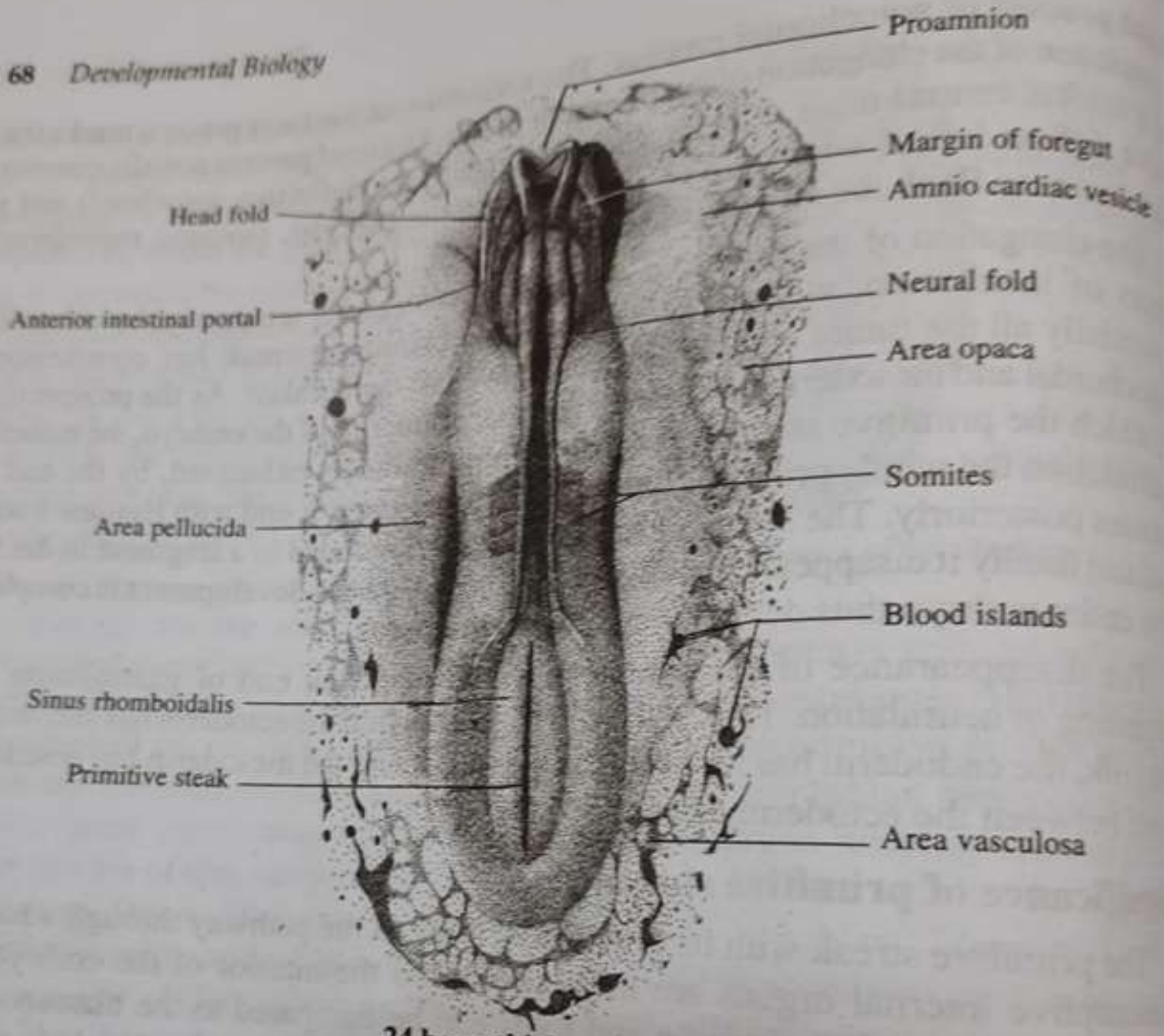
1. the completion of mesoderm devpt.
2. the completion of gastrulation
3. Beginning of Neurulation

Significance of Primitive streak

1. Equivalent of blastopore (except it is elongated & blastopore is circular) Hensen's node- dorsal lip
2. Site of gastrulation
3. anus develop from this site same case with blastopore
4. The first cells migrate through it become foregut
5. Unlike blastopore do not open to archenteron

24 hr chick embryo

- Gastrulation is completed
- Area opaca & Area pellucida are distinct
- 4 pairs of somites
- Neurulation begins
- Definitive notochord extends to proamnion as head process
- The anterior end of the embryo raised above the blastoderm as a crescentic fold called Head Fold.The space between head fold & blastoderm endoderm is folded to form the cavity of the fore gut called subcephalic pocket



24 hour chick embryo

- In area opaca aggregations of mesoderm seen as blood islands which later form blood vessels & blood corpuscles
- Area opaca dfifferentate into proximal Area Vasculosa & distal Area Vitellina
- Lateral plate mesoderm is developed which will split into somatic & splanchnic layers with coelomic cavity in between.
- Percardial cavity is formed from dilated ciliated chambers in anterior intestinal portal region and heart primordia develop from splanchenic mesoderm

