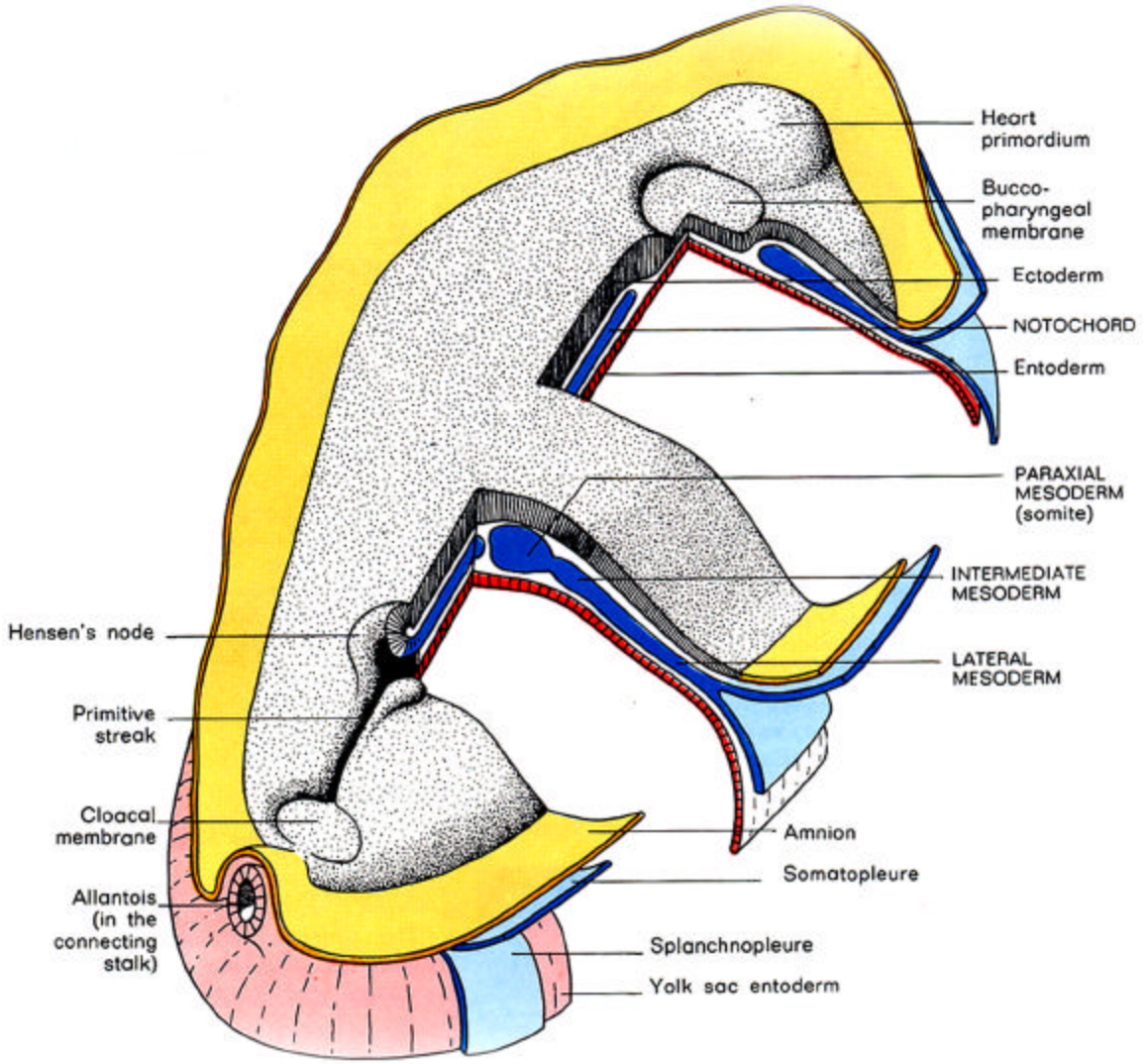
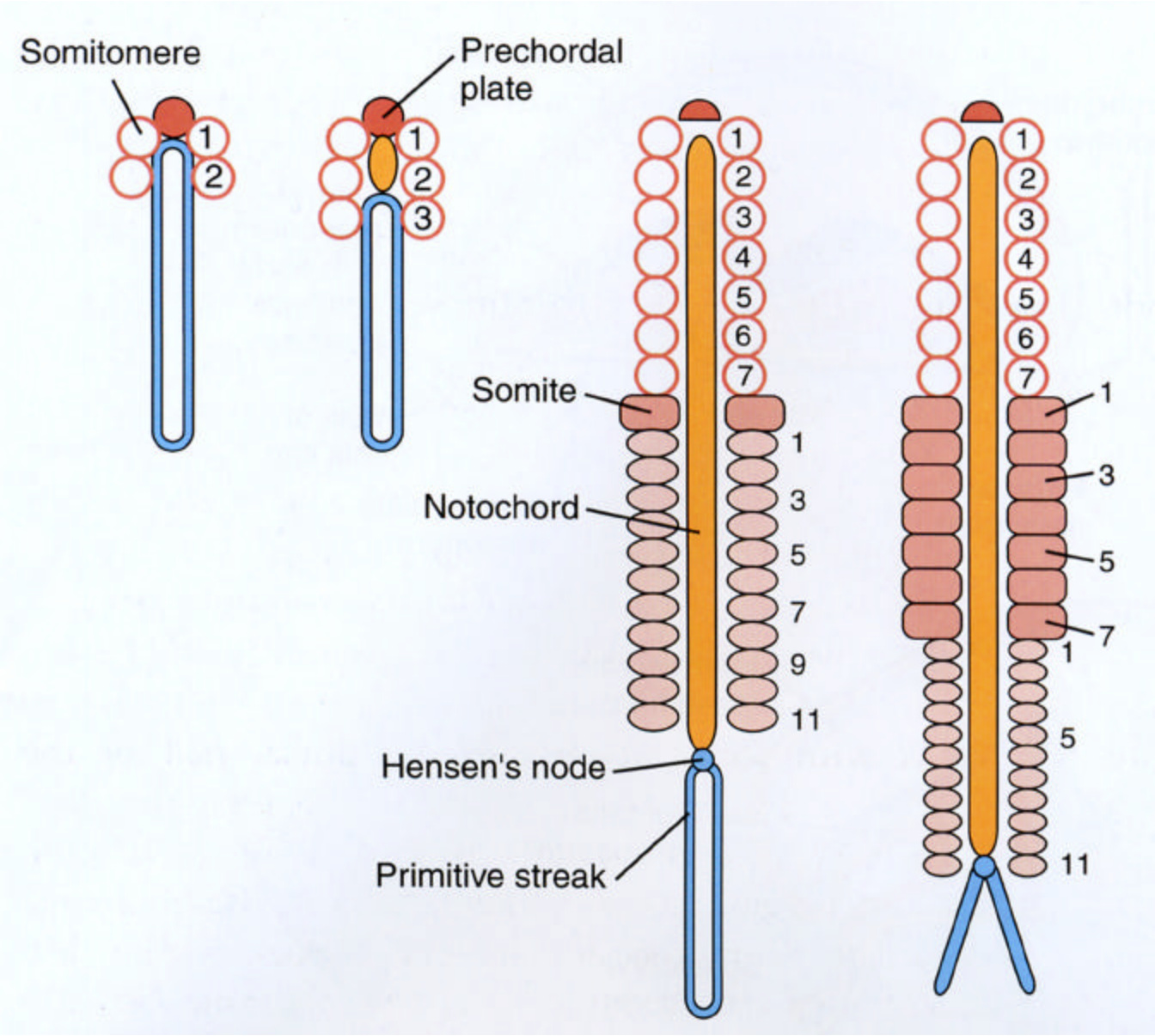
Mesoderm formation & Segmentation

