TOPIC: EMBRYONIC INDUCTION AND ORGANIZER

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EMBRYONIC INDUCTION

Embryonic induction defines as the process of communication between cells required for their differentiation, morphogenesis and maintenance.

In amphibian embryos, the dorsal ectodermal cells in a mid-longitudinal region differentiate to form a neural plate, only when the chorda-mesoderm is below it. Chorda-mesoderm is the layer formed by cells invaginated from the region of the dorsal blastoporal lip, which forms the roof of archenteron.

Mangold (1927) selected a small part of dorsal blastoporal lip from an early gastrula of Triturus cristatus and grafted it at a place near the lateral lip of the blastopore of the host gastrula of T. taeniatus. The graft cells grew in number and spread inside the host gastrula to form an additional chorda-mesoderm at this place. This chorda-mesoderm subsequently induced the ectoderm of the host gastrula to form an additional neural tube.

The graft cells themselves formed an additional notochord. As the host gastrula developed further, it grew into a double embryo joined together. One of the embryos was the regular one, while the second was the induced one. The latter did not develop a complete head. This experiment clearly showed that the dorsal blastoporal lip of the blastula had the ability to induce the formation of the neural plate in the ectoderm of the host. This phenomenon is called neural induction. Other parts of an embryo can similarly induce the formation of other structures. This influence of one structure in the formation of another structure is called embryonic induction.

In fact, the entire development of an organism is due to a series of inductions. The structure, which induces the formation of another structure, is called the inductor or organizer. The chemical substance that is emitted by an inductor is called an evacuator. The tissue on which an evacuator or inductor acts is called the responsive tissue.

(a) **Historical Background of Embryonic Induction:** For the discovery of neural induction, the German embryologist, Hans Spemann and his student, Hilde

Mangold (1924) worked a lot and for his work Spemann received Nobel Prize in 1935.

These two scientists performed certain heteroblastic transplantations between two species of newt, i.e., Triturus cristatus and Triturus taeniatus and reported that the dorsal lip of their early gastrula has the capacity of induction and organization of presumptive neural ectoderm to form a neural tube and also the capacity of evocation and organization of ectoderm, mesoderm and endoderm to form a complete secondary embryo.

They called the dorsal lip of the blastopore the primary organizer since it was first in the sequence of inductions and as it had the capacity to organize the development of a second embryo. Later on, the primary organizer was reported to exist in many animals, e.g. in frogs (Daloq and Pasteels, 1937); in cyclostomes (Yamada, 1938); in bony fishes (Oppenheimer, 1936); in birds (Waddington, 1933) and in rabbit (Waddington, 1934).

Primary organizer and neural induction have been reported in certain pre-vertebrate chordates, such as ascidians and Amphioxus (Tung, Wu and Tung, 1932). In 1960 and 1963 Curtis investigated and reported that the organizer of gastrula of Xenopus laevis can be distinguished in the cortex of gray crescent of a fertilized egg.

Holtfreter (1945) gave an account of how an enormous variety of entirely unspecific substances-organic acids, steroids, kaolin, methylene blue, sulphhydryl compounds, which had nothing in common except the property of being toxic to sub-ectodermal cells-produced neurulation in explants. Barth and Barth (1968, 69) provided further information about the chemical nature of embryonic induction.

Types of embryonic induction:

Lovtrup (1974) classified different types of embryonic induction into two basic categories-endogenous and exogenous inductions.

Endogenous induction:

Certain embryonic cells gradually assume new diversification pattern through the inductors that are produced by them endogenously. Due to these inductors, these cells undergo either self-transformation or self-differentiation. Examples of such induction were reported in Mesenchymal cells of ventral pole of Echinoid and in small sized, yolk-laden cells of dorsal lip of amphibian blastopore.

Exogenous induction:

When some external agent or a cell or a tissue is introduced into an embryo, they exert their influence by a process of diversification pattern upon neighbouring cells through contact induction. This phenomenon is called exogenous induction. It may be homotypic or heterotypic depending on the fact that whether the inductor provokes the formation of same or different kind of tissues respectively (Grobstein, 1964). In homotypic induction, a differentiated cell produces an inductor. The inductor not only serves to maintain the state of the cell proper, but also induces adjacent cells to differentiate according to it, after crossing the cell boundaries. Best example of the heterotypic exogenous induction is the formation of a secondary embryonic axis by an implanted presumptive notochord in amphibians.

