TOPIC:EMRYONIC INDUCTION(contd..)

LECTURE NO:07

BSC(HONS.) PART 1-PAPER II-GROUP B

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One factor hypothesis of neural induction:

Nieuwkoop (1966) using living notochord as the inductor, postulated that only one factor which first evokes ectoderm to form neural tissue and later causes ectoderm to transform into more posterior and mesodermal structure (Fig.3.9) is involved.

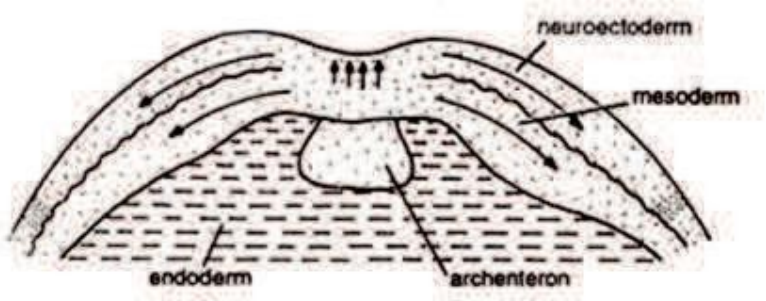

Fig. Medio lateral spreading of an inductive action within the mesoderm & a similar spreading of the neutralizing action in the overlying ectoderm.

In one experiment, consisting of combining isolated gastrular ectoderm with a piece of notochord and then removing the notochord tissue after varying lengths of

time, it was found that only 5 minutes exposure to inductor caused a part of the ectoderm to transform into brain and eye structures.

Ionic theory of neural induction:

According to Barth and Barth (1969), the actual process of induction may be initiated by release of ions from bound form, representing a change in the ratio between bound to free ions within the cell of the early gastrula. Induction of nerve and pigment cells in small aggregates of prospective epidermis of the frog gastrula were found to be dependent on the concentration of the sodium ions.

Normal induction of nerve and pigment cells by mesoderm in small explants from the dorsal lip and lateral marginal zones of the early gastrula is dependent on the external concentration of sodium. Thus, normal embryonic induction depends on an endogenous source of ions and that an intracellular release of such ions occurs during late gastrulation.

Genetic basis of neural induction:

There are evidences that the component tissues of neural inductor become differentiated prior to ectodermal cells. During this process, the rate of transcription of mRNA and differential activation of genes becomes many fold,

while the differentiation of ectodermal cells is set in only after mid-gastrulation.According to experiments conducted by

Tiedemann (1968), after 2 to 7 days of cultivation of dorsal blastopore lip of young Triturus gastrula with adjacent ectoderm in a medium containing sufficient quantities of Actinomycin-D to inhibit RNA synthesis, induction could not take place, but some differentiation of muscle and notochord occurred. It shows that mRNA by transcription from the DNA was required, which also requires the presence of Actinomycin-D. Therefore, no neural induction could be detected in this experiment.

Time of neural induction:

Neural induction occurs at the time when the material of chordamesoderm moves from the dorsal lip of blastopore inward and forward (Saxen and Toivonen 1962). The inductive stimuli exhibit a time gradient, which may be crucial with regard to action and reaction events.

Embryonic induction in different chordates:

Although neural induction was first discovered in urodele amphibians, it was found that the dorsal lip of the blastopore and the roof of the archenteron of other vertebrates have the same function. The chordamesoderm in all vertebrates induces the nervous

system and sense organs. Neural inductor has been investigated in the following chordates:

In Cyclostomes, especially in lampreys, the property of neural induction lays in the presumptive chorda mesodermal cells of dorsal lip of the blastopore. Prior to cyclostomes, in Ascidians different blastomeres of eight cell stage have the following presumptive fates-(i) the two anterior animal pole blastomeres produce head epidermis, pulps and the brain with its two pigmented sensory structures, (ii) two posterior animal pole blastomeres produce epidermis, (iii) two anterior vegetal blastomeres produce notochord, spinal cord and part of the intestine (iv) two posterior vegetal cells produce mesenchyme, muscles and part of the intestine.

From these experiments, Raverberi (1960) concluded that the formation and differentiation of brain by two anterior animal blastomeres is dependent on the induction of two anterior vegetal blastomeres, which act as neural inductors. It was further concluded that the two anterior vegetal blastomeres gave rise to diverse tissues, namely, endoderm, notochord and spinal cord.

Wu and Tung (1962) proved the existence of the primary organizer and neural induction in Amphioxus. They

transplanted pieces of tissues from the inner surface of the dorsal blastopore lip of an early gastrula of Amphioxus into the blastocoel of another embryo in the same stage (Fig.3.10) and observed that secondary embryo developed in the ventral region of the host with a notochord and mesoderm produced by the graft and the neural tube from host tissue.