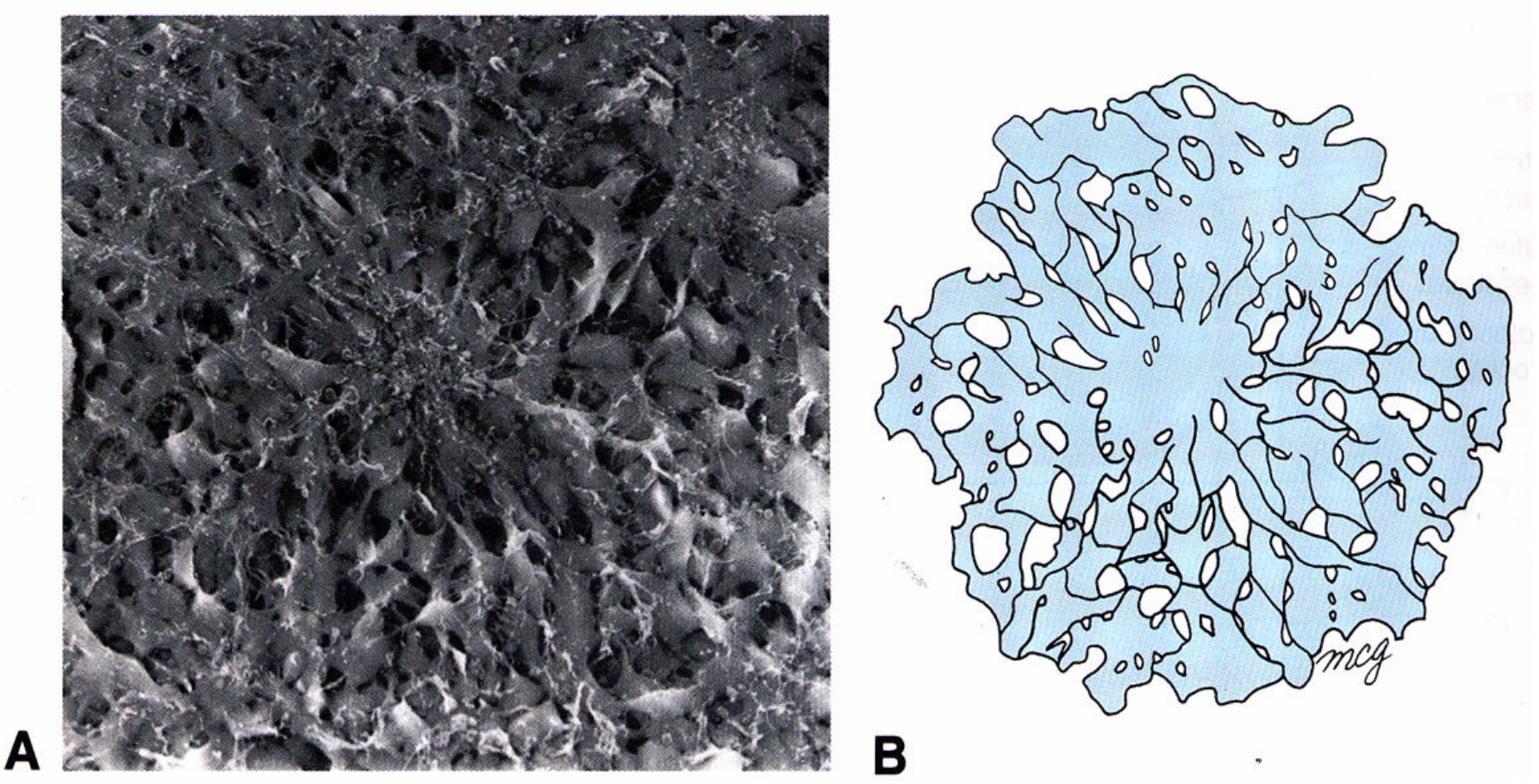
Organization of the mesoderm toward the end of gastrulation.



