An experimental study on the relative distribution of the somitic and somatic plate mesoderm to the abdominal wall of avian embryos[1]

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Summary. The origin of the structures of the abdominal wall in avian embryos was studied by using the quail-chick marker system. It was concluded that the muscles originate from somitic cells while tendons, fasciae and the intramuscular fibroblasts, as also the remaining connective tissue, derive from the somatic plate mesoderm.

In young embryos of higher vertebrates, the rudimentary body wall consists of somatic plate mesoderm and somites. As a result of the studies concerning the formation of the abdominal wall, the contribution of somitic cells was often discussed. Based on morphological grounds, as well as on descriptive studies, it has often been stated that the musculature of the abdominal wall is formed entirely from the somites[2-6].

Straus and Rawles[7] concluded, from their experiments on chick embryos, that the ventral parts of the 3 lateral abdominal muscles and the whole of the rectus abdominis muscle develop in situ from cells of the somatic plate mesoderm. However, Detwiler[8] and Theiler[9] have adduced, from their observations on urodeles and mammals, evidence supporting a somitic origin for these muscles. Analogous results were established for the chick by recent experimental studies[10-12]. Whereas the greater part of the connective tissue of the abdominal wall is traced back to the somatic plate mesoderm, no definitive experimental data exist on the origin of the muscle-associated connective tissue (fasciae, tendons and i.m. connective tissue).

It is the purpose of the present study to obtain new experimental evidence on the contribution of the somitic and somatic plate mesoderm to the different structures of the abdominal wall in avian embryos by using the quail-chick marker system.

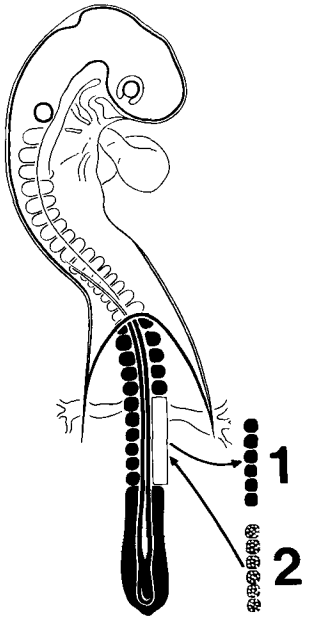

Fig. 1. Diagram showing the microsurgical procedure. After removal of the chick somites (1), the corresponding quail somites (2) were implanted after being previously isolated from an embryo at the same stage of development.

Since the interphase nuclei of Japanese quail cells are characterized by a large mass of nucleolus-associated heterochromatic DNA, which does not exist in chick cell nuclei, it is possible to identify individual cells in Feulgen-stained sections after experimental intermixture of quail and chick cells[13-15].

Material and methods. The following microsurgical procedure was employed. The somites 22–27 of chick embryos (White Leghorn) at stage 15, according to the criteria of Hamburger and Hamilton[16], were removed unilaterally and corresponding somites of quail embryos (*Coturnix coturnix japonica*) at the same stage were grafted into the mesodermal defect (figure 1). After subsequent incubation (2–8 days), the host embryos were fixed in Serra's fluid, dehydrated with graded propanol solutions and embedded in paraplast. The 7-µm serial sections were treated according to the Feulgen and Rossenbeck's technique[17], and then post-stained with light green.

Most of the embryos were normally developed and showed, when macroscopically examined, no alteration of form and bilateral symmetry of the body wall. After 2 days of postoperative incubation, the myotome layer extends in the ventro-lateral direction within the mesenchyme of the body wall up to the level of the Wolffian duct. Whereas the epithelial structure has been lost in the central part of the dermatome, it is still maintained at the dorsomedial and ventro-lateral edges. The ventro-lateral part of the dermatomyotome ('Muskelbläschen' according to Zechel[5]), which is located near the coelomic epithelium, consists of an epithelial wall which surrounds a central cavity. The following distribution of quail and chick cells was observed. All cells of the ventro-lateral edge, of the myotome layer, as well as those of the mesenchyme which have originated from the dermatome, are characterized by nuclei of the quail type. On the other hand, most of the cells of the mesenchyme surrounding the ventro-lateral edge of the dermatomyotome exhibit nuclei of the chick type (figure 2, A). Single cells or small groups of cells con-

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taining nuclei of the quail type are found within the mesenchyme ventrally of the dermatomyotomic edge, from which they emigrate, as analysis of the serial sections show.

After a postoperative incubation period of 8 days, the 3 lateral abdominal muscles and the rectus abdominis muscle including their fasciae and tendons are well developed and very close to their final location. Analysing the cellular composition of all abdominal muscle primordia, it can be stated that the cells (myotubes and myoblasts) which make up the muscle bundles contain nuclei of the quail type (figure 2 B). The fibroblasts of the tendons, of the fasciae and those of the connective tissue between the muscle bundles exhibit nuclei of the chick type (figure 2, B and C).