Experimental evidences to induction:

Spemann and Mangold (1924) transplanted heteroplastically a piece of the dorsal lip of the blastopore of an early gastrula of pigmented newt, Triturus cristatus and grafted it near the ventral or lateral lip of the blastopore of the early gastrula of pigmented newt T. taeniatus. Most of the graft invaginated into the interior and developed into notochord and somite’s and induced the host ectoderm to form a neural tube, leaving a narrow strip of tissue on the surface.

With the development of host embryo, an additional whole system of organs was induced at the graft – placement area. Except for the anterior part of the head, almost a complete secondary embryo comprising of the additional organs was formed. Posterior part of the head was present as indicated by a pair of ear rudiments. Since in this experiment the type of transplantation involved was heteroplastic, it was found that notochord of secondary embryo consisted exclusively of graft cells; the somites consisted partly of graft and partly of host cells (Fig. 3.5). Few cells, which did not invaginate during gastrulation, were left in the neural tube. The bulk of the neural tube, part of the somites, kidney tubules and the ear rudiments of the secondary embryo consisted of host cells. The graft becomes self-differentiated and at the same time induces the adjoining host tissue to form spinal cord and other structures including somites and kidney tubules. Spemann (1938) described dorsal lip of the early gastrula as a "primary organizer" of the gastrulative process.However, organization of the secondary embryo results from a series of both inductive interactions and self-differentiate changes in the host and donor tissues. Hence, now a days the term "embryonic induction" or "inductive interactions" is preferred. The part, which is the source of induction, is called "inductor".

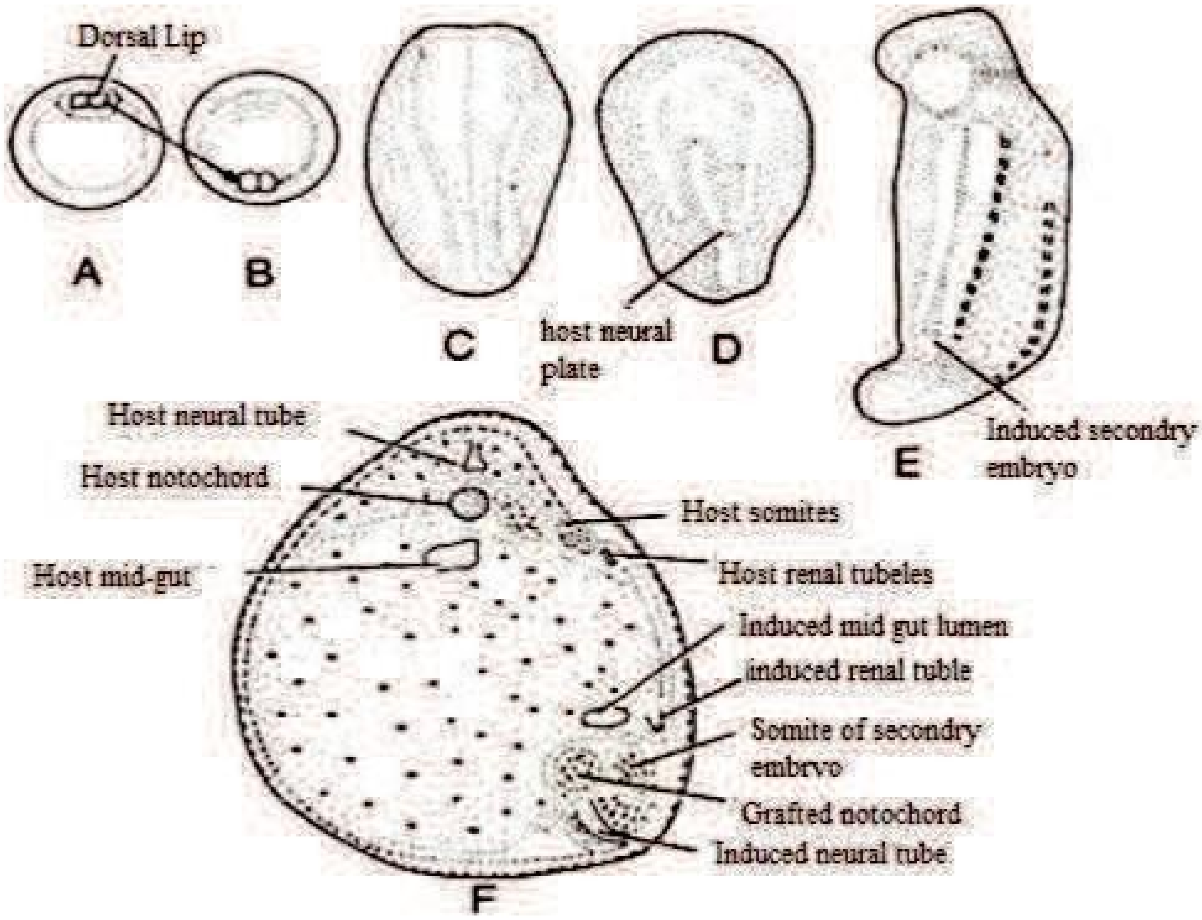

Fig. Induction of secondry embryo in triturus by transplanting a piece of dorsal lip to the future belly region of another gastrula(A-B) and C-E are the stage of resulting primary embryo with a secondry embryo attached to it,where F is the T.S of same embryo.

