SOMITE DIFFERENTIATION IN *MICROTUS OCHROGASTER* WITH SPECIAL REFERENCE TO THE ORIGINS OF THE DERMIS

by

SALLY ROBINSON

B.A., Stephens College, 1972

A MASTER'S THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of
Anatomy and Physiology

KANSAS STATE UNIVERSITY
Manhattan, Kansas

1979

Approved by:

Major Professor

ACKNOWLEDGEMENTS

Sincere thanks and appreciation are extended to the author's supervisory committee, Dr. R. D. Klemm and Dr. D. E. Weinman, for their patience throughout this study. A special thanks is extended to Dr. Klemm for his invaluable assistance in preparing the figures.

To the late Dr. Herschel T. Gier, for his faith in my ability, sincere appreciation and thanks are tendered. Without his constant help, support and encouragement, this effort could not have been completed.

The use of facilities furnished by the Division of Anatomy and Physiology and the Division of Biology is acknowledged with gratitude.

To my mother and father, for their spiritual and financial support, a deep appreciation and heartfelt thanks is given.

TABLE OF CONTENTS

TABLES AND ILLUSTRATIONS

INTRODUCTION

INTRODUCTION

The original purpose of this study was to determine the embryonic structures involved in the development of dermal connective tissue using *Microtus ochrogaster* as the experimental animal. A review of the literature proved dermal development to be an area of confusion and controversy. In 1888, Rabl (fide William, '10) proposed a portion of the somite, the dermatome, developed into dermis (Williams, '10). Bardeen (1900) stated that the dermatome was only involved in muscle development, with the dermis being derived from "mesenchyme." In 1953, Straus and Rawles discovered that grafts of embryonic tissue which contained no somitic mesoderm and therefore no dermatome produced dermis as well as those which did contain dermatome. They concluded the dermis arose from any mesoderm, including somitic mesoderm of the dermatome and somatopleural mesoderm, in contact with or subjacent to the epidermal ectoderm.

In view of the literature, I focused my research on the dermatome and lateral mesoderm to determine what role, if any, they played in dermal development. In addition, any mesoderm found subjacent to the epidermal ectoderm was examined to determine if it was involved in dermal development.

As my research progressed, it became evident that portions of the somite were involved in dermal development. Although a large amount of work has been compiled on somite differentiation, it is as confusing as the material on the origins of the dermis. It became necessary to consider the total process of somite differentiation to obtain a clear picture of the origins of the dermis.

LITERATURE REVIEW

LITERATURE REVIEW

Somites are an integral part of amniote embryos and as such they have been extensively studied. The process of somite differentiation into sclerotome, myotome and dermatome was described for the chick by Williams ('10), Patten ('51) and Arey ('74), for the pig by Patten ('48) and Arey ('74), and for the white rat by Butcher ('29). Each author had a different interpretation of the process.

Somites are generally described as block-like structures which form progressively from cranial to caudal from the segmental plate of mesoderm located lateral to the developing neural tube, with the first somite located lateral to the hindbrain (Patten, '48, '51; Williams, '10; Butcher, '29; Arey, '74). Both Williams ('10) and Butcher ('29) reported later somites did not recapitulate the development of earlier somites and each succeeding somite was more advanced structurally when it first appeared than was the one just cranial; the caudal somites omitted many of the initial stages of formation.

Somites were described as a core of mesenchymal cells surrounded by a cortex of radially arranged columnar epithelioid cells by Patten ('48, '51) and Arey ('74). Davis ('23) for the human plus Williams ('10) and Butcher ('29) considered the cells of the cortex to be a syncytium.

Myocoele

The term myocoele has been used to designate a cavity observed in the center of the somite during its formation and between myotome and dermatome during its differentiation. Patten ('48, '51) stated the myocoele of formation was eventually filled with cells creating the core of the somite; when these cells migrated from the core during sclerotome formation,

a portion of the cavity remained for a time, as the myocoele of differentiation.

According to Williams ('10) and Butcher ('29), only the cranial somites produced myocoeles of formation, the caudal somites were more structurally advanced when they first appeared and the myocoele was one of the initial stages of formation which was omitted. Butcher ('29) reported the myocoele of differentiation was present between dermatome and myotome, after migration of the core. Williams ('10) did not mention the myocoele of differentiation in his text but did include it in his illustrations. Arey ('74) stated there was an indication of a myocoele during somite formation but that it disappeared early and was only of historical significance. He did not mention the myocoele of differentiation. Haldiman ('73) stated that no myocoele was found in the bovine during somite formation and the myocoele of differentiation was an artifact of fixation which occurred due to differential shrinkage of dermatome, myotome and sclerotome.

Somite Differentiation

Somite differentiation begins with the disorganization of cells in portions of the somitic cortex to form a mass of mesenchymal cells, the sclerotome (Patten, '48, '51; Williams, '10; Butcher, '29; Arey, '74). Arey ('74) stated that the ventral wall and a portion of the medial wall of the somitic cortex disorganized into a mass of diffuse cells, the sclerotome, which migrated towards the notochord and surrounded it. For the human, Hamilton et al. ('46) and Langman ('69) also considered the ventral and a portion of the medial cortical walls were involved in sclerotome formation. Patten ('48, '51) stated the cells of the ventromesial part of the cortex lost their original definite boundaries and merged with those of the core and this aggregation, the sclerotome, extended

towards the notochord. Lewis ('10), Watt ('15), Johnson ('17), Davis ('23), Dodds ('46) and Sensenig ('49) for the human plus Hamilton ('52) for the chick and Haldiman ('73) for the bovine described involvement of the ventral wall and a portion of the medial wall in sclerotome formation along with the cells of the somitic core. Boyd ('60) for the human plus Butcher ('29) reported the cells from the lower portions of the cranial and caudal cortical walls produced sclerotome along with those of the core, ventral wall and lower portion of the medial wall. Williams ('10) concurred with the description of sclerotome formation as given by Butcher ('29) and Boyd ('60), but he considered this to be a primary sclerotome with the remaining upper portions of the cranial and caudal cortical walls producing a secondary sclerotome.

After sclerotome formation, the remaining portion of the original somite, the dermomyotome, differentiates into a layer of myotome and dermomyotome (Patten, '48, '51; Williams, '10; Butcher, '29; Arey, '74). Arey ('74) gave two differing accounts of myotome formation. At one point, he stated: "The portion of a somite that is left after emigration of the sclerotome mass...is the myotome or muscle plate. This plate thickens and its cells differentiate into myoblasts." Yet later, in the same publication, he stated: "The remaining portions of the somite constitute the dermomyotome. The cells of the dorsomedial wall of the plate, the myotome, eventually give rise to the skeletal musculature of the body. The lateral plate is the dermatome which contributes to the connective tissue of the integument." Patten ('51) stated: "The dorso-mesial portion of the outer zone of the somite becomes the myotome. It is folded somewhat laterad from its original position next to the neural tube and comes to lie ventro-mesial to the dermatome and parallel to it." He

continued that the myotome underwent an extensive growth giving rise to skeletal musculature but he did not describe this growth. Haldiman ('73) reported the dermomyotome developed an outer layer of radially arranged epithelioid-like cells (dermatome) and a deeper layer of mesenchymal cells (myotome) which became oriented parallel to the embryonic axis but he did not discuss how these two layers developed. According to Lewis ('10), Dodds ('46), and Hamilton ('52), the dorsal portion of the dermomyotome doubled back and came to lie next to the medial surface of the dermomyotome and then grew ventrally producing a two-layered structure, the inner layer being myotome and the outer layer being dermatome. In addition, Lewis ('10) and Hamilton ('52) stated the dorsal growing edge united with the ventral edge. Williams ('10) and Hamilton et al. ('46) reported both the dorsal and ventral edges of dermomyotome grew to produce a layer of myotome between sclerotome and dermatome. Williams ('10) described this growth as a proliferation of cells from the dorsal and ventral edges of dermomyotome. Butcher ('29) reported all four edges of dermomyotome (dorsal, ventral, cranial and caudal) proliferated cells producing a layer of myotome except in the first somite which produced no myotome.

