Textbook of Oral Biology

SHAW • SWEENEY

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Textbook of Oral Biology

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Preface

The *Textbook of Oral Biology* grew out of a course for postdoctoral students in the Harvard School of Dental Medicine. This course in Oral Biology was designed primarily for first-year students in the postdoctoral program for the degree Doctor of Medical Sciences in Oral Biology, in which advanced courses in the biomedical sciences, original research, and specialty training are combined. Since the term oral biology is not yet clearly defined, the faculty for this course took as their guiding definition:

> Oral biology is that body of scientific knowledge that deals broadly with the oral tissues, their development and structure, function and interrelationships, diseases, and relations to other organ systems in health and disease.

Instructors in this course quickly found that no textbook or even small group of textbooks was available to help the students become versed in the rapidly progressing frontiers of the numerous and diverse facets in oral biology. Instead, faculty members had to assign extensive reading lists to the students, with chapters and reviews from a variety of books and monographs and articles from a host of scientific journals. This situation automatically placed a major burden on the faculty to produce such lists, on the students to locate the readings, and on libraries to have more duplicates than would have been necessary had one or more suitable textbooks been available. Probably most serious was the fact that no source was available to tie the subject matter together or to indicate the relevance to clinical dentistry in the fashion that we desired in this course and later incorporated into this textbook.

As this Oral Biology course became known around the country, frequent requests were received from faculty members in other dental schools, not only for the outline of the course but also for the lecture outlines and reference lists that our instructors had prepared to distribute in advance to students. The need for a textbook in oral biology has become increasingly evident as more Oral Biology courses were offered as key components in predoctoral curricula and as more graduate students began to specialize in Oral Biology during preparation for either the degrees of Master of Science, Doctor of Philosophy, or Doctor of Medical Sciences.

The nature and breadth of the information encompassed in the above definition of oral biology made it impossible to have adequate presentation in a book that was written by only a single author or even by three or four. Therefore, the decision was made to have an editorial board of four, of whom two are instructors who participated in Oral Biology courses here and two are former graduate students who took the first-year postdoctoral Oral Biology course. This board selected 44 men and women, specialists in their respective fields, to write the individual chapters. Almost all the authors participated in the teaching of oral biology here, either as faculty members, guest lecturers, or students. In this way an unusual experiential understanding for the needs and problems of instruction in oral biology has been incorporated into this book.

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Part I

Anatomic Basis in Oral Biology

Chapter 1

Tissue Interaction in Development

Concept of Embryonic Induction; Inductive Mechanisms in Orofacial Morphogenesis

ELIZABETH D. HAY and STEPHEN MEIER

The student of oral biology will have much cause to be familiar with the concept of embryonic induction. During the development of the teeth and other craniofacial organs, there are many examples of what seems to be interaction of an informative nature between the **somatic cells** [1]* that reside in embryonic epithelial and **mesenchymal** [2] tissues.

The purpose of this chapter is to acquaint the student with the literature that gave rise to the concept of embryonic induction, to follow subsequent studies (especially those of orofacial organs) critically, and to evaluate the usefulness of the concept of induction as a means of explaining developmental phenomena. It is tempting when one sees two developing tissues in close proximity to each other to believe that they are interacting in an informative manner. This descriptive criterion, that two tissues are interacting in an inductive sense merely because they are adjacent, will not be allowed here. To be called embryonic induction, a phenomenon must exist in which the progressive differentiation of one tissue can be shown to require the presence or the products of another tissue.[1,2] The proof of the existence of the phenomenon necessitates tissue isolation and transplantation in vivo or in vitro. We shall discuss only such experiments here. No experimental procedures have been carried out along these lines on the human embryo, but it is reasonable to expect that the same principles will apply in a general way to all vertebrate embryos.

*See Glossary at end of chapter.

ORIGIN OF THE CONCEPT OF EMBRYONIC INDUCTION

It is important to realize that the concept of embryonic induction arose in the early part of this century, during the beginning period of experimental manipulation of embryos at the dawn of biochemistry and prior to the birth of modern cytology. Concepts are created, or arise spontaneously, as the case may be, to summarize large masses of facts in terms that can be understood by the human mind. The major experiments that led to the concept of embryonic induction can be restated in simplified fashion as follows.

