DEVELOPMENT OF THE HEAD AND NECK

Placodes and the development of organs of special sense

L. Moss-Salentijn

PLACODES

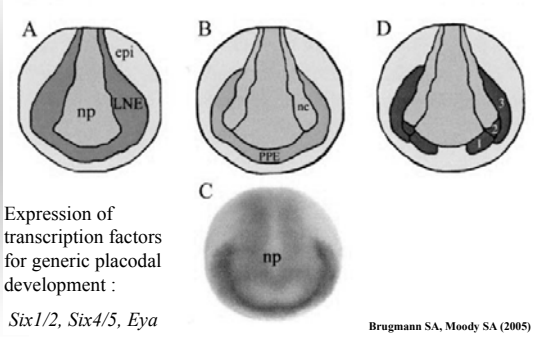
Localized thickened areas of specialized ectoderm, lateral to the neural crest, at the border between neural plate and the future epidermis

Placodes give rise to several evolutionary novelties in the "new heads" of vertebrates:

- Specialized paired sense organs. However, structures analogous to placodes are present in non-vertebrate chordates.
- Cranial placodes that will contribute to cranial ganglia of the branchiomeric nerves in pharyngeal arches.

Life in the Lower Cambrian Period

Panplacodal ectoderm

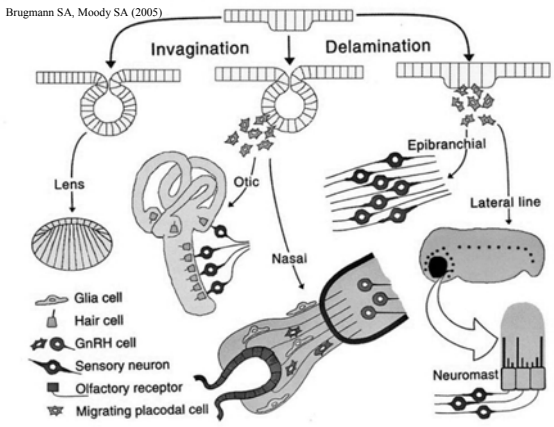


Expression of transcription factors for generic placodal development :

Six1/2, Six4/5, Eya

Brugmann SA, Moody SA (2005)

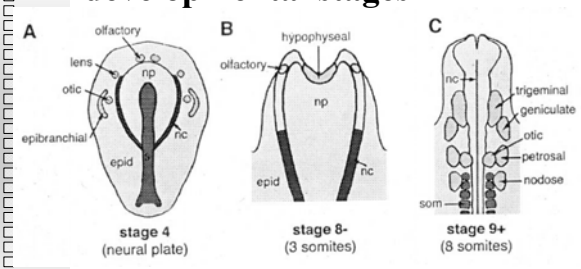
Brugmann SA, Moody SA (2005)



Different kinds of placodes

- Contributing to organs of special sense:
  - Olfactory
  - Lens (only placode that does not have neural fate)
  - Otic
- Contributing to distal ganglia of branchiomeric nerves:
  - Trigeminal (profundal + V 2/3)
  - Epibranchial (3)
- Hypobranchial (2) (contribute to hypobranchial ganglia - frog only; not in chick, mouse, zebrafish)

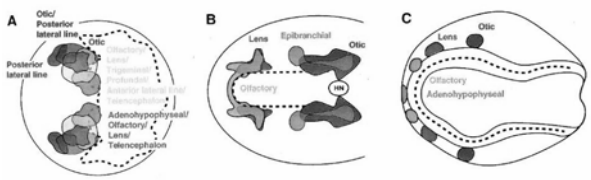
Distribution of placodes at 3 developmental stages



A. Initial induction of placodes in pre-placodal ectoderm field

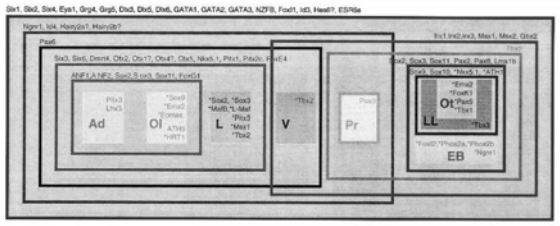
B. Olfactory placodal cells are incorporated in outer folds of anterior neural ridge

Fate maps of cephalic placodes in zebrafish, chick and salamander



Schlosser G (2006)