As a result of these experiments, it can be concluded that the cells of all abdominal muscles are of somitic origin, whereas the complete connective tissue of the abdominal wall including tendons, fasciae and i.m. connective tissue derives from the somatic plate mesoderm. This supports the conception of Seno[10], Pinot[11] and Chevalier[12] concerning the development of the abdominal muscles in the avian embryo.

The contribution of the somitic and somatic plate mesoderm cells to the different structures is analogue to that which has been described for the development of the ventral thoracic region[18] and of the wing of the avian embryo[19–21].

The cells which were found to have emigrated from the ventro-lateral edge of the dermatomyotome during the early development of the body wall must have been integrated into the muscle blastema, since no other structures of the ventro-lateral abdominal wall contain cells with quail-type nuclei.

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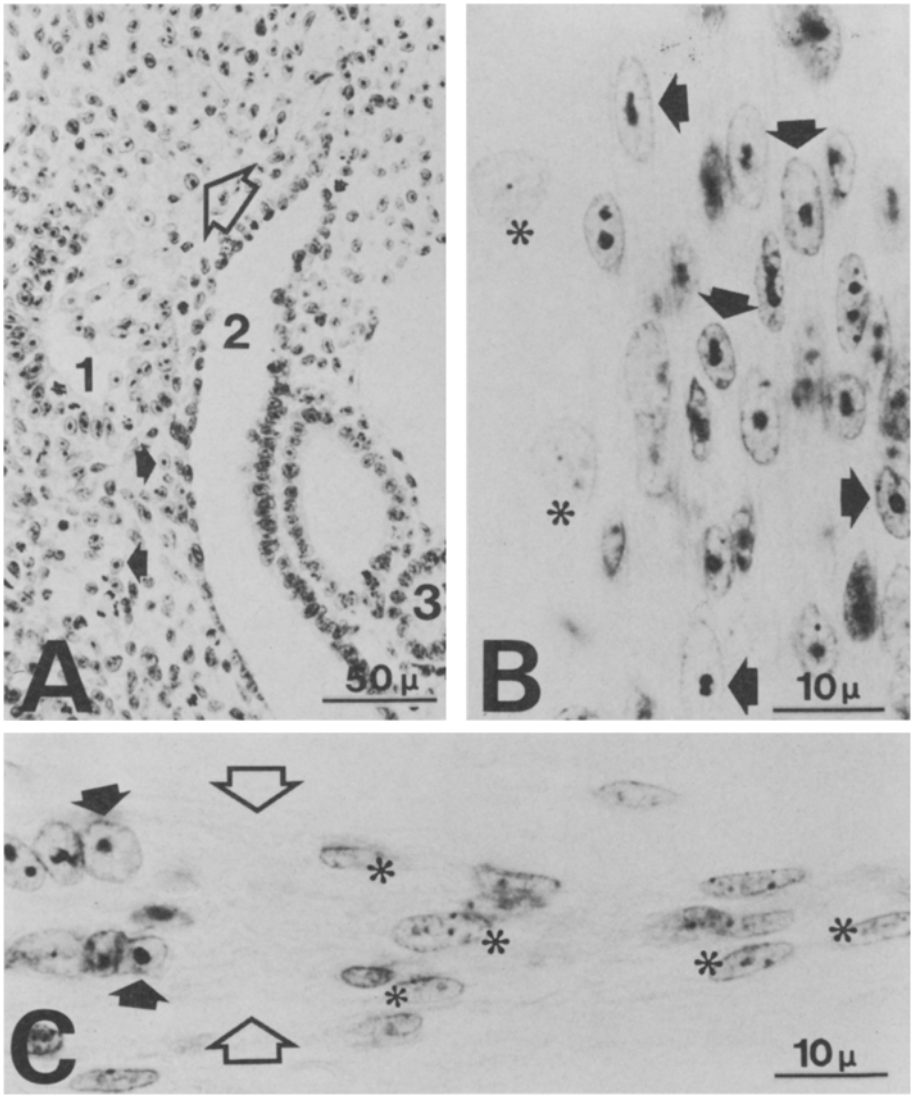

Figure 2. *A* Transverse section through a chick embryo at the level of the somitic graft after a post-operative incubation period of 2 days. Large arrow: myotomic cells with quail-type nuclei. Small arrows: single cells with quail-type nuclei within the mesenchyme of the body wall. Feulgen-Rossenbeck reaction, post-stained with light green. *B* Ventral part of the m.obliquus abdominis internus 8 days after substitution of chick somites by an equal graft from a quail embryo. Arrows mark quail nuclei of myotubes. Asterisks: chick nuclei of connective tissue cells bordering the muscle primordia (fascia). Feulgen-Rossenbeck reaction, post-stained with light green. *C* ventral part of the m. transversus abdominis 8 days after substitution of chick somites by an equal graft from a quail embryo. Large arrows mark the border between muscle and tendon. Small arrows: quail-type nuclei of myotubes. Asterisks: chick nuclei of the tendinous cells. Feulgen-Rossenbeck reaction, post-stained with light green.