Thus, the chordal tissue of Amphioxus gastrula possesses the power of neural induction, while mesodermal and endodermal tissues have little such inductive power.

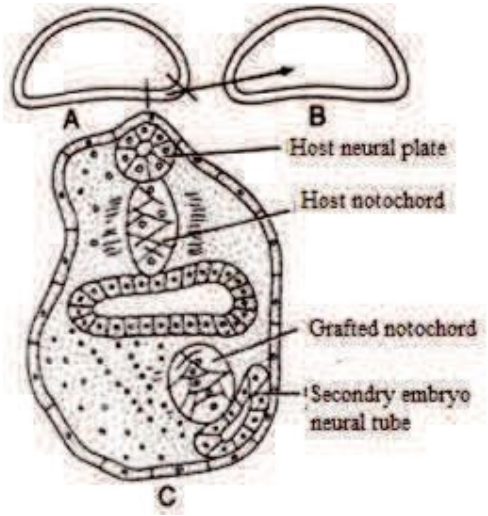

Fig. Neural induction in Amphioxus

In bony fishes, inductions of secondary well developed embryos were produced by transplanting the posterior edge of the blastodisc which corresponds to the dorsal lip of the blastopore, into the blastocoel of another embryo

(Fig.) or by transplanting the chordamesoderm and ectoderm. Neural inductions were also obtained by transplanting the dorsal lip of the blastopore in the sturgeon.

In frogs, the induction of secondary embryo can be produced by the dorsal lip of the blastopore transplanted into the blastocoel of a young gastrula, in very much the same way as in newts and salamandars.

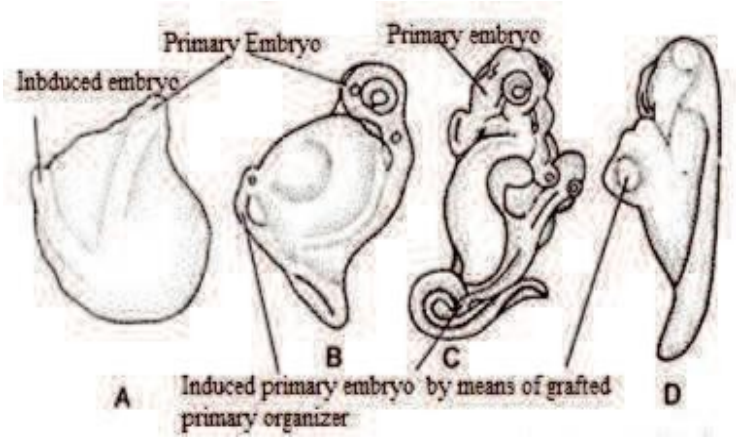

Fig Induction of secondary embryo by means of grafted primary organizer in (a) Lamprey, Pench & Frog.

In reptiles archenteron has the same inducing activity as in other vertebrates but there is no experimental proof of occurrence of neural inductor.

In birds the existence of primary organizer was established by Waddington and co-workers. Anterior half of the primitive streak was the inducing part similar to

the lips of the blastopore in amphibians. In the experiment whole blastoderms were removed from the egg in early gastrulation and cultivated in vitro on the blood plasma clot.

From another embryo, parts of the primitive streak were then inserted between epiblast and hypoblast, inductions of secondary embryos obtained. Primitive streak was found dependent on the underlying hypoblast for its formation (Fig)

A successful neural induction was performed in a rabbit embryo by cultivating the early blastodisc on a plasma clot and implanting the primitive streak of the chick as inductor. Tissues of the mammalian gastrula were found having competence for neural induction. Anterior end of a rabbit embryo, with two pairs of somites, induced a neural plate in a chick embryo when placed under a chick blastoderm.