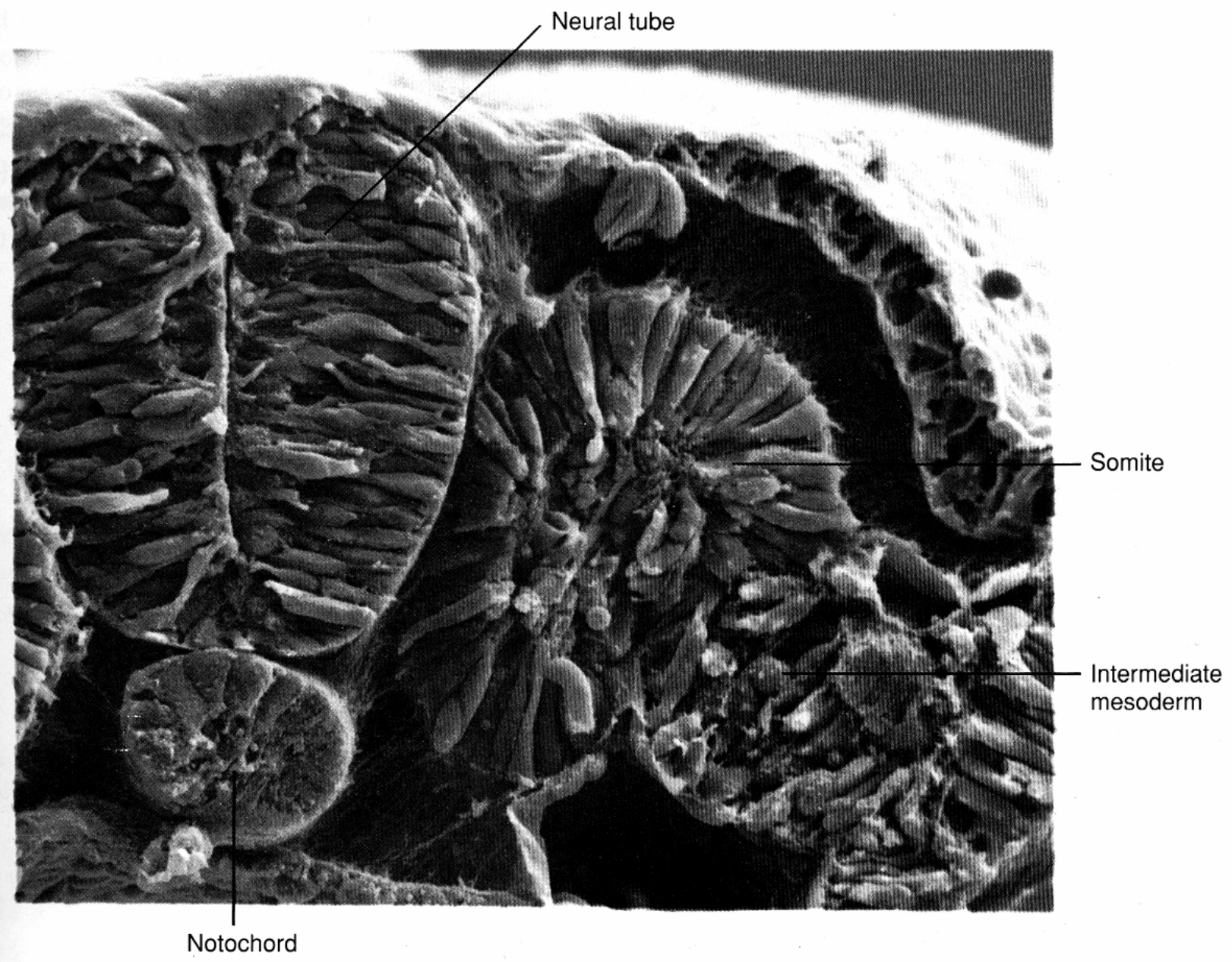
Sequential appearance of somitomeres and somites