Transcription factor expression domains in panplacodal primordium



Schlosser G (2006)

Xenopus

Development of placodes: similarities

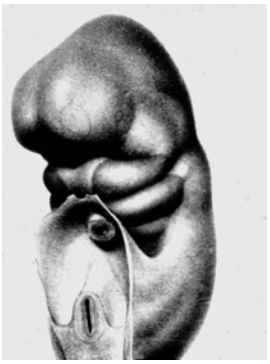
- Under influence of surrounding tissues – no evidence for role of neural crest in this process
- All express one or more members of Pax family as transcription factors early in development

Development of placodes - differences

- Epibranchial placodes: pharyngeal endoderm (BMP-7 signal), Pax2 and Sox3
- Ophthalmic placode of V: neurectoderm of mesencephalon (diffusible signal ?), Pax3
- Otic placode: initially axial and non-axial mesoderm, Pax 8; later hindbrain (FGF-3,-8,-10 signals), Pax2, Sox3, Notch
- Lens placode: forebrain & anterior mesoderm (BMP-4, later BMP-7 signals), Pax6, later Pax2
- Olfactory placode: anterior mesoderm (and forebrain? – no signal identified as yet), Pax6

Location of placodes (1)

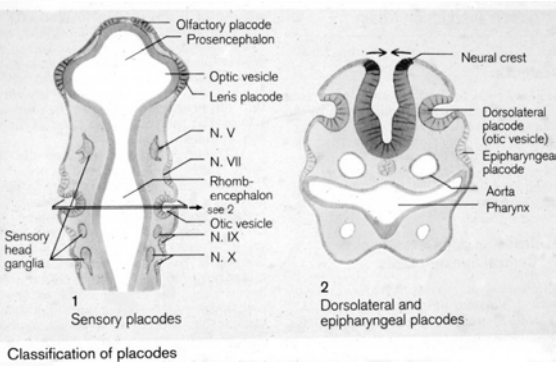
- *Near forebrain* :
  - Olfactory placode
  - Lens placode



Location of placodes (2)

- *Dorsolateral* :

  Otic placode: related to (= evolved from or having common origin with) lateral line system

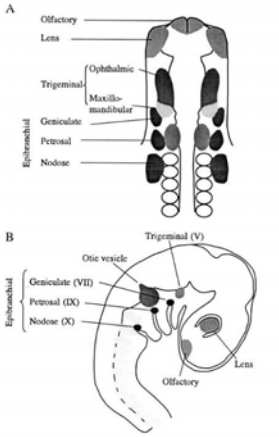


Classification of placodes

Location of placodes (3)

- *Intermediate* between otic placode and epibranchial placodes :

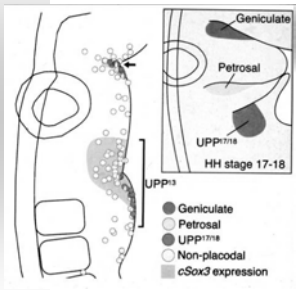
  Ophthalmic (profundal component) and trigeminal placode

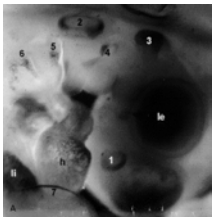


Streit A (2004)

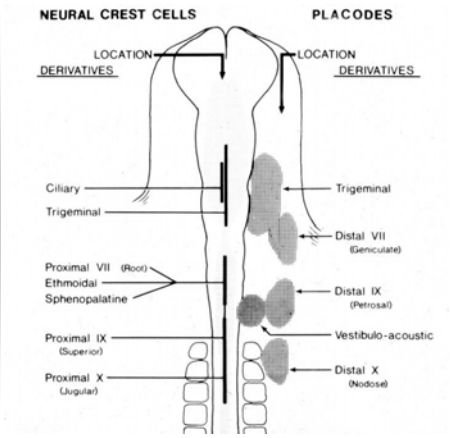
Location of placodes (4)

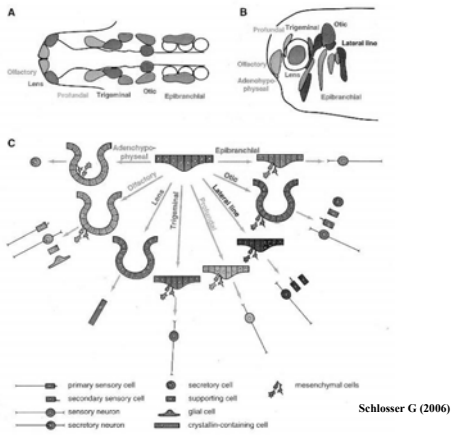
- *Epibranchial series* – dorsal ends of 2nd – 4th pharyngeal grooves
- *Hypobranchial series* in frogs – ventral ends of 2nd – 3rd pharyngeal grooves ?