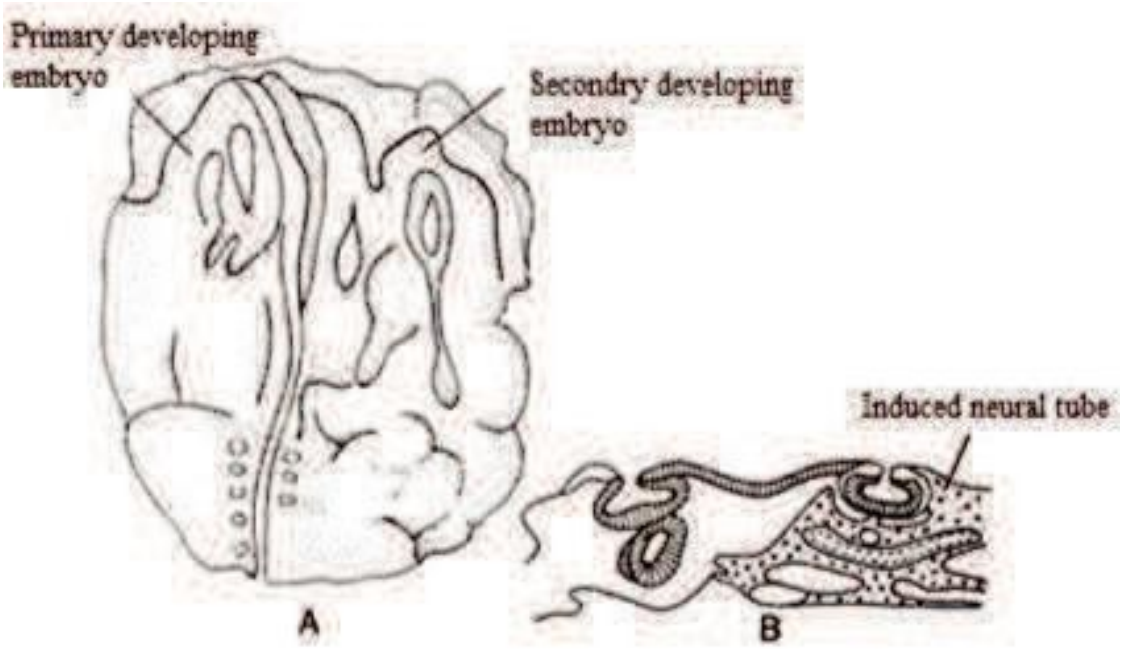

Fig Induction of secondary embryo by means of grafted primitive streak in a birds

Other types of embryonic inductions:

Along with gastrulation growth, various organ systems of the embryo begin to differentiate and acquire the power of inducing the differentiation of later formed structures or organs such as eyes, ears, limbs and lungs, etc. These organs develop organizing property and become the source of induction.

Therefore, this series of organizers can be called as secondary, tertiary and quaternary organizers. Progressive development of embryonic organs is dependent on sequential induction. One embryonic tissue interacts with the adjacent one and induces it to develop and this process continues in sequence.

Development of eye in chick:

The first sign of the development of the eyes is a bulging at the lateral sides of the prosencephalon. These are the rudiments of the optic vesicles which lie beneath the head ectoderm. Meanwhile, the distal part of each optic vesicle (the future sensory layer) invaginates and presses against the proximal part (the future pigment layer of the retina,

iris and ciliary body). This results in the formation of the optic cup, the elimination of the original lumen of the optic vesicle and the formation of a new lumen, the future vitreous chamber.

The lens is formed from the lens placode, a thickening of the ectoderm formed in response to an inductive signal from the optic cup. The lens sinks beneath the surface of the ectoderm, the latter becoming the cornea.

As the lens continues to grow, the cells in the thickened region lose their ability to divide and become converted into fibres that will become the core of the adult lens. New fibres are formed from the cells at the periphery of the lens which divide rapidly and become arranged in concentric circles around the original core. By the time of hatching there are three concentric layers of fibres, the core, the intermediate layer of irregularly arranged fibres, and the radial layers which continue to grow after hatching. The lens capsule, which is an extracellular material with a high collagenous component, starts to form about day 7. The ciliary body develops close to the lens, its role being to secrete the fluid of the vitreous chamber.

As the lens loses contact with the ectoderm a space is formed, the anterior chamber of the eye. The corneal epithelium develops from the ectoderm covering the anterior chamber, whilst the corneal stroma forms from the mesenchyme and becomes visible on day 4 as a thin layer beneath the epithelium. It becomes thicker as mesenchyme cells migrate into it during day 7.

The iris arises from cells at the margin of the anterior chamber at about day 7. Removal of the lens results in disorganization of the components of the anterior chamber. The retina is formed from the optic cup. Its inner layer becomes the neural retina and its outer layer the pigmented retina.

The choroid and sclera differentiate from the mesenchyme around the optic cup, forming the inner pigmented vascular layer, and the outer, fibrous layer, respectively. The melanophores of the choroids are derived from cells of the neural crest that reach the eye during day 2 and develop pigment on day 7. Cartilage starts to form in the sclera on day 8.

The eyelids start to form at about 7 days from a circular fold of skin surrounding the eye.The choroid fissure usually begins lo close in the region near the lens about day 4. At this time a ridge of mesoderm, carrying with it a

blood vessel, migrates along the choroid fissure into the posterior chamber of the eye and enlarges during day 5 to form the pectin. The pigment cells of the pecten are derived from the pigmented retina. The pecten is a structure characteristic of birds, and it is thought that it acts not only by bringing oxygen and nutritive materials to the eye but that it may also play a role in vision. The vitreous humour is secreted by the cells of the optic cup.

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