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Review

Agreement and disagreement among fate maps of the chick neural plate

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Abstract

Fate maps are essential to understand embryonic development; they provide a background for deducing maps of differential cellular specification in the context of other experimental data and molecular expression patterns. Due to its accessibility, the chick neural plate has been fate-mapped many times, albeit without complete agreement with respect to its shape, extent and fated subdivisions. In this review, we first comment about avian neural plate fate maps reported since the early period of experimental embryology, referring to the different methods followed. We next review a perfected fate-mapping methodology, which recently allowed us rather precise delimitation of the chick neural plate at stages 3d/4. This leads to a general discussion about the apparent border of the neural plate and the prospective main rostrocaudal and longitudinal divisions of the neural tube.

Theme: Development and regeneration
Topic: Pattern formation, compartments, and boundaries

Keywords: Homotopic graft; Prospective fate; Neural tube; Neuroectoderm; Neural/non-neural boundary; Adenohypophysis; Alar; Basal; Floor; Eye field; Forebrain; Midbrain; Hindbrain; Spinal cord

Contents

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1. Introduction

Embryonic fate maps establish at a particular stage the relative position and size of the precursor cell populations that normally give rise to particular organs or organ parts during subsequent development. A particular fate does not imply a specified or determined status of the relevant cells. At the early stages addressed here, dynamic processes of gastrulation, neural induction and neurulation occur in rapid, partially overlapping sequence, encompassing various sorts of cellular interactions related to neural induction, cell proliferation and relative cell movements, which lead to a rather complex morphogenesis (transformation of the flat epiblast into the trilaminar body rudiment). Fate maps obtained at appropriate early stages provide a background for interpretation of specification maps (location of the cell fields that express specific combinations of developmental gene products; such cells are interpreted to be at least partly specified towards a particular line of development, i.e., regulation of growth and differentiation). Fate and specification maps jointly provide guides to understand gene functions and the molecular control of neural patterning and differentiation (see Fernández-Garre et al., this volume, for review of chick neural plate specification).

The chick neural plate has been fate-mapped several times, at earlier or later stages (i.e., Refs. [1,3,6,9,14,16,28,34,35,44,53,56,65,72,76]). In general, the epiblast was sampled only partially in these studies, and diverse labeling methods were employed [21]. The resolution of such maps tends to be limited, among other causes, by the partial methods of sampling, some preconceived notions about the limits of the neural plate, and the absence of proper staging criteria at the time when the studies were performed.

In the sections below, we first considered the diverse fate-mapping methods used, jointly with the reported results. Some discrepancies resulting from technical drawbacks of these studies stand out. Recently, these problems were addressed using a modified grafting procedure designed to resolve neural plate fates in finer detail [13,14]. We therefore recapitulate our own experience with chick neural plate fate-mapping, in comparison with some other fate maps. The discussion is centred on the deduced border of the neural plate and the prospective main rostrocaudal and longitudinal divisions of the neural tube.

2. Fate maps of the avian neural plate

A good number of complete or partial fate maps of the avian epiblast were performed over time, due to persistent interest on such maps and efforts for greater precision [1,3,4,5,6,7,9,13,16,18,21,29,34,35,36,37,39,42–51,53,56,58,62,64–68,72,73,75,76]. These maps were made using different techniques (Table 1).

The first experimental fate maps were performed with the vital staining technique (gelatine pellets impregnated with Nile blue or Bismarck brown dyes were applied to given loci, obtaining supravital incorporation of the colorants; Table 1). This technique has a limited value for determining the destination of the marked fields due to fading and

Table 1
Avian fate map references classified according to technique employed

Vital staining
Gräper [18]
Wetzel [75,76]
Rawles [42,43]
Pasteels [37]
Rudnick [53]
Waddington [73]
Malan [29]
Carbon marking
Spratt [64–66]
Spratt and Codon [67]
Tritiated thymidine labelling
Rosenquist [44–50]
Rosenquist and DeHaan [51]
Orts-Llorca and Collado [36]
Nicolet [34,35]
Stalsberg and DeHaan [68]
Quail-chick graft
Vakaet [72]
Bortier and Vakaet [3]
Alvarez and Schoenwolf [1]
Garcia-Martinez et al. [16]
Schoenwolf [56]
Catala et al. [7]
Callebaut and Van Neuten [5]
Callebaut et al. [6]
Cobos et al. [9]
Carbocyanine labelling
Selleck and Stern [62]
Hatada and Stern [21]
Psychoyos and Stern [39]
Brown and Storey [4]
Intracellular fluorescent marking
Schoenwolf and Sheard [58]
Fernández-Garre et al. [13]