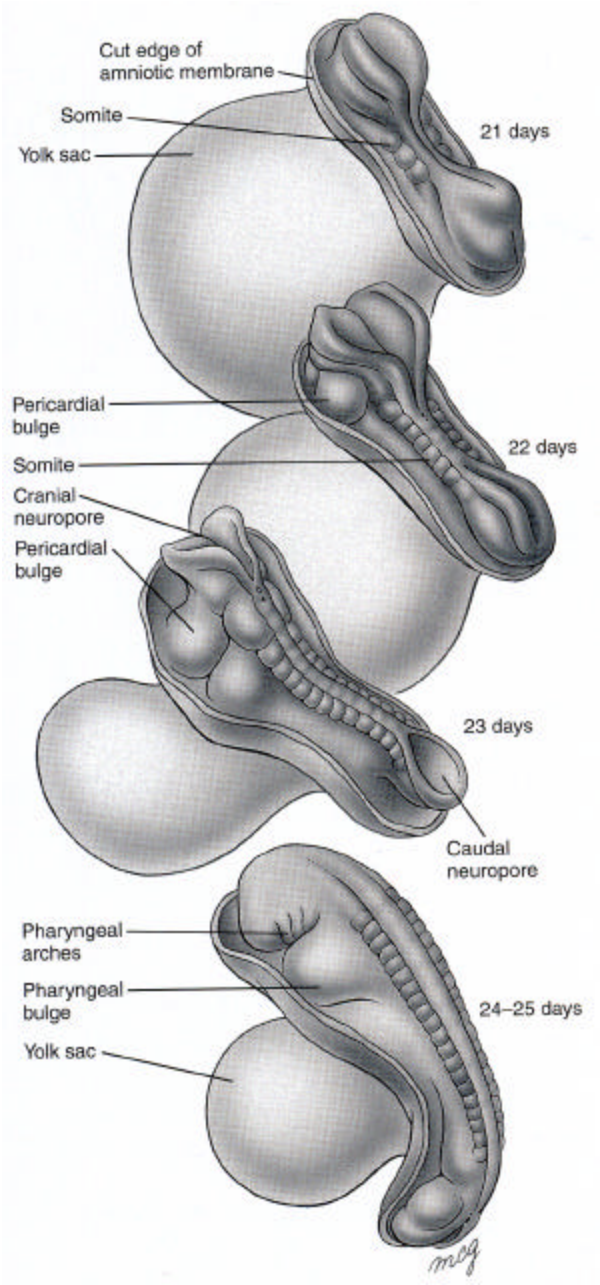
Scanning EM and diagram of somitomere.



Scanning EM of the epithelial somite.



Sequential addition of somites from day 21-day 25 post-conception



Steps in the addition of somites.

1. Paraxial mesoderm is laid down sequentially by the retreating primitive streak.

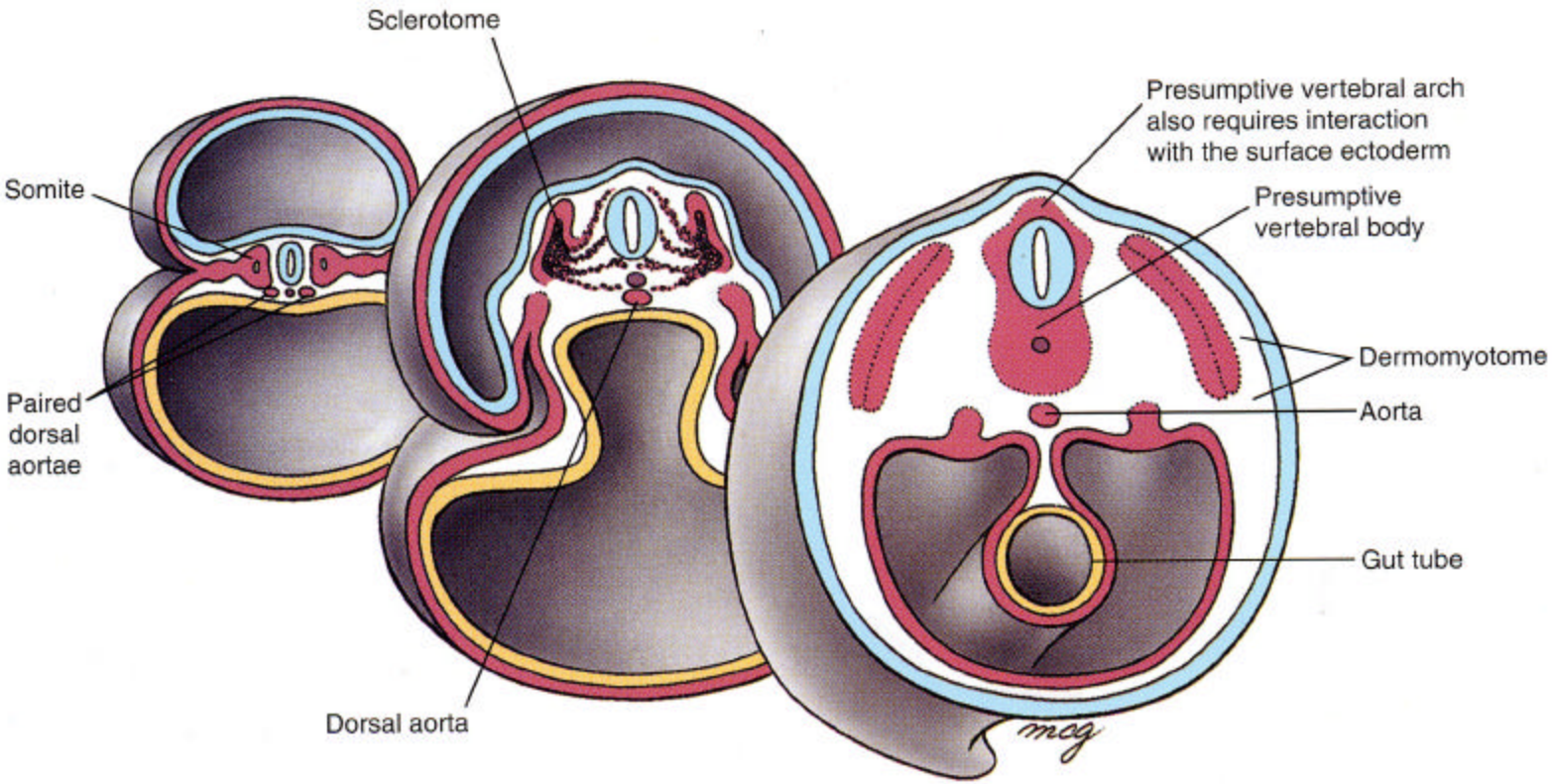
2. An oscillation of gene transcription generates each somite pair in sequence.