Langman and Nelson ('68) studied chick embryos autoradiographically and concluded that the myotome was produced along the entire medial surface of dermomyotome and not by growth of its edges. They found labeled cells randomly along the entire medial surface of dermomyotome and not first at the edges and then progressively along its medial surface, as would be expected if myotome was produced by growth from the edges. They noted mitotic figures were rarely observed at the edges of the dermomyotome but were seen frequently along its medial surface which supported their autoradiographic findings.

Dermatome

Williams ('10) reported the dermatome transformed from an epithelioid into a mesenchymal form. He described the transformation as beginning near the center of the dermatome and spreading in all directions. According to him, the edges of the dermatome did not transform but remained for some time as zones of growth. The cranial and caudal edges produced mesenchymal cells for the most part while the dorsal and ventral edges produced myoblasts. Butcher ('29) reported that after formation of the myotome, the cells of the dermatome separated and loosened and were converted into a mass of mesenchyme under the ectoderm. The transformation began in the center and spread ventrally in the somites of the cervical, forelimb and hindlimb region, with a small mass of dermatome cells persisting for some time at the dorsal edge of the dermatome; some cells of this persisting mass became myoblasts but many became mesenchyme. In the dermatomes of the thoracic region, transformation began in the center then spread dorsally leaving a prominent mass of dermatome cells ventrally, many of which apparently became myoblasts. Butcher ('29) did not mention in his text that any cells in the dorsal part of the thoracic dermatomes remained after dermatome transformation but he did illustrate them. He explained that the cells of the dermatome which remained as caps over the dorsal and ventral edges of the myotome represented zones of growth as indicated by the numerous mitotic figures present. According to Butcher ('29), a few of the cells of the dorsal cap became myoblasts but the majority became dermal mesenchyme and those of the ventral cap formed mostly muscle tissue.

Bardeen (1900) considered the dermatome of the pig was totally converted into muscle tissue except for a few cells which degenerated.

He described a distinct limiting capsule surrounding the dermatome and myotome and concluded this capsule prevented the dermatome from diffusing and producing dermis; instead it produced muscle tissue.

Neither Patten ('48, '51) nor Arey ('74) discussed the dermatome after its initial formation except to mention its possible involvement in the production of dermal connective tissue as related in the next section.

Origins of the Dermis

Patten ('48, '51) stated of the dermatome: "While some cells from this region of the somite undoubtedly are contributed to the formation of the deep layers of the skin, the conviction has been gaining ground that many, perhaps most, of them take part in the formation of muscle." He continued that the dermis received many cells from the somatic mesoderm in general and from the diffuse mesenchyme in the cephalic region where there were no somites. He concluded that while the dermatome did contribute to the dermis, it probably did not do so any more extensively than other regions of the mesenchyme which were in close proximity to the ectoderm.

Arey ('74) stated that while the dermis was customarily traced to cells of the dermatome, evidence in support of this claim was lacking for mammals and the so-called dermatome might belong to the myotome. He concluded that if the dermatome did contribute cells to the dermis, it did not supply the dermis far beyond the vicinity of the somites and that much of the dermis differentiated from nonspecific mesenchyme subjacent to the epidermis, most of which came from the lateral sheets of somatic mesoderm.

According to Bardeen (1900) the dermatome transformed totally into muscle tissue while loose vascular mesenchyme migrated from surrounding areas between dermatome and ectoderm to form the dermis.

Murray ('28) grafted fragments from the region of the hindlimb of 2-day chicks, to the chorioallantois of 8-day chicks and then examined the grafts after 9 days of further incubation. He found a definite dermis was developed in several of the grafts including those which contained no somitic mesoderm and therefore no dermatome. He proposed the dermal connective tissue in the grafts arose from the cells of the grafted somatopleur. He concluded the dermis of the dorsal and dorsolateral regions of the chick arose from the dermatome while the remainder of the dermis arose from the cells of the somatopleur.

Straus and Rawles ('53) used both carbon marking and grafting to study chick development. They marked the mesoderm of 2.5-3 day chicks in the area of somites 20-25, continued incubation for 3-12 days and then examined the marked areas. Areas similar to those marked with carbon were isolated and grafted into the embryonic coelom of host chicks, incubation was continued for 7-11 days and then the grafts were examined. Both somites and lateral plate mesoderm were marked and grafted but no somitic material was included in any of the grafts of lateral plate mesoderm. They found that somitic material contributed to the dorsal part of the dermis while lateral plate mesoderm contributed to the ventral part of the dermis. They concluded the dermis arose from any mesoderm in contact with and subjacent to the ectoderm and not from one restricted area of mesoderm arbitrarily designated "dermatome."

MATERIALS AND METHODS

MATERIALS AND METHODS

Twenty-five timed embryos of *Microtus ochrogaster* were collected by observing copulation after induced estrus and collecting embryos of desired ages. As ovulation occurs 10.5 hours $\pm$ 1 hour after copulation, this time period was taken into account in the aging of embryos. Embryos were removed from the female at 8.5 to 15 days after copulation.

The females were opened, uteri removed and spread flat on appropriate sized cards, then immersed in a fixing solution of 10% formalin or Bouins fluid. After prefixation of 30 to 60 minutes, uterine swellings were opened to allow free access of fixative to the embryos.

After complete fixation, the embryos were removed from the uterus, dehydrated in isopropyl alcohol, embedded in paraffin and serially sectioned at 10 µm. Alternate slides of each embryo were stained with PAS-Hematoxylin and Harris Hematoxylin - Mallory's Triple stain.

The embryos were studied at 40X magnification for general features and at a magnification of up to 1200X as needed.

Photographs were taken at the desired magnification to show details as needed.

RESULTS AND DISCUSSION

RESULTS AND DISCUSSION

Microtus ochrogaster

Embryological studies require accurately aged embryos if the data obtained is to be reliable. *Microtus ochrogaster* was chosen as the experimental animal for this study because its embryos can be aged within plus or minus one hour.

Females are induced into estrus by the presence of a male for 48-72 hours. Ovulation occurs 10.5 $\pm$ 1 hour after copulation (Christenson, '69). By recording the time of copulation and subtracting 10.5 hours, embryos can be collected within plus or minus one hour of the age required for study.

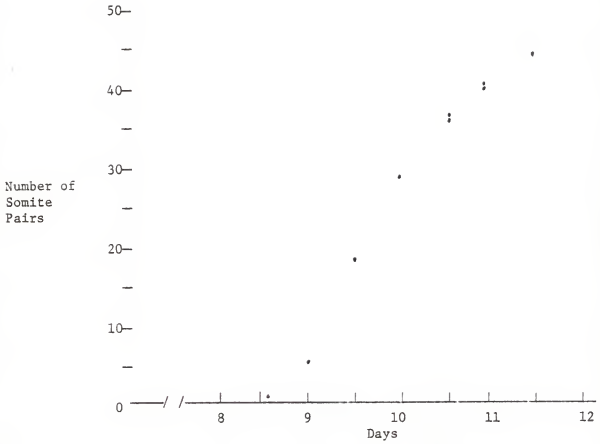
The accuracy of the system and uniformity of development in this species is attested by the consistency of somite counts as shown in figure 1.