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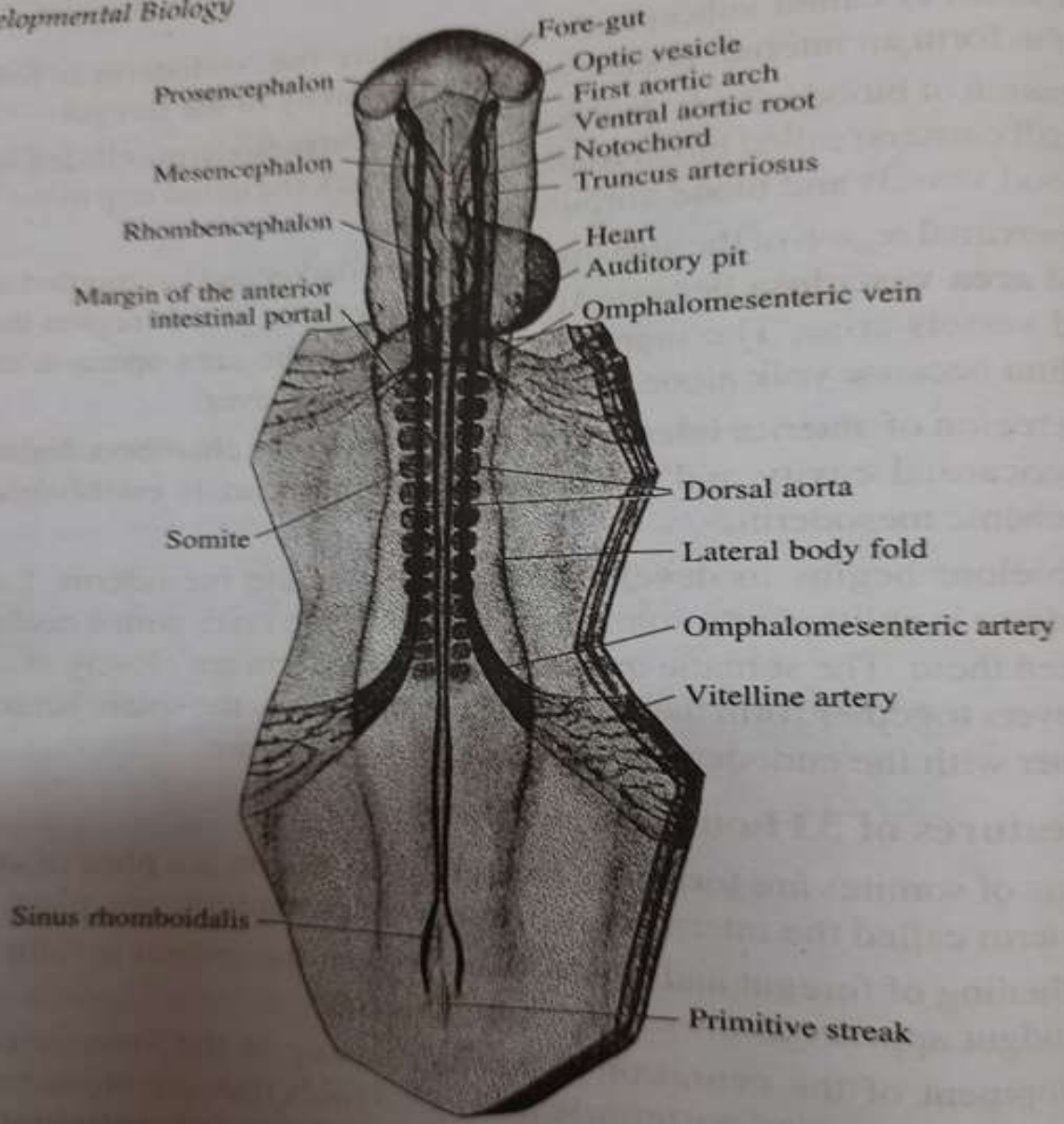
33 hr chick embryo

- 13 pairs of somites
- Primitive streak is disappearing
- Neural tube is well developed & differentiated into fore brain, mid brain & Hind brain with neuropore & flared out at posterior region which form sinus rhomboidalis.
- The neural crest cells are seen on either sides of neural tube
- From the lateral walls of procencephalon Optic vesicles are developed& from the floor infundibulm
- The fore gut & subcephalic pocket are elongated , mid gut & Hind gut also appeared



33 hour chick embryo

- Heart appear as a straight double tube slightly bent to right side at the mid ventral region of the fore gut.