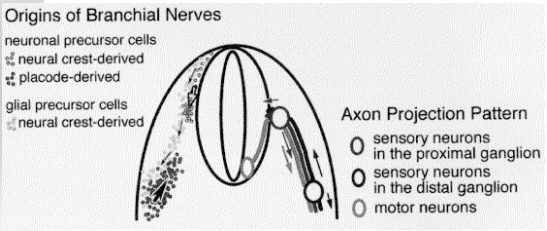
1. Olfactory
2. Otic
3. Trigeminal (V)
4. Facial (VII)
5. Glossopharyngeal (IX)
6. Vagal (X)



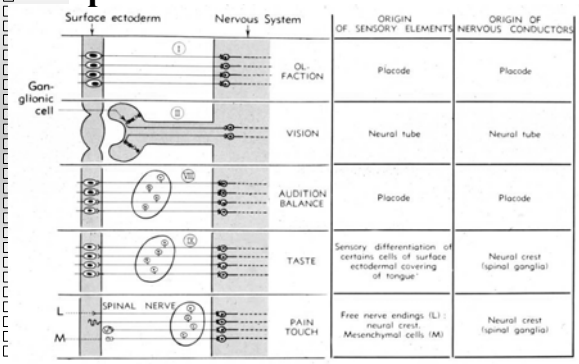


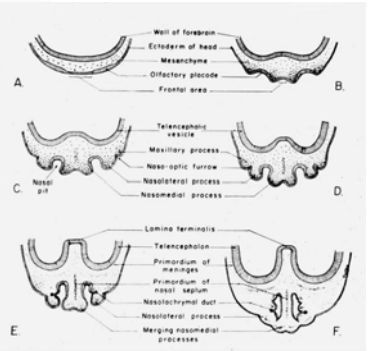
Schlosser G (2006)

Branchiomeric nerves: origins and axon projection patterns



Development of organs of special sense





Olfactory epithelium: development of the nose

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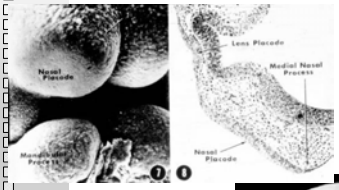
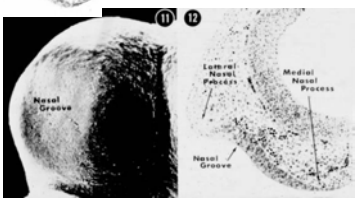
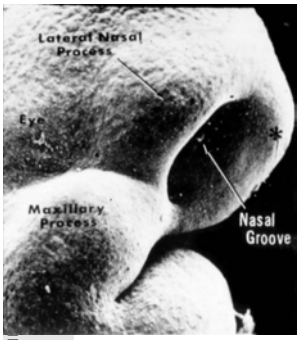
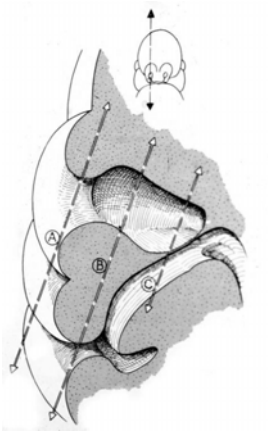
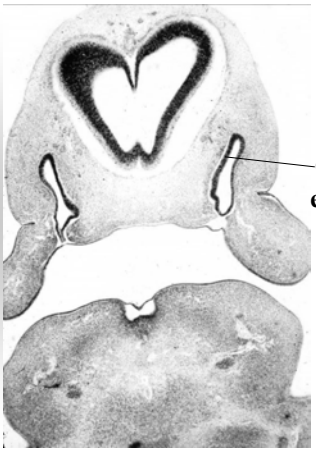