Somite Formation

Somites form from the somitic mesoderm of the segmental plate located lateral to the developing neural tube, somewhat as described for the chick and pig by Patten ('48, '51) and Arey ('74). The method by which the 44 pairs of block-like somites condense from this plate of mesenchymal cells was not examined although the information in the literature is inadequate and nonspecific.

The first visible somites in *Microtus* show early in the second half of the ninth day after fertilization: 8 days 14 hours after fertilization, 9 days after copulation. No 8 day 12 hour embryos had visible somites, 9 day embryos consistently had 6 pairs, 9.5 day embryos had 18 pairs, 10.5 day embryos had 37 pairs and the final number of 44 pairs was attained at

Figure 1. Somite counts of 25 aged embryos. The first somite pair appears at approximately 8 days 14 hours and the total number of 44 is present at 11.5 days. Somite formation is not an even progression. The majority of somites are formed between days 9 and 10. The only observed variation in somite numbers was in a 10.5 day and an 11 day embryo. Each had one less somite pair than the normal number for embryos of that age.


50
40
30
20
10
0
Number of Somite Pairs
8
9
10
11
12
Days

11.5 days. The greatest observed variation in somite numbers was one less pair at 10.5 and 11 days (Fig. 1).

Somite formation is progressive from cranial to caudal, as described by Patten ('48, '51), Williams ('10), Butcher ('29) and Arey ('74). The first pair is formed lateral to the caudal portion of the hindbrain immediately caudal to cranial nerve X and the last pair is formed lateral to the caudal portion of the neural tube. Somite formation in *Microtus* is not an even progression but occurs at different rates (Fig. 1), as described for the bovine by Haldiman ('73) and the white rat by Butcher ('29). After the formation of the first somite pair at about 8 days 14 hours, 5 more pairs of somites are formed in the remaining 10 hours of day 9, a rate of approximately one somite pair every 2 hours. After day 9, the rate of formation increases with 23 pairs formed in the next 24 hours, 12 pairs being formed between 9 and 9.5 days and 11 pairs between 9.5 and 10 days, a rate of approximately one pair every hour. The rate of formation progressively decreases after 10 days, with 8 pairs formed between 10 and 10.5 days, 4 pairs between 10.5 and 11 days and the last 3 pairs between 11 and 11.5 days (Fig. 1). This rate of somite formation is probably comparable to that of *Mus* and *Rattus* although no reliable references are available for these species due to the impossibility of accurately aging their embryos.

Somites extend from the caudal region of the head to the caudal region of the tail and, except for the first 5 pairs located in the head, they correspond to the positions of the vertebrae of the adult (Table 1). Somites corresponding to the cervical, thoracic and lumbar vertebrae (somites 6-29) plus those of the head (somites 1-5) were examined closely in this study.

Table 1

Somite Number	Vertebrae Type
1- 5	Head
6-12	Cervical
13-24	Thoracic
25-29	Lumbar
30-34	Sacral
35-44	Caudal

Somite Differentiation

After formation, each somite differentiates into 3 mesodermal components, sclerotome, myotome and dermatome. Differentiation is progressive from cranial to caudal, as is formation. Both processes occur concurrently so that in a single embryo it is possible to examine both somite formation and differentiation.

For descriptive purposes, I have divided somite differentiation into 6 stages, D-0 through D-5. Characteristic features, as listed in Table 2, are used to differentiate one stage from another. Since somite differentiation is progressive it is possible to examine successive stages of somite differentiation in a single embryo, the 10 day embryo has somites at all stages of differentiation (Table 3). These divisions are arbitrary and are used only to facilitate the description of somite differentiation; the process as a whole is progressive with one stage shading imperceptibly into the next.

Both Williams ('10) for the chick and Butcher ('29) for the white rat reported that each succeeding somite did not recapitulate the history of preceeding somites, either in formation or differentiation. According to them, each somite was more advanced when it first appeared than the one just anterior; the caudal somites omitting many of the stages formed in the more cranial somites. Both authors discussed and gave examples of this process as it pertained to somite formation but they were not as specific concerning differentiation. They implied that caudal somites omitted formation altogether and were in the process of differentiation when they first appeared. The only concrete example was given by Butcher ('29) who stated the 27th somite was in the process of sclerotome formation (stage D-1) when it first appeared. In *Microtus* each somite condenses from the

Table 2

Stages of Differentiation

Stage	Characteristic
D-0	Fully formed somite
D-1	Disorganization of ventral cortical wall
D-2	Disorganization of medial cranial and caudal cortical walls
D-3	Proliferation of myoblasts from hooks of dermomyotome
D-4	Formation of myotubules
D-5	Dermatome diffusion

Table 3

10 Day Embryo

Stage of Differentiation	Somite Number
D-0	24-26
D-1	20-23
D-2	15-19
D-3	10-14
D-4	4- 9
D-5	1- 3

somitic mesoderm into a D-0 somite and then proceeds through the remaining stages of differentiation. There is no omission of formation or any stages of differentiation.

Myocoele

The term myocoele has been used by different authors to describe a cavity observed in the somite during formation and/or differentiation. No indication of a myocoele of formation was observed in any of the specimens examined. The myocoele of differentiation which was described and/or illustrated between myotome and dermatome by Bardeen (1900), Williams ('10), Butcher ('29) and Patten ('48, '51) is nothing but an artifact, the result of differential shrinkage between sclerotome, dermatome and myotome during fixation, as discussed by Haldiman ('73).

Somite Structure: Stage D-0

A fully formed or D-0 somite consists of a core of mesenchymal cells surrounded by a cortex of epithelioid columnar cells, which are oriented radially to the core (Fig. 2), somewhat as described by Williams ('10), Butcher ('29), Patten ('48, '51) and Arey ('74). The cells of the cortex, although described as epithelioid are not a true epithelium since no basement membrane could be demonstrated with any of the membrane stains. The cortex is composed of distinct individual cells (Fig. 3) and is not a syncytium as described by Williams ('10), Davis ('23) and Butcher ('29). Failure of early workers to detect cell membranes was probably the result of poor fixation, inadequate stains or both.

In order to describe differentiation more clearly, I have divided the somitic cortex into 5 walls, cranial, caudal, medial, ventral and dorsolateral (Fig. 2). These walls are bounded by caudal and cranial walls of adjacent somites, neural tube, dorsal aorta and nephrotome and epidermal

ectoderm, respectively (Fig. 2). The cortical walls are separated from these structures by a noncellular jelly-like material, through which vascularization is developed providing circulation between and around all somites (Fig. 2 and 4).

The D-0 somite, as described above, is the product of somite formation and is transformed into sclerotome, myotome and dermatome during the process of differentiation.

Sclerotome Formation: Stages D-1 and D-2

Stage D-1 begins with the disorganization of the ventral cortical wall of the D-0 somite; the cells lose their epithelioid arrangement and columnar shape and become mesenchymal like those of the core (Fig. 4). As shown in figures 2 and 3, the ventral wall is angular with its medial portion bounded by the dorsal aorta and lateral portion bounded by the nephrotome. Disorganization begins in the medial portion and proceeds to the lateral portion (Fig. 4) which does not complete disorganization until stage D-2 is in progress.

As the cells of the ventral wall become disorganized, they migrate along with those of the core by ameboid movement ventromedially into the space between dorsal aorta and nephrotome (Fig. 5). The noncellular jelly apparently offers no resistance to the cellular movement.

Cells in the medial portion of the ventral wall are totally disorganized into a mass of mesenchymal cells but when the lateral portion completes its disorganization during stage D-2, a row of its cells, 2 or 3 cells in width, remains along the dorsolateral wall (Fig. 6). These cells retain their epithelioid arrangement and columnar shape, at least for a time.

Stage D-2 begins with the disorganization of the cells of the medial, cranial and caudal cortical walls, which lose their epithelioid arrangement and columnar shape and become mesenchymal like those of the core and disorganized ventral wall. Disorganization begins at the free or ventral edges and proceeds dorsally towards the dorsolateral wall (Fig. 5). As the cells disorganize, they join in the migration of the cells of the core and ventral wall. The medial, cranial and caudal cortical walls do not totally disorganize. A row of cells, 2 or 3 cells in width, remains along the dorsolateral wall retaining their epithelioid arrangement and columnar shape (Fig. 6), as did those in the lateral portion of the ventral wall.

With the completion of stage D-2, the D-0 somite has been transformed into a diffuse mass of mesenchyme medially (sclerotome) and a plate of epithelioid cells laterally (dermomyotome) (Fig. 6).

In *Microtus*, the sclerotome is composed of cells from the core and a majority of the cells from the ventral, medial, cranial and caudal cortical walls of the D-0 somite. Williams ('10), Butcher ('29) and Boyd ('60) mentioned all of these components of the D-0 somite as contributing to the sclerotome. However, they did not describe a portion of the ventral wall as remaining after its disorganization as a part of the dermomyotome. They described the "upper" portions of the other three walls as remaining but did not define "upper." Patten ('48, '51), Lewis ('10), Watt ('15), Johnson ('17), Davis ('23), Dodds ('46), Sensenig ('49), Hamilton ('52) and Haldiman ('73) did not include the cranial and caudal cortical walls in their discussion of somite differentiation. They described the somite as block-like, therefore, it must have cranial and caudal walls, but they ignored these walls in their discussion of differentiation. According to

them, only the core and medial and ventral cortical walls of the D-0 somite were involved in sclerotome formation. Arey ('74), Hamilton et al. ('46) and Langman ('69) omitted the core cells along with those of the cranial and caudal walls, considering only the ventral and medial walls as disorganizing to form sclerotome. They ignored the cranial and caudal walls in their discussion of somite differentiation, even though their initial description of the somite included these walls. In addition, they ignored the somitic core after its initial description.

Differentiation of Myotome and Dermatome: Stage D-3

With the completion of stage D-2, the D-0 somite has been transformed into a medial mass of sclerotome and a lateral epithelioid plate of dermomyotome (Fig. 6). The majority of the dermomyotome is composed of the dorsolateral cortical wall of the D-0 somite but along its edges are cells from the otherwise disorganized walls (Fig. 6). These cells give the edges of the dermomyotome a hook-like appearance in section (Fig. 6). These edges or hooks of the dermomyotome play an important role in myotome formation and they retain the names of the walls from which they are derived, except for the remnant of the medial wall, which is now designated the dorsal hook (Fig. 6).

During stage D-3, cells are proliferated from the dermomyotomic hooks (Fig. 7). As they are proliferated, the cells move along the medial surface of the dermomyotome, eventually creating a complete layer of cells (Fig. 8). In this way, the dermomyotome is transformed into a bilayered structure, the medial layer designated as myotome and the lateral layer as dermatome (Fig. 7). The proliferated cells which form the myotome are precursors to muscle cells and as such are designated myoblasts. The dermomyotomic hooks are now considered to be part of the dermatome and they continue to proliferate myoblasts, thus increasing the size of the myotome.

Williams ('10) considered the cranial and caudal hooks to be contributors of cells to a secondary sclerotome, while those of the dorsal and ventral hooks produced myoblasts. I find no evidence in *Microtus* of the production of a secondary sclerotome by the cranial and caudal hooks, rather they supply cells to the myotome. Hamilton et al. ('46) described only the dorsal and ventral hooks as contributing to the myotome. As stated earlier, they ignored the cranial and caudal walls and therefore their hooks after their initial description of the somite. Lewis ('10), Patten ('48, '51) and Hamilton ('52) described only the dorsal hook as producing myoblasts. They, too, ignored the cranial and caudal walls in somite differentiation. In addition, they have overlooked the participation of the ventral hook which definitely provides cells for the myotome in *Microtus*, as shown in figure 8. Haldiman ('73) and Arey ('74) stated the dermomyotome transformed into myotome and dermatome but did not describe the process by which it occurred. Butcher ('29) described all four hooks as being involved in myoblast production. He stated the dermomyotome of the first somite produced no myotome. I find the first somite does produce a myotome (Fig. 9).

Langman and Nelson ('68) concluded from their autoradiographic studies of the chick that the myotome did not proliferate from the hooks but from the entire medial surface of dermomyotome. They found labeled cells randomly distributed throughout the myotome and not first at the hooks with a progressive movement along the medial surface of the dermomyotome. They also found mitotic figures frequently along the medial surface but rarely at the dermomyotomic hooks which supported their autoradiographic data. I find the number of mitotic figures at the hooks to be approximately equal to those present along the medial surface of

the dermomyotome. The mitotic figures present along the medial surface could explain, in part, the random placement of labeled cells Langman and Nelson ('68) found in the myotome, but I believe the majority of cells produced in the body of the dermomyotome remain in position to increase the size of the dermomyotome and do not contribute to the myotome. Figures 7 and 8 show cells are definitely proliferated from the hooks of the dermomyotome and the majority of myotome cells are produced in this manner.

Formation of Myotubules: Stage D-4

During their proliferation and movement in stage D-3, the myoblasts progressively changed into myocytes by enlargement and elongation (Fig. 10). During stage D-4, the myocytes align themselves parallel to the long axis of the embryo with the cranial end of one myocyte adjacent to the caudal end of another. The cell membranes between longitudinally oriented cells break down forming myotubules (Figs. 11 and 12). An account of myotubule formation and its further development into muscle tissue is given by Boyd ('60) and Davis ('70). The dermatomic hooks continue to produce myoblasts during stage D-4.

Lateral Mesoderm and Vascularization

Before discussing stage D-5, the last stage of somite differentiation, it is necessary to describe the lateral mesoderm and vascularization because they play an important role in stage D-5.

During stage D-2 and D-3, the lateral mesoderm begins to migrate dorsally into the space between dermatome and epidermal ectoderm (Figs. 7 and 8). By the end of stage D-4, the lateral mesoderm has filled the space between the ventral one-third of the dermatome and epidermal ectoderm (Fig. 13). This ventral one-third of the dermatome is now designated the

ventral hook, including the ventral one-third of the cranial and caudal hooks.

As the somites form and differentiate, vascularization is developed providing circulation to the somites. Segmental arteries branch off of the aorta dorsally towards the intersomitic space (Fig. 4). As it proceeds, a branch is given off to the neural tube (Fig. 15) and the remainder of the artery continues on between adjacent somites (Fig. 14). Once within the intersomitic space, the artery continues to the epidermal ectoderm and then turns ventrally into the lateral mesoderm (Fig. 4). While in the vicinity of the somite, the artery gives off branches which course cranially and caudally in the space between the somite and epidermal ectoderm (Fig. 16). The blood is returned to the cardinal veins by segmental veins which run deep to the arteries (Fig. 17).

Dermatome Diffusion: Stage D-5

During stage D-5, the cells of the dermatome, except for those located in the hooks, loosen and diffuse outward towards the epidermal ectoderm (Figs. 18 and 19). The cells of the ventral hook remain in position (Figs. 18 and 19) and are gradually incorporated into the myotome. Cells at the dorsal hook also remain for a time. They have the appearance of an upside-down U, with cells being proliferated from both ends of the "U" (Figs. 18 and 19). The cranial and caudal hooks also remain but they are not as distinct as the dorsal hook.

Dermatome diffusion begins at the junction of the ventral hook with the rest of the dermatome (Figs. 18 and 19). The area of diffusion then spreads until all of the cells of the dermatome between its hooks are diffused. When diffusion begins, an artery is found within the dermatome at the point where diffusion first starts (Fig. 20). It is possible that

the ingrowth of blood vessels within the substance of the dermatome is the stimulus for dermatome diffusion.

Diffusion of the dermatome is limited ventrally by lateral mesoderm, dorsally by sclerotome and cranially and caudally by the diffused dermatomes of adjacent somites.

Neither Patten ('48, '51) nor Arey ('74) described the process of dermatome diffusion. Both Williams ('10) and Butcher ('29) reported diffusion began at the center of the dermatome, and according to Williams ('10), the diffusion then spread in all directions. Butcher ('29) stated the diffusion spread ventrally in the dermatomes of the cervical, forelimb and hindlimb regions while that of the thoracic dermatomes spread dorsally. In *Microtus*, there is no difference in the method of diffusion between the dermatomes of different regions. Diffusion does not begin in the center of the somite but near the junction between the ventral hook and the remainder of the dermatome (Figs. 18 and 19). The diffusion never spreads ventrally because it would include the ventral hook which does not diffuse (Fig. 19). Both Williams ('10) and Butcher ('29) reported the dermatomic hooks remained as zones of growth for some time after dermatome diffusion. Williams ('10) considered the cranial and caudal hooks to produce mesenchymal cells while the cells of the dorsal and ventral became myoblasts. Butcher ('29) only mentioned the dorsal and ventral hooks, with the dorsal hook producing mostly mesenchyme and the ventral hook producing mostly myoblasts. In *Microtus*, the dorsal, cranial and caudal hooks contribute cells to both the dermatome and myotome and the ventral hook is incorporated into the myotome. Neither Williams ('10) nor Butcher ('29) mentioned the lateral mesoderm and its part in the development of the ventral hook nor did they mention the presence of arteries within the substance of the dermatome.

Bardeen (1900) reported the dermatome of the pig was totally converted into muscle tissue, except for a few cells which degenerated. He described a limiting capsule surrounding the dermatome and myotome, which prevented the dermatome from diffusing. I find no such limiting capsule in *Microtus* and as figures 18 and 19 show, the dermatome definitely diffuses.

At the end of stage D-5, the three products of somite differentiation, sclerotome, myotome and dermatome, are present and in the process of forming their definitive structures.

Sclerotome

After its formation in stages D-1 and D-2, cells of the sclerotome migrate by ameboid movement filling and expanding the space between dorsal aorta and neural tube with the sclerotomes of opposite sides meeting and producing a complete layer of sclerotome between the two structures (Figs. 7, 13 and 21). As somite differentiation proceeds, the sclerotome cells move between notochord and neural tube eventually surrounding the notochord and separating it from the neural tube (Fig. 22). A portion of the sclerotome cells migrates dorsally towards the epidermal ectoderm filling the space between the original D-0 somite and neural tube (Figs. 7, 13, and 18). By stage D-5, the dorsal sclerotome cells have reached the ectoderm and migrated medially producing a complete layer of sclerotome between neural tube and ectoderm (Fig. 22). The presence of this dorsal sclerotome limits the dorsomedial diffusion of dermatome.

Most of the sclerotome is involved in the formation of the vertebral column and ribs and the base of the skull, as discussed by Haldiman ('73) and Matthews ('72), respectively. The dorsal sclerotome, that portion next to the ectoderm, however, is not involved in bone formation but dermis formation. Sensenig ('49) mentioned the dorsal migration of

sclerotome but considered it to be incorporated into the neural arch. It is probable that a majority of the sclerotome which migrates dorsally does participate in the production of the neural arch but that portion which comes in contact with the epidermal ectoderm is involved in dermis formation.

Origins of the Dermis

The actual process by which mesoderm becomes dermal connective tissue was not examined in detail, but its progress was followed from the end of somite differentiation to full-term embryos. I find that four embryonic structures are involved in dermal development.

The dermis directly over the neural tube is derived from the dorsal sclerotome, the dermis on either side of the neural tube is derived from the diffused dermatome, the dermis of the head is derived from head mesoderm and that of the rest of the body is derived from lateral mesoderm.

Each of these mesoderms which become dermis are all located adjacent to the epidermal ectoderm. It appears that when somitic, somatic or head mesodermal cells are adjacent to the epidermal ectoderm they form dermis. Only that portion of the sclerotome which comes to lie next to the ectoderm forms dermis, while the remainder forms bone. The participation of sclerotome in the formation of dermal connective tissue has never been reported before this study. Only the portion of the dermatome which is adjacent to the epidermal ectoderm diffuses and transforms into dermis. The ventral dermatomic hook, which is separated from ectoderm by lateral mesoderm, does not diffuse and is incorporated into the myotome. The importance of lateral mesoderm in dermatome diffusion has never been reported before this study. Those portions of the lateral mesoderm and head mesoderm next to the ectoderm become dermis, while deeper cells convert into muscle tissue or other mesodermal structures.

It has been recognized that the underlying dermis has an effect on the development of the epidermal ectoderm and its derivatives (Montagna, '62; Sengel, '76). It now appears that the epidermal ectoderm induces the underlying mesoderm to form dermis.

Patten ('48, '51) and Arey ('74) concluded, in general, that while part of the dermis was derived from dermatome, much of the dermis developed from other mesenchyme subjacent to the epidermis, most of which came from the sheets of lateral mesoderm and head mesoderm. Neither had any direct evidence to support their conclusion.

Murray ('28) provided some evidence for the multiple origin of dermis when he discovered fragments of 2 day chicks grafted to the chorioallantois of 8 day chicks produced dermis whether or not the grafts contained somitic mesoderm. He concluded that the dermis of the dorsal and dorsolateral regions arose from the dermatome while the remainder of the dermis arose from cells of the somatopleur but he made no direct observation of the transformation.

Straus and Rawles ('53) used both carbon marking and grafting to study chick development. They also found that dermis could be developed with or without the presence of somitic mesoderm. They concluded the dermis arose from any mesoderm in contact with or subjacent to the ectoderm and not from one restricted area of mesoderm arbitrarily designated "dermatome."

My observations agree basically with those of Straus and Rawles ('53). In *Microtus*, when somitic, somatic or head mesoderm comes in contact with the epidermal ectoderm, it is induced to form dermis.

LITERATURE CITED

LITERATURE CITED

Arey, L. B. 1974 Developmental Anatomy. Seventh Edition. W. B. Saunders Co., Philadelphia, pp. 286; 426-429; 439-441; 569-570.

Bardeen, C. R. 1900 The development of the musculature of the body wall in the pig, including its histogenesis and its relations to the myotomes and to the skeletal and nervous apparatus. Johns Hopkins Hosp. Rep., 9:367-400.

Boyd, J. D. 1960 Development of striated muscle. In: The Structure and Function of Muscle. G. H. Bourne, ed. Academic Press, New York, Vol. 1, pp. 63-84.

Butcher, E. O. 1929 The development of the somites in the white rat (*Mus norvegicus albinus*) and the fate of the myotomes, neural tube, and gut in the tail. Am. J. Anat., Vol. 44, 3:381-439.

Christenson, C. M. 1969 Some Factors Relating to Behavioral Characteristics of *Microtus ochrogaster*. Ph.D. Dissertation, Kansas State University. 93 pp.

Davis, C. L. 1923 Description of a human embryo having twenty paired somites. Contributions to Embryology No. 2, Carnegie Inst. Wash. Pub. 332, pp. 1-51.

Davis, M. M. 1970 Muscle Differentiation in the Forelimb of Mammals. Ph.D. Dissertation, Kansas State University. 44 pp.

Dodds, G. S. 1946 The Essentials of Human Embryology. Third Edition. John Wiley and Sons, Inc., New York, pp. 81-85; 95; 111-118.

Haldiman, J. T. 1973 Development of the Bovine Axial Skeleton. Ph.D. Dissertation, Kansas State University. 49 pp.

Hamilton, W. J., J. D. Boyd and H. W. Mossman. 1946 Human Embryology. W. Heffer and Sons Ltd., Cambridge, pp. 44; 294; 309-313; 322.

Hamilton, H. L. 1952 Lillie's Development of the Chick. Third Edition. Holt, Rinehard and Winston, New York, pp. 149; 229-237; 510-513; 546.

Johnson, F. P. 1917 A human embryo of twenty-four pairs of somites. Contributions to Embryology No. 19, Carnegie Inst. Wash. Pub. 226, pp. 5-44.

Langman, J. and G. R. Nelson. 1968 A radioautographic study of the development of the somite in the chick embryo. J. Embryol. exp. Morph., Vol. 12, 2:217-226.

Langman, J. 1969 Medical Embryology. Second Edition. The Williams and Wilkins Co., Baltimore, pp. 129-147; 364-366.

Lewis, W. H. 1910 The development of the muscular system. In: Manual of Human Embryology. F. Keibel and F. Mall, eds. J. B. Lippincott Co., Philadelphia, Vol. 1, pp. 454-522.

Matthews, G. 1972 The Bovine Skull. M. S. Thesis, Kansas State University. 30 pp.

Montagna, W. 1962 The Structure and Function of Skin. Second Edition. Academic Press, New York. pp. 430-432.

Murray, P. D. F. 1928 Chorio-allantoicgrafts of fragments of the two-day chick, with special reference to the development of the limbs, intestine and skin. Aust. J. Exp. Biol. and Med. Sci., Vol. V, 4:237-256.

Patten, B. M. 1948 Embryology of the Pig. Third Edition. The Blakiston Co., Philadelphia, pp. 54; 80-83; 286.

_____. 1951 Early Embryology of the Chick. Fourth Edition. McGraw-Hill Book Co., Inc., New York, pp. 89-91; 153-155.

Rabl, C. 1888 Ueber die Differenzierung des Mesoderms. Verh. d. Anat. Geo., Wurzburg, Vol. 2, pp. 140-146. (*fide* Williams, 1910).

Sengel, P. 1976 Morphogenesis of Skin. Cambridge University Press, Cambridge, pp. 68-70; 118-122.

Sensening, E. C. 1949 The early development of the human vertebral column. Contributions to Embryology No. 214, Carnegie Inst. Wash. Pub. 583, pp. 21-41.

Straus, W. L. and M. E. Rawles 1953 An experimental study of the origin of the trunk musculature and ribs in the chick. Am. J. Anat., Vol. 92, 3:471-509.

Watt, J. C. 1915 Description of two young twin human embryos with 17-19 paired somites. Contributions to Embryology No. 2, Carnegie Inst. Wash. Pub. 222, pp. 21-41.

Williams, L. W. 1910 The somites of the chick. Am. J. Anat., Vol. 11, 1:55-100.

ABBREVIATIONS

A	segmental artery	G	gut
a	branch of segmental artery	LM	lateral mesoderm
CrH	cranial hook	M	myotome
Co	core	Md	medial cortical wall
Ct	cortex	N	notochord
D	dermatome	Ne	nephrotome
DA	dorsal aorta	NT	neural tube
DH	dorsal hook	CaH	caudal hook
Dl	dorsolateral cortical wall	S	sclerotome
DM	dermomyotome	V	segmental vein
DS	dorsal sclerotome	VH	ventral hook
EE	epidermal ectoderm	Vt	ventral cortical wall

PLATE I

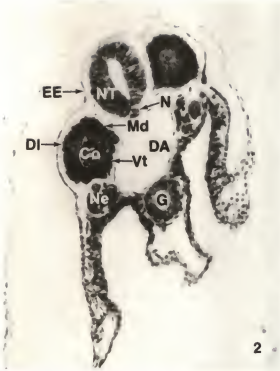
Explanation of Figures

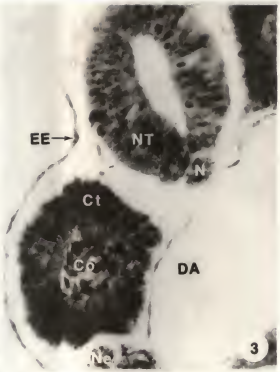
2 Transverse section of a D-0 somite in the thoracic region of a 9.5 day embryo. The medial (Md), ventral (Vt) and dorsolateral (Dl) cortical walls are bounded by neural tube (NT), dorsal aorta (DA) and nephrotome (Ne) and epidermal ectoderm (EE), respectively. PAS-Hematoxylin X 144.

3 Higher magnification of somite in Figure 2. Mesenchymal core cells (Co) are surrounded by epithelioid, columnar, radially arranged cortical cells (Ct). PAS-Hematoxylin X 144.

4 Transverse section of a D-1 somite in the thoracic region of a 9.5 day embryo. Cells of the ventral cortical wall (Vt) are disorganizing and becoming mesenchymal. On the opposite side of the embryo, a segmental artery (A) branches off the dorsal aorta (DA). It runs dorsally, in the intersomitic space towards the epidermal ectoderm (EE). Upon reaching the epidermal ectoderm, it turns ventrally towards the lateral body wall. PAS-Hematoxylin X 144.

5 Transverse section of a D-2 somite in the cervical region of a 9.5 day embryo. The medial portion of the ventral cortical wall is totally disorganized and the lateral portion (Vt) continues disorganization. The cells of the medial cortical wall (Md) are disorganizing. The newly formed sclerotome cells (S) are migrating into the space between neural tube (NT) and dorsal aorta (DA). PAS-Hematoxylin X 144.


EE
NT
N
Md
DI
Co
Vt
DA
Ne
G
2


EE
NT
N
Ct
Co
DA
Ne
3


A
EE
DA
Co
Vt
G
4

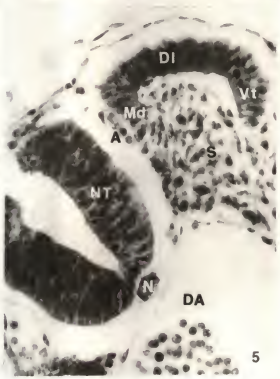

DI
Vt
Md
A
S
NT
N
DA
5

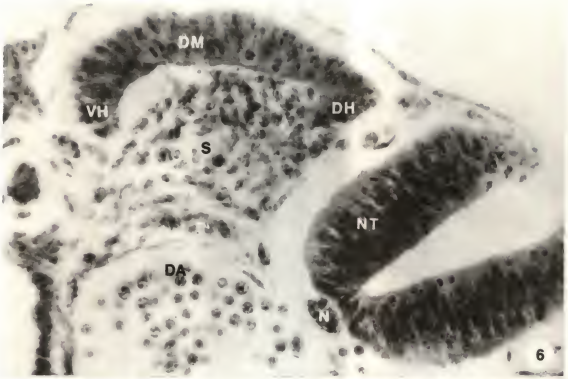
PLATE II

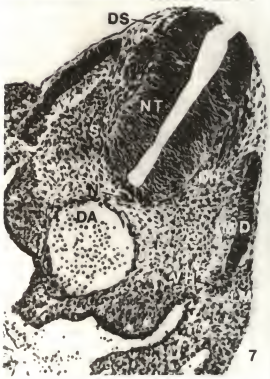
Explanation of Figures

6 Transverse section of a late D-2 somite in the cervical region of a 9.5 day embryo. The D-0 somite, as seen in Figure 2, has been transformed into a medial mass of sclerotome (S) and a lateral plate of dermomyotome (DM). Portions of the ventral and medial cortical walls remain as the ventral (VH) and dorsal hooks (DH) of the dermomyotome, respectively. PAS-Hematoxylin X 456.

7 Transverse section of a D-3 somite in the thoracic region of a 10.5 day embryo. The D-3 somite consists of a lateral layer of dermatome (D) and medial layer of myotome (M). Sclerotome (S) has filled the space between neural tube (NT) and dorsal aorta (DA). Dorsal sclerotome (DS) is present. Lateral mesoderm (LM) is migrating dorsally separating dermatome from epidermal ectoderm (EE). Harris Hematoxylin-Mallory's Triple X 144.

8 Higher magnification of somite in Figure 7. The dermomyotome, as seen in Figure 6, has been transformed by myoblast proliferation, into a medial layer of myotome (M) and a lateral layer of dermatome (D). Myoblasts are proliferating from the dorsal (DH) and ventral hooks (VH) of dermatome. Lateral mesoderm (LM) is migrating dorsally between dermatome and epidermal ectoderm (EE). Sclerotome cells (S) are migrating dorsally between neural tube (NT) and dermatome. Harris Hematoxylin-Mallory's Triple X 287.


DM
VH
DH
S
NT
DA
N
6


DS
NT
S
N
DA
MD
7

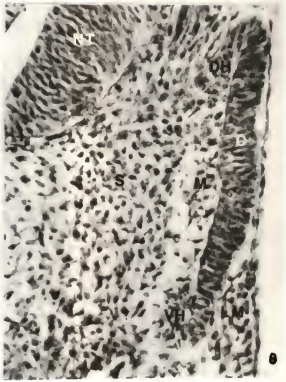

NT
DH
S
VH
8

PLATE III

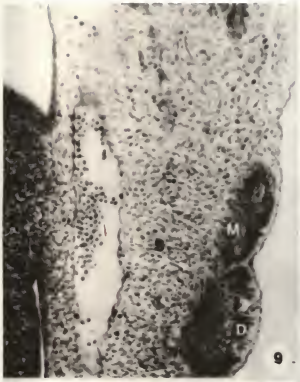
Explanation of Figures

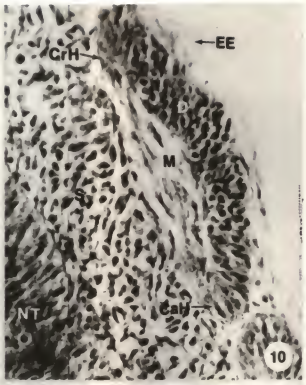
9 Sagittal section of D-5 somites of a 10 day embryo. The myotome (M) of somite number one is present. Levaditi X 144.

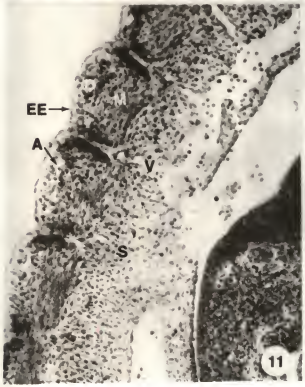
10 Coronal section of a D-3 somite in the tail region of an 11.25 day embryo. Myocytes are found in the myotome (M). Myoblasts are proliferating from the cranial (CrH) and caudal hooks (CaH). PAS-Hematoxylin X 144.

11 Sagittal section of a D-5 somite in the head region of a 10 day embryo. The myocytes of the myotome (M) have transformed into myotubules. Segmental arteries (A) are present within the dermatome (D). A segmental vein is returning blood from the somites. Levaditi X 144.

12 Sagittal section of a D-5 somite in the head region of a 10 day embryo. Myotubules of the myotome (M) are present. A segmental artery (A) is present within the dermotome (D). Levaditi X 144.


M
D
9


CrH
EE
D
M
NT
CaH
10


EE
A
V
S
11

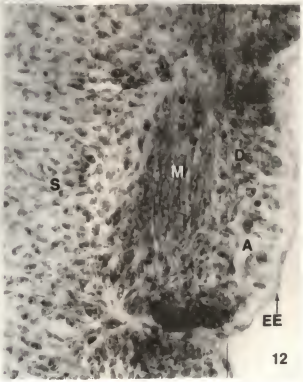

S
M
D
A
EE
12

PLATE IV

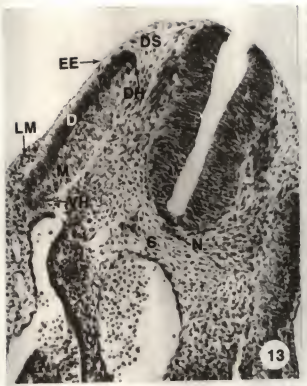
Explanation of Figures

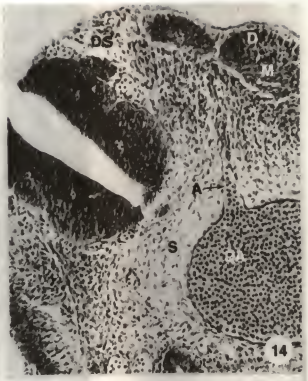
13 Transverse section of a D-4 somite in the thoracic region of a 10.5 day embryo. Lateral mesoderm (LM) has separated the ventral one-third of the dermatome (VH) from the epidermal ectoderm (EE). Dorsal sclerotome (DS) is present. Sclerotome (S) has expanded the space between neural tube (NT) and dorsal aorta (DA). Harris Hematoxylin-Mallory's Triple X 144.

14 Transverse section of D-4 or D-5 somites in the thoracic region of an 11 day embryo. A segmental artery (A) branches off the dorsal aorta (DA) and travels through the sclerotome (S) to the intersomitic space. PAS-Hematoxylin X 144.

15 Transverse section in the thoracic region of an 11.25 day embryo. An artery (a) branches off the segmental artery (A) and runs towards the neural tube (NT). The segmental artery (A) continues towards the dermatome. PAS-Hematoxylin X 144.

16 Coronal section of D-4 somites in the thoracic region of an 11 day embryo. A segmental artery (A) sends branches (a) cranially and caudally between dermatome (D) and epidermal ectoderm (EE). PAS-Hematoxylin X 144.


EE
DS
DH
LM
D
M
VH
V
S
N
13


DS
D
M
A
S
14


NT
A
S
A
15

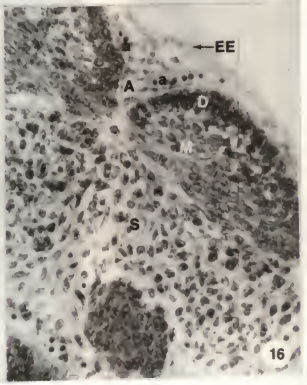

EE
A
D
M
V
S
16

PLATE V

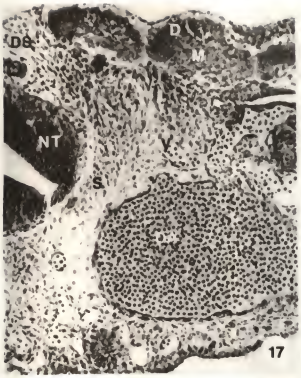
Explanation of Figures

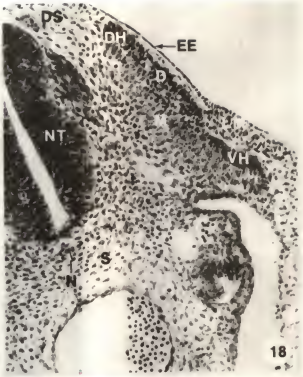
17 Transverse section of D-4 or D-5 somites in the thoracic region of an 11 day embryo. A segmental vein (V) is returning blood from the somite. PAS-Hematoxylin X 144.

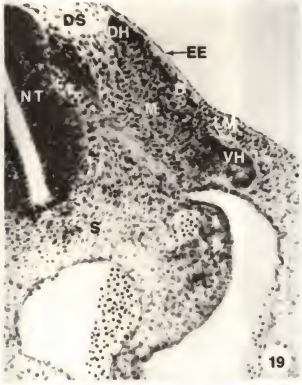
18 Transverse section of a D-5 somite in the thoracic region of an 11.25 day embryo. Dermatome (D) has begun diffusion. Dorsal sclerotome (DS) is present. Sclerotome (S) is separating the notochord (N) from neural tube (NT). PAS-Hematoxylin X 144.

19 Transverse section of a D-5 somite in the thoracic region of an 11.25 day embryo. Dermatome (D) is diffusing. The dorsal (DH) and ventral hooks (VH) are not participating in the diffusion. PAS-Hematoxylin X 144.

20 Coronal section of D-4 or D-5 somites in the thoracic region of an 11 day embryo. A segmental artery (A) is seen within the dermatome (D). PAS-Hematoxylin X 144.


DS
D
M
NT
S
17


DS
DH
EE
D
M
NT
VH
S
N
18


DS
DH
EE
NT
M
VH
S
19

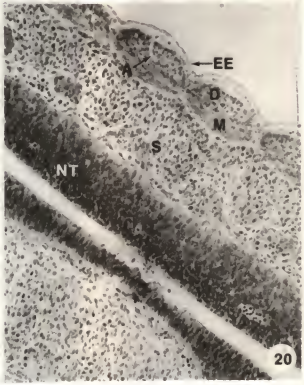
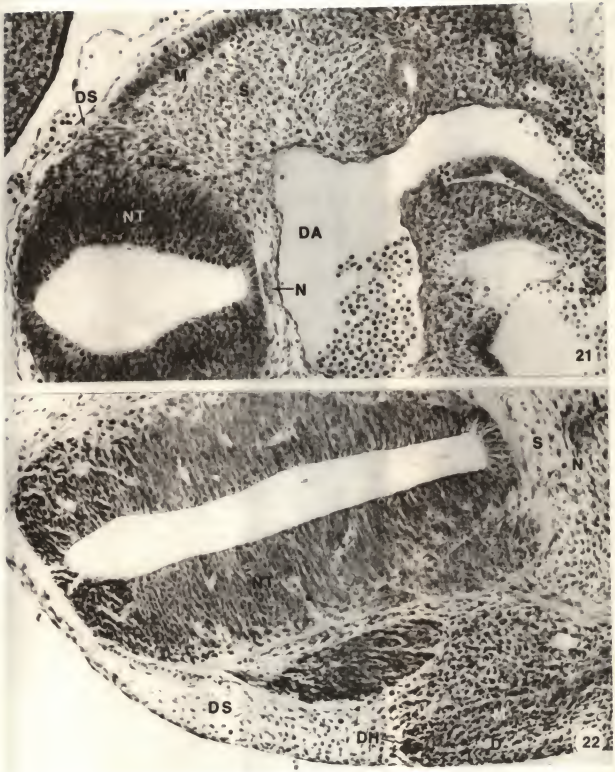

EE
D
M
S
NT
20

PLATE VI

Explanation of Figures

21 Transverse section of a D-3 somite in the hind limb region of a 10 day embryo. Sclerotome (S) is filling the space between neural tube (NT) and dorsal aorta (DA) and is migrating dorsally between neural tube and dermatome (D). Levaditi X 478.

22 Transverse section in the front limb region of an 11.25 day embryo. Dermatome is totally diffused. The dorsal hook (DH) remains. Dorsal sclerotome (DS) is present. Sclerotome (S) has separated notochord (N) from neural tube (NT). Harris Hematoxylin-Mallory's Triple X 652.


DS
M
S
NT
DA
N
21
S
N
NT
DS
DH
22

SOMITE DIFFERENTIATION IN MICROTUS OCHROGASTER WITH SPECIAL REFERENCE TO THE ORIGINS OF THE DERMIS

by

SALLY ROBINSON

B. A. STEPHENS COLLEGE, 1972

AN ANSTRACT OF A MASTER'S THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of
Anatomy and Physiology

KANSAS STATE UNIVERSITY
Manhattan, Kansas

1979

ABSTRACT

Somites form from the somitic mesoderm of the segmental plate located lateral to the developing neural tube. In Microtus, the first somite pair is visible at approximately 8 days 14 hours. At 9 days, there are 6 somite pairs. At 10 days, 29 pairs are present. Eleven day embryos have 41 pairs and the total number of 44 is attained at 11.5 days. The first somite pair is located immediately posterior to cranial nerve X and the remaining pairs extend to the tip of the tail.

After formation, somites differentiate into sclerotome, myotome and dermatome. I have divided differentiation into 6 stages, D-0 through D-5. Stage D-0 somites have not begun differentiation and are composed of a core of mesenchymal cells surrounded by a cortex of epithelioid columnar cells, which are arranged radially to the core. The cortex is divided into 5 walls, ventral, medial, dorsolateral, anterior and posterior.

During stages D-1 and D-2, the cells of the ventral, medial, anterior and posterior walls disorganize and become mesenchymal, producing the sclerotome. The remaining portion of the D-0 somite, the dermomyotome, is composed primarily of the dorsolateral cortical wall but around its edge is a row of cells (2 or 3 cells in width) from the otherwise disorganized walls. These remnants give the edges of the dermomyotome a hook-like appearance when sectioned.

Myoblasts are proliferated from the hooks during stage D-3 changing the dermomyotome into a medial layer of myotome and a lateral layer of dermatome. The myoblasts progressively become myocytes by enlargement and elongation. In stage D-4, the myocytes become myotubules.

During the above stages, lateral mesoderm migrated dorsally separating the ventral one-third of dermatome from the epidermal ectoderm and a por-

tion of the sclerotome migrated dorsally filling the space between neural tube and epidermal ectoderm. This sclerotome is termed the dorsal sclerotome.

During stage D-5, the cells of the dermatome located between the hooks diffuses toward the epidermal ectoderm. The diffusion is restricted by dorsal sclerotome dorsally, lateral mesoderm ventrally and diffusing dermatomes of adjacent somites anteriorly and posteriorly. Arteries are found within the substance of the dermatome while it is diffusing.

Dermis is derived from the dorsal sclerotome, diffused dermatome and the portions of the lateral and head mesoderms located adjacent to the epidermal ectoderm. All of these mesoderms, which become dermis are located next to epidermal ectoderm, while the portions of the same structures not located next to the ectoderm do not become dermis. It appears that epidermal ectoderm somehow induces somitic, somatic and head mesoderm to become dermis.