  Intra embryonic & Extra embryonic blood vessels are connected to the heart. Anterior to foregut ventral aorta turn upward then backward as dorsal aorta and then pass onto extra embryonic area as omphalomesentric arteries. And also connected to

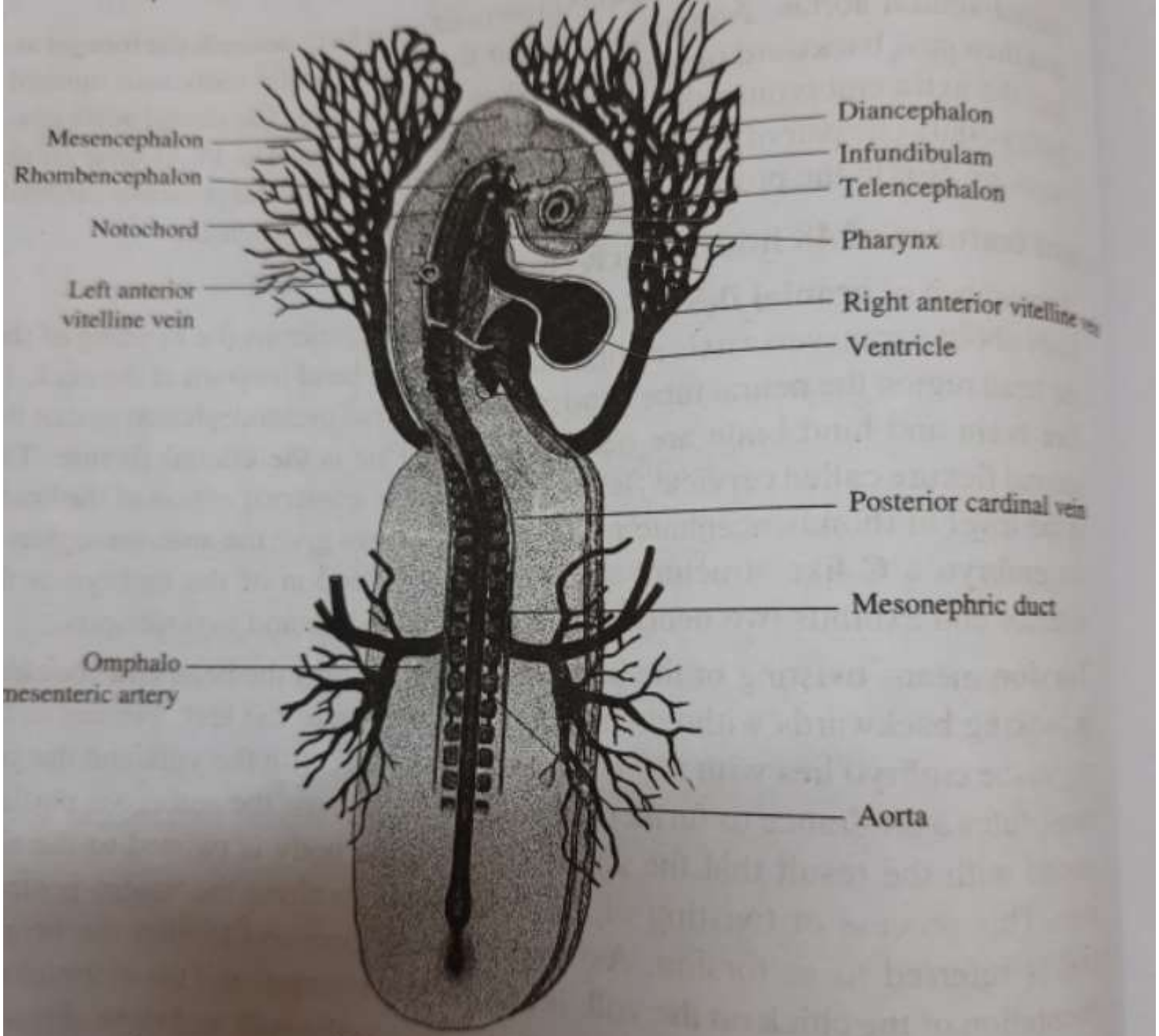
  a pair of omphalomesentric /vitelline veins

  One pair of aortic arches are seen connecting dorsal & ventral aorta .

- Area vasculosa is bounded by dark band which will develop into circular blood vessel called sinus terminalis.

48hr chick embryo

- 28 pairs of somites
- Cranial flexure at mesencephalon & Cervical flexure at rhombencephalon giving embryo ‘C’ shape. (characteristic of amniotes for space in devt)
- Torsion -leading to partial turn of the embryo with anterior part twisted to right side (characteristic of embryos developing on huge amt. of yolk)
- 11 neuromeres t the cephalic region-3+ 2+6
- Procencephalon divided into telencephalon & Diencephalon



48 hour chick embryo

- Rhombencephalon divided into metencephalon & Mylencephalon
- A pair of auditory & optic vesicles are developed. Optic cup & lens are also formed
- Pronephric kidney is formed
- Heart acquires ‘S’ shape & beat, blood flow starts
- 3 pairs of branchial grooves & 3 pairs of aortic arches develop.

- Intra embryonic blood vessels are developed - dorsal & ventral aorta, ant. & Post cardinal veins
- Devt of Extra embryonic/ Vitelline circulatory system is completed with omphalomesentric arteries, omphalomesentric /vitelline veins & sinus terminalis.
- Devt of Thyroid & liver
- Devt of 4 pairs of visceral pouches
- Devt of Infundibulam& Rathke's pocket
- Devt of extra embryonic membranes from somatopleure & splanchnopleure