Transient pioneer neurons set up scaffold

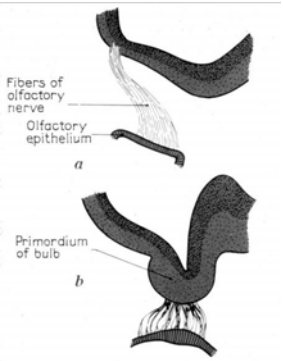






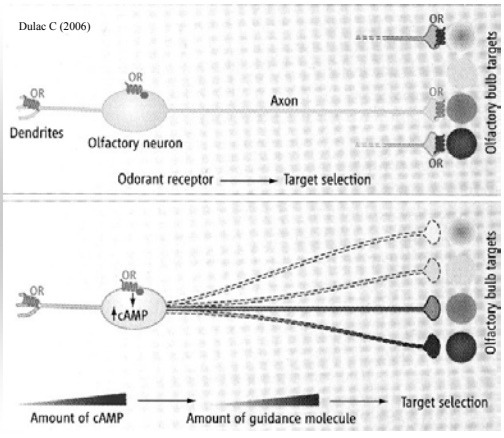


Olfactory epithelium



46-54 days

68-84 days



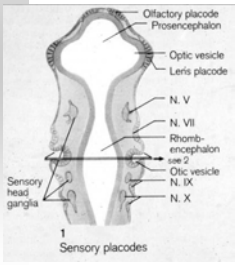
Olfactory placode gives rise to:

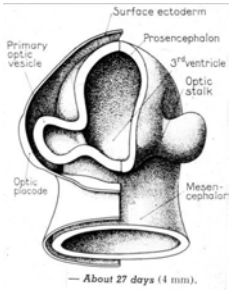
- Sensory receptor cells of olfactory epithelium of the nose (odorant sensing)
- Sensory receptor cells of vomeronasal epithelium (pheromone sensing)
- Basal cells and support cells (olfactory ensheathing cells - glia)

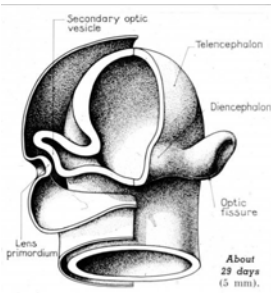
Development of the eye :

1. evagination of forebrain (optic vesicle)

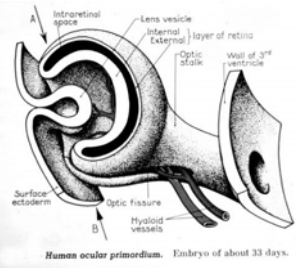
2. invagination of lens placode



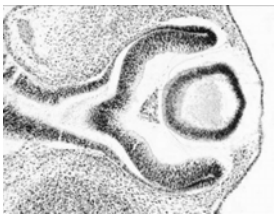




Optic vesicle forms optic cup under influence of lens primordium. Between developing lens vesicle and optic cup : primary vitreous body.



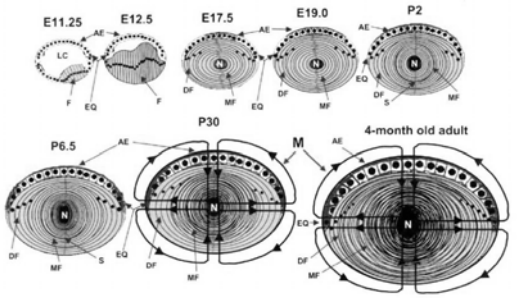
Hyaloid A.: terminal branch of ophthalmic A. (future central artery of retina)



In lens vesicle posterior cells elongate to form primary lens fibers. In third month the equatorial cells of the anterior epithelium form secondary lens fibers (most of mature lens).

