DEVELOPMENT OF THE HEAD AND NECK

Placodes and the development of organs of special sense

L. Moss-Salentijn

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 ganglia of the branchiomeric nerves in pharyngeal arches.

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)

expression of genes for generic placodal development:

Six1/2, Six4/5, Eya

Panplacodal ectoderm

Expression of genes for generic placodal development:

Six1/2, Six4/5, Eya

PLACODES

Localized thickened areas of specialized ectoderm, lateral to the neural crest, at the border between neural plate and the future epidermis
Brugmann SA, Moody SA (2005) 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

Transcription factor expression domains in panplacodal primordium

Xenopus

Schlosser G (2006)

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 of genes 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, Pax8; 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

Location of placodes (3)

- Intermediate between otic placode and epibranchial placodes:
  - Ophthalmic (profundal component) and trigeminal placode

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)

Branchiomeric nerves: origins and axon projection patterns

Development of organs of special sense

Olfactory epithelium: development of the nose
Olfactory epithelium: development of the nose

1. Transient pioneer neurons set up scaffold

2. 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.

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)

Primary and secondary lens fibers

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)

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

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

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.
Animation of inner ear morphogenesis in chick embryos

Brigande JV et al. (2000)

Movie produced by Donna Fekete & Laurie Bon (Purdue University)

Factors controlling the patterning of the otocyst

Chen, D (2007)

Otic capsule: future petrous part of temporal bone