The availability and large size of the amphibian egg led to its immediate popularity at the turn of the century as a laboratory animal that could be used to probe the secrets of the embryo. Roux in 1888 cauterized one of the cells (blastomeres) of the two cell frog embryo to determine whether or not the remaining blastomere could develop into a whole organism.[3] The negative answer that he obtained was soon challenged by Driesch in experiments on sea urchins and subsequently it was shown that, in the amphibian, the developmental result of bisecting the cleaving embryo depends on whether or not the **presumptive** [3] dorsal lip of the embryonic **blastopore** [4] happens to be included in both halves.[3]

The dorsal lip makes its appearance during the late cleavage or blastula stage on the outside of the amphibian embryo in a metabolically active region characterized by numerous microvilli and what seems to be a distinctive surface coat. Here, as it was dramatically proved by Vogt in 1925, the tissue that will become the **chordamesoderm** [5] first invaginates and then gives rise to the roof of the gastrocoele or so-called archenteron.[3] The embryo is now called a gastrula (Fig. 1–1). Subsequently, the dorsal lip extends ventrally to encompass the blastopore around which invaginate the remaining tissues destined to lie within the embryo. The dorsal lip is easily visualized with a dissecting microscope. In 1907, Lewis in this country noticed this interesting area and transplanted it to older frog embryos in which it developed in accordance with its presumptive fate: it became notochord and mesodermal tissues, but did not induce a secondary embryo.[3]

Spemann and his colleagues at the University of Freiburg carried out the definitive experiments that established the concept of embryonic induction.[2] They showed that parts of the gastrula could be interchanged, while parts of older embryos seem **determined** [6] to develop along given pathways. In 1924, Spemann and his graduate student, Hilda Mangold, reported that they had transplanted the dorsal lip (presumptive chordamesoderm) of one gastrula to the front end of another gastrula of the same stage. Under these circumstances, the transplanted dorsal lip is capable of inducing a secondary embryo to form on the host. This secondary embryo is composed partly of mesodermal tissues contributed by the transplant and partly of host tissue (Fig. 1–2). Since the host gastrula is "competent" at the time of the transplant, it responds to the inducer. Older embryos, such as those used by Lewis, are not "competent," presumably because differentiation is already underway.

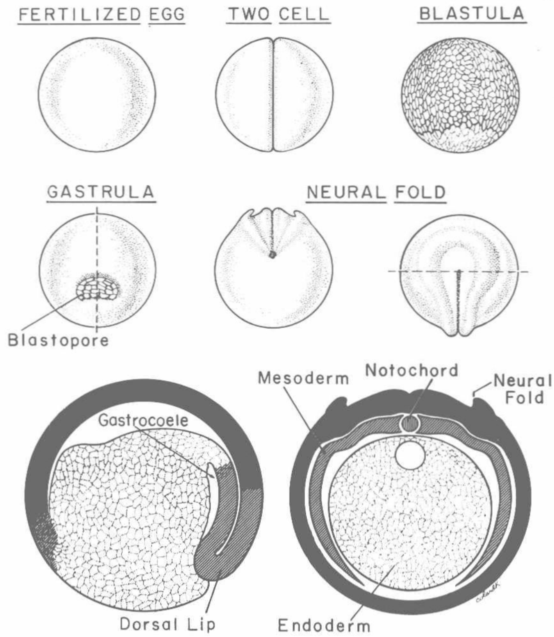

Figure 1–1 Early stages in the development of the amphibian embryo. The six upper diagrams depict the external morphology of the embryo. A schematic section through the gastrula in the plane indicated by the dotted line is shown in the lower left hand corner. The neural fold embryo (neurula) is shown in posterior view to match the first four drawings and also in dorsal view to indicate (dotted line) the plane of section of the drawing in the lower right hand corner. (From Hay, 1963.)

A number of second-order inductions