Primary and secondary lens fibers

Varadaraj K et al (2007)



Optic cup:

Inner layer ⟶ neural retina

Outer layer ⟶ pigment retina

Optic stalk:

Axons from neural retina grow through the choroidal fissure to brain ⟶ optic nerve

NC derived mesenchyme around the optic cup:

Thin inner choroid

Outer fibrous sclera

NC derived mesenchyme anterior to lens:

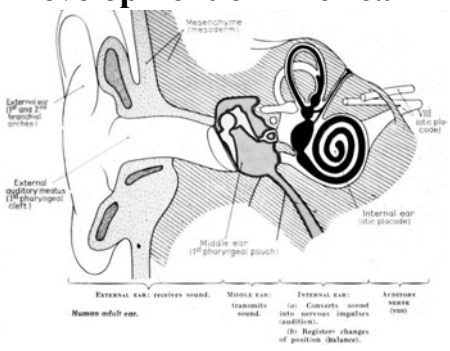
Anterior layer ⟶ contributes to cornea

Posterior layer ⟶ pupillary membrane

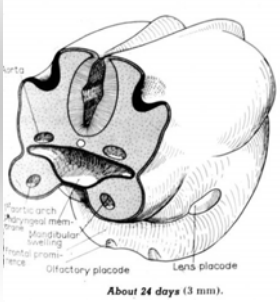
Between anterior and posterior layers: anterior chamber of eye

Behind posterior layer: posterior chamber.

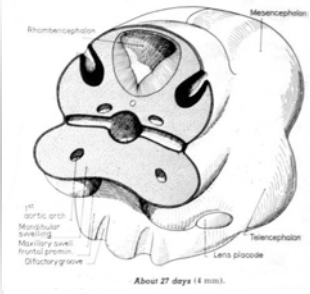
Development of inner ear



Otic placode invagination: otic pit



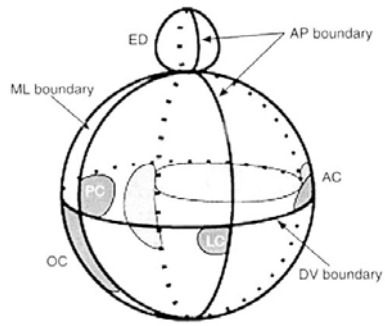
Otic pit to otic vesicle



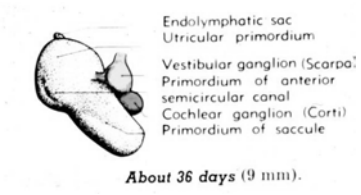
Some placodal cells migrate out of vesicular wall: ⟶ statoacoustic ganglion of CN VIII

Differentiation compartments in the otocyst

Choo, D (2007)

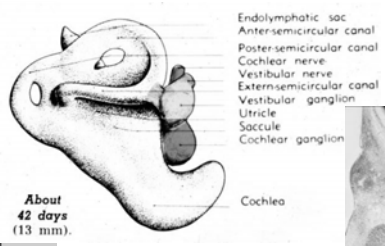


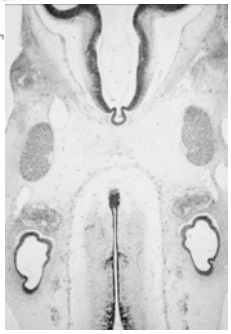
Differential growth of otic vesicle

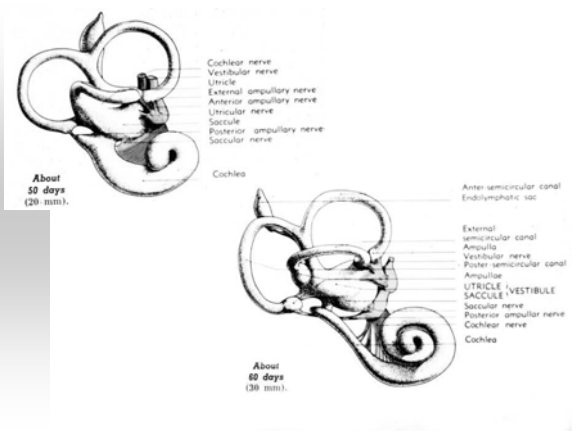


Saccule: ventral, will give rise to mature saccule and cochlea.

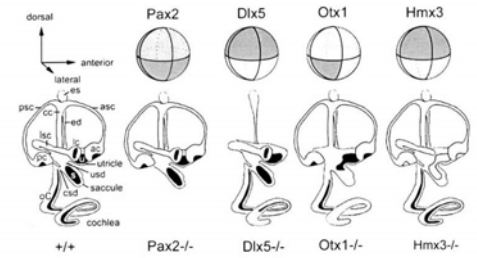
Utricle: dorsal, will give rise to mature utricle, semicircular canals and endolymphatic duct.







Factors controlling the patterning of the otocyst



Choo, D (2007)

Otic capsule: future petrous part of temporal bone