3. This pulsatile pattern is initiated in the somite precursors/presomitic mesoderm.

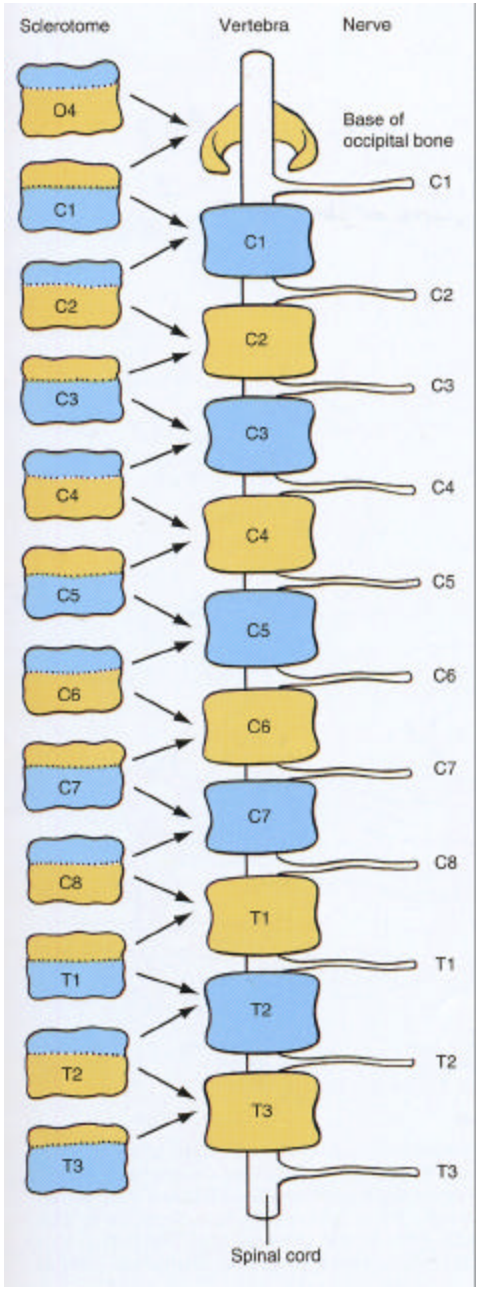
TABLE 6-1 *Subdivisions of the Epithelial Somite*

	Dorsal	
	DERMATOME	**DERMATOME**
	Dermis	Dermis
	Myotome	Myotome
	Intrinsic back muscles (epaxial)	Limb muscles
		Muscles of ventrolateral body wall
MEDIAL	**SOMITOCOEL CELLS**	**LATERAL**
	Intervertebral joint surfaces	
	SCLEROTOME	**SCLEROTOME**
	Vertebral body	Vertebral arch
	Intervertebral disk	Pedicle of vertebra
	Proximal part of rib	Distal part of rib
	Connective tissue	Connective tissue around dorsal root ganglion
	Ventral	

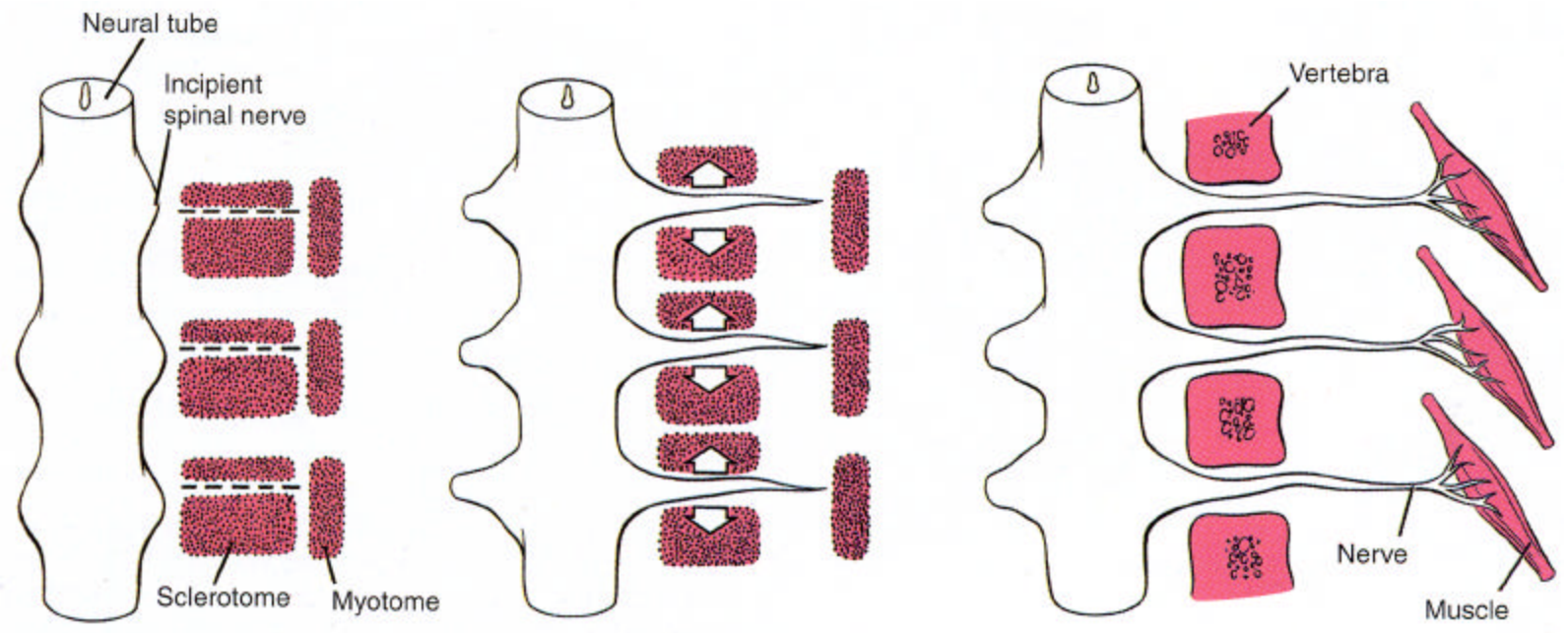
Fate of medial ventral somite: sclerotome.

