THE PRESENCE OF A COMMON EMBRYONIC BLASTEMA FOR OVARIAN AND TESTICULAR PARENCHYMAL (FOLLICULAR, INTERSTITIAL AND TUBULAR) CELLS IN CATTLE, *BOS TAURUS*

A. GROPP
Pathologisches Institut, Universität Bonn, Deutschland

S. OHNO
Department of Biology, City of Hope Medical Center, Duarte, California (USA)

Received April 7, 1966

Summary. The early embryonic gonadal development in the cattle is characterized by the appearance of an alkaline phosphatase positive blastema. Its derivatives in gonads of both sexes, follicular cells in the female and interstitial cells in the male, also show positive alkaline phosphatase reaction. Primordial germ cells are equally alkaline phosphatase positive, but loose this activity when they later transform to oögonia and oöcytes, or to spermatogonia respectively. Using the enzyme activity as label to trace these constituents in the developmental steps of the bovine gonads, the following results were obtained.

Differentiation processes leading to the appearance of the sex cords take place in situ within the gonadal blastema which occupies the main central part of the gonadal fold. It is essentially a segregation process of the follicular cell cords or of the interstitial cells and the tubular primordia from the undifferentiated common anlage.

The so-called "germinal epithelium" is not involved in the differentiation of sex cords. Its participation — if any — in the gonadal development is restricted to a very short and rather early period. Secondary sex cords (Pflügers cords) do not occur. In the cattle there is no reason to assume a cortico-medullary antagonism in the sex determined gonadal development.

It can be assumed that the follicular cells in the ovary and the interstitial cells in the testis are homologous. This applies possibly also to the tubular cells of the testis. Homology should be admitted also for the rete structures, which remain small and undeveloped in the ovary while in the male they show considerable development.

In the ovary the follicular cell cords differentiating within the central blastema match in a junctional zone with the peripheral layer of oögonia. These are taken up by the most peripheral branches of the follicular cell cords, thus transforming to ovigerous cords. During the downward movement within these cords the germ cells transform to oöcytes which for their part proceed through first meiotic prophase and reach the diplotene stage. The maturation of the germ cells seems to be controlled by the follicular cells and may even temporarily get out of control until an adequate number of follicular cells is found in vicinity of individual oöcytes to form primordial follicles.

The alkaline phosphatase reaction reveals the presence of numerous persisting remnants of follicular cell cords in the developing and even adult ovary.

It is suggested that the findings in the cattle gonads can be applied also to other mammals, mainly to those with longer gestation periods like man.

In mammals and other vertebrates, differentiation of the gonadal ridges begins soon after the migration of primordial germ cells is completed. The sex chromosome constitution of primordial germ cells, however, does not appear to be a

* Contribution No 58--66, Department of Biology, City of Hope Medical Center. This work was supported in part by a grant (CA 05138) from the National Cancer Institute, U.S. Public Health Service. The project was undertaken during a five-month visit to Dr. Ohno's laboratory by the senior author whose expenses were covered by the Deutsche Forschungsgemeinschaft.
deciding factor in directing the development of indifferent gonads either into a testis or into an ovary. Surgical removal of the functional left ovary of the female domestic fowl (Gallus gallus domesticus) invariably induces compensatory development of the residual right gonad into a testis (Benoit, 1923). The germ cells of the right gonad are transformed into functional spermatogonia while retaining the heterozygotic sex chromosome constitution characteristic of the avian female (Miller, 1938).

Faced with this apparent neutrality of primordial germ cells with regard to gonadal development, Witschi (1951, 1962) introduced the concept of cortico-medullary antagonism in sex differentiation. From the phylogenetic as well as the ontogenic viewpoint, gonads are essentially hermaphroditic. Experimental data on sex reversal indicate that vertebrate gonads display marked bipotentiality early in development (Wolff, 1962). Witschi's hypothesis claims that indifferent gonads of vertebrate embryos contain both cortical and medullar primordia. The differentiation of the ovary is supposed to be characterized by the prevalence of the cortex over the medulla, while in the male the medulla predominates, and a testis results. When this view is used at the cellular level, the cortex brings forth the follicular cells with their endocrine function of producing estrogenic steroid hormones, while the medulla furnishes the interstitial cells which play the major role in the androgenic endocrine system. This concept implies that follicular cells and interstitial cells are derived from different progenitors which are antagonistic to each other. Specifically, follicular cells were thought to be derived from the proliferating surface epithelium of the gonad, the so-called “germinal epithelium”. Indeed, the cortical origin of ovarian follicular cells appears to have been the general consensus for many years (Felix, 1911; Gillman, 1948; Watzka, 1961; Franchi et al., 1962).

However, a recent investigation of fetal cattle gonads combining cytological observations with histology (Ohno and Smith, 1964) revealed that initially deeper parts of the female gonad were endowed with more follicular cells than the superficial layer, and that an area directly beneath the “germinal epithelium” was always deficient in follicular cells. This observation cast some doubt on the cortical origin of follicular cells and tended to support the view originally expressed by Fischel (1930) that follicular cells also are derived from a blastema situated deep in the central part of an undifferentiated gonad.

Without an appropriate marker, any attempt to trace the ontogenic ancestry of a particular cell type is a hazardous venture. The histochemical reaction for alkaline phosphatase helped to clarify the original site and migration route of primordial germ cells in various mammalian species, including man (McKax et al., 1953; Chiquoine, 1954; Mintz, 1957). During these studies on fetal cattle gonads of various stages, intense alkaline phosphatase activity was noted not only in the primordial germ cells of early embryos, but in fetal follicular cells and fetal interstitial cells as well. This enabled us to trace the ancestry of both cell types to a common blastema situated within the morphologically indifferent gonad.

**Material and Methods**

Fresh cattle embryos and fetuses of various stages (Holstein-Friesian breed) were collected from local slaughterhouses, brought to the laboratory in refrigerated containers within three