Characteristics of the organizer:

Organizer has the ability for self-differentiation and organization. It also has the power to induce changes within the cell and to organize surrounding cells, including the induction and early organization of neural tube. Primary organizer determines the main features of axiation and organization of the vertebrate embryo.

Induction is a tool-like process, utilized by this center of activity through which it affects changes in surrounding cells and as such influences organization and differentiation. These surrounding cells, changed by the process of induction, may in turn act as secondary inductor centers with abilities to organize specific sub-areas.

Thus, the transformation of the late blastula into an organized condition of the late gastrula appears to be dependent upon a number of separate inductions, all integrated into one coordinated whole by the “formative stimulus” of the primary organizer located in the pre-chordal plate area of the endodermal -mesodermal cells and adjacent chorda-mesodermal material of the early gastrula.

Regional specificity of the organizer:

Vital-staining experiments of Vogt with newt eggs have shown that the material successively forming the dorsal blastoporal lip moves forward as the archenteron roof. Transplants taken from this region are also able to induce a secondary embryo or the belly of a new host i.e. the archenteron roof acts as a primary inductor in essentially the same way as does the dorsal lip tissue proper. The inductions of neural inductor are found to be regionally specific and the regional specificity is imposed on the induced organ by the inductor.

Therefore, the inductive capacity of the blastoporal lip varies both regionally and temporally. Most of the dorsal and dorso-lateral blastoporal material is necessary for a graft to induce a more or less complete secondary embryo. Spemann (1931) demonstrated that during gastrulation anterior part of the archenteric roof invaginates over the dorsal lip of the blastopore earlier.

Dorsal blastopore lip of the early gastrula contains the archenteric and deuterocephalic organizer and the dorsal blastopore lip of the late gastrula contains the spinocaudal organizer. Inductions produced by the dorsal lip of the

blastopore taken from the early and the late gastrula differ in accordance with exception; the first tends to produce head organs and the second tends to produce trunk and tail organs (Fig.).

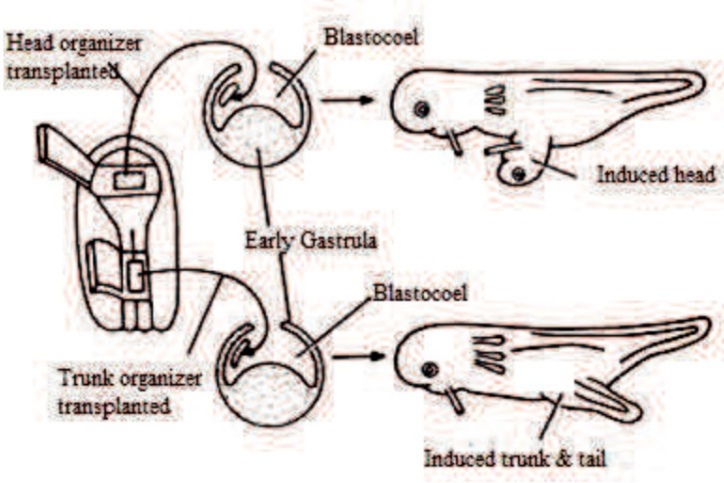

Fig: The separation of neural inductor into head & trunk organizer

As invagination continues and the dorsal lip no longer consists of prospective head endo-mesoderm but progressively becomes prospective trunk mesoderm; it acts as a trunk-tail inductor. The most caudal region of the archenteron roof, in fact, specifically induces tail somites and probably other mesodermal tissues. The archenteron roof induces entirely different class of tissues; various neural and meso-ectodermal tissues by its anterior region and various mesodermal tissues by its most posterior region.

Therefore, differences in specific induction capacities exist between head and trunk level of archenteron roof and are related to the regional differentiation of the neural tissue into archencephalic (including fore-brain, eye, nasal pit), deuterencephalic (including hind-brain, ear vesicle) and spinocaudal components. Thus, archenteron roof consists of an anterior head inductor including an archencephalic inductor and a deuterencephalic inductor and a trunk or spinocaudal inductor.

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