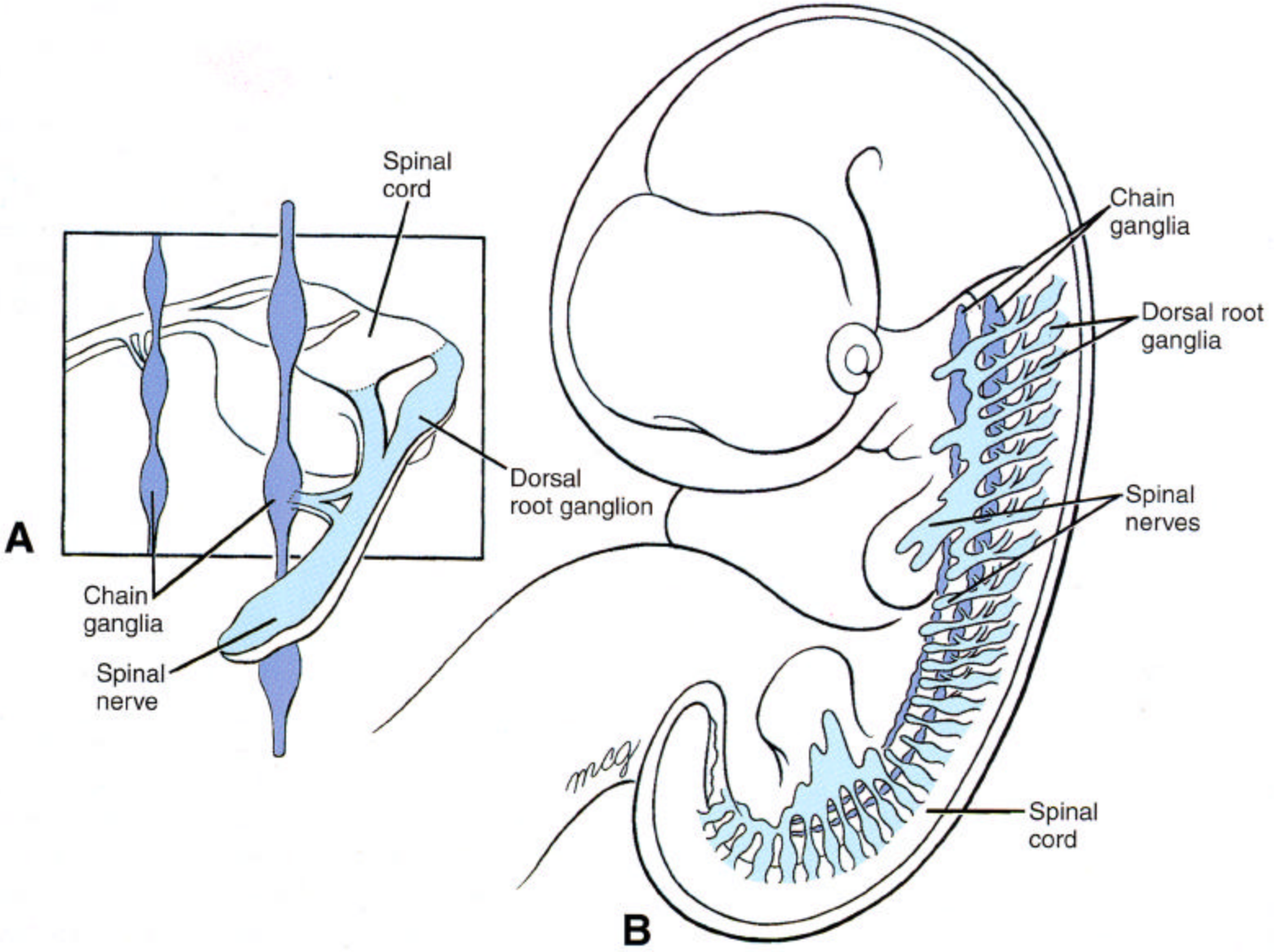


Each vertebrate is formed from the caudal portion of one somite and the cranial portion of the next.

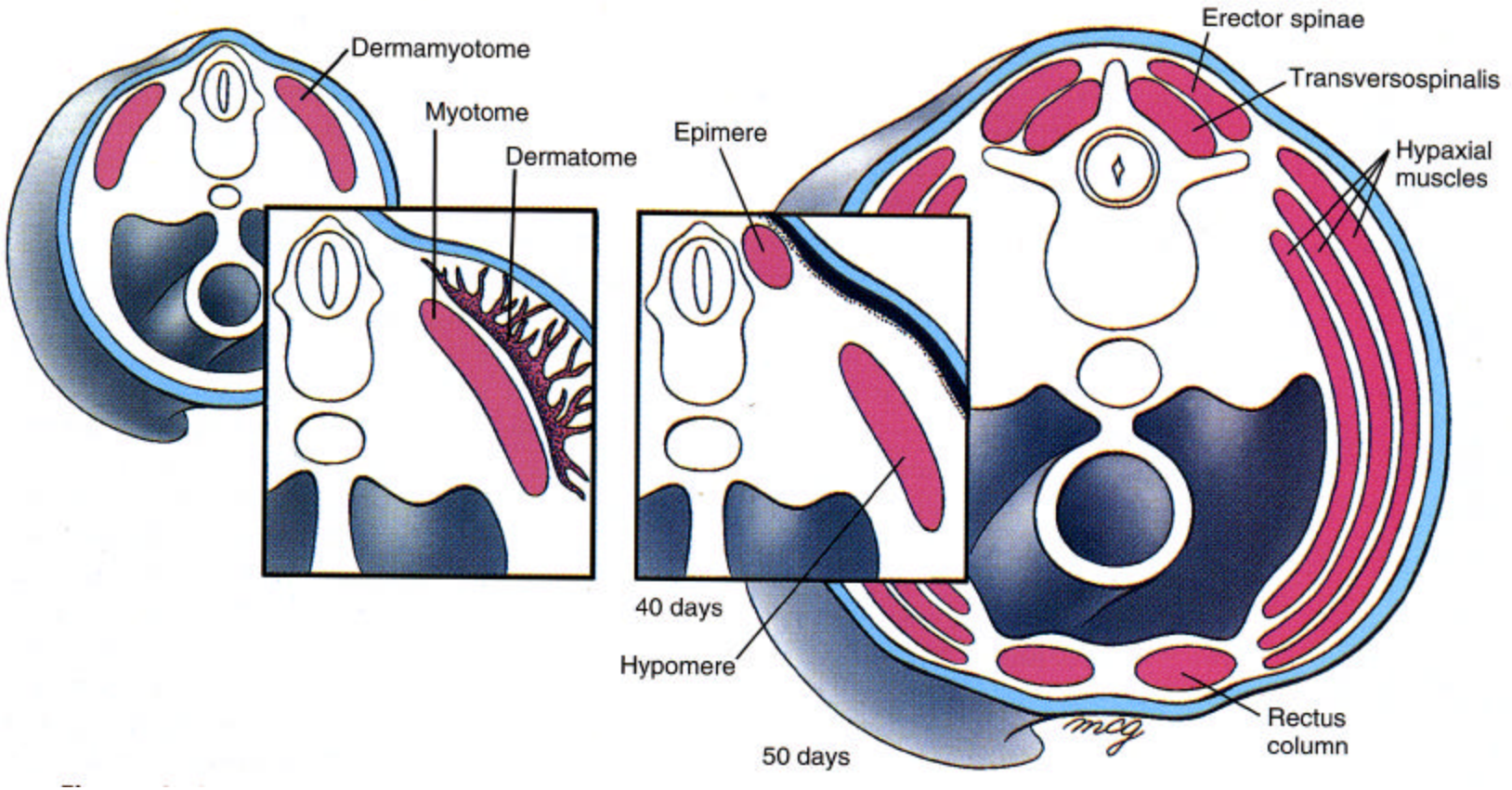


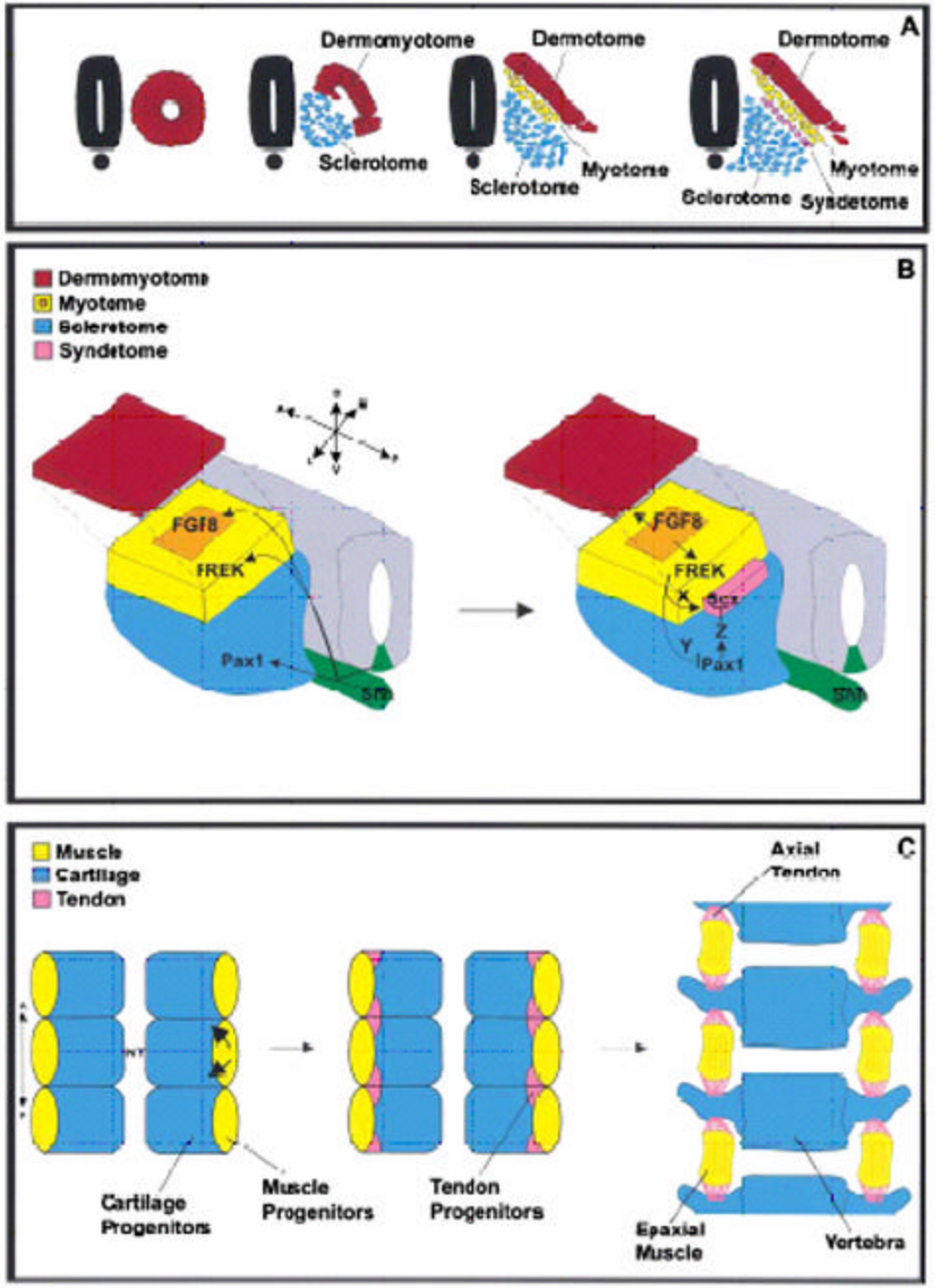
Each spinal nerve traverses the cranial aspect of the sclerotome as it grows to innervate the myotome. The segmental nature of the PNS is due to segmentation of somites.



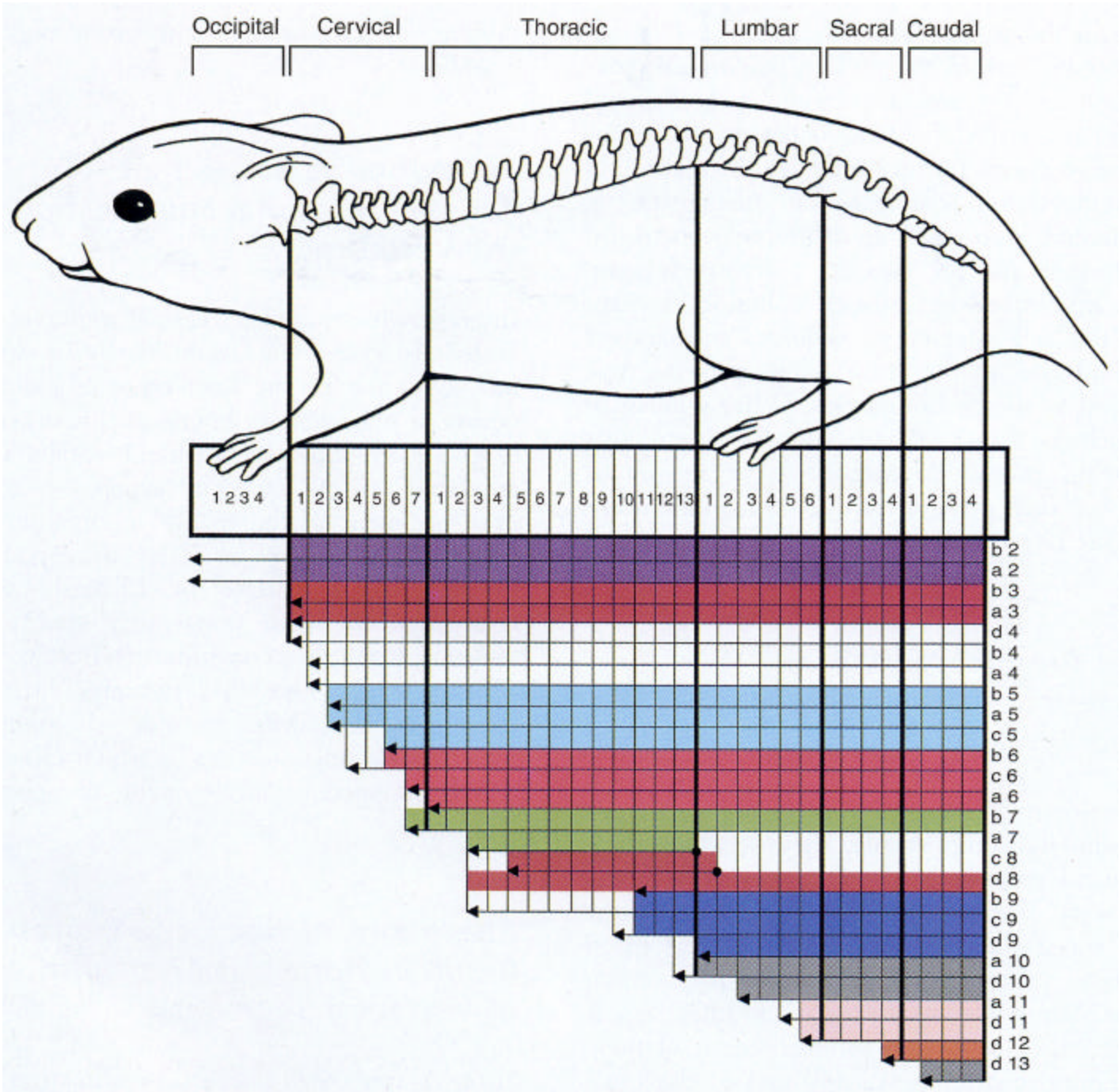

Spinal cord
Chain ganglia
Spinal nerve
A
Dorsal root ganglion
Chain ganglia
Dorsal root ganglia
Spinal nerves
mcg
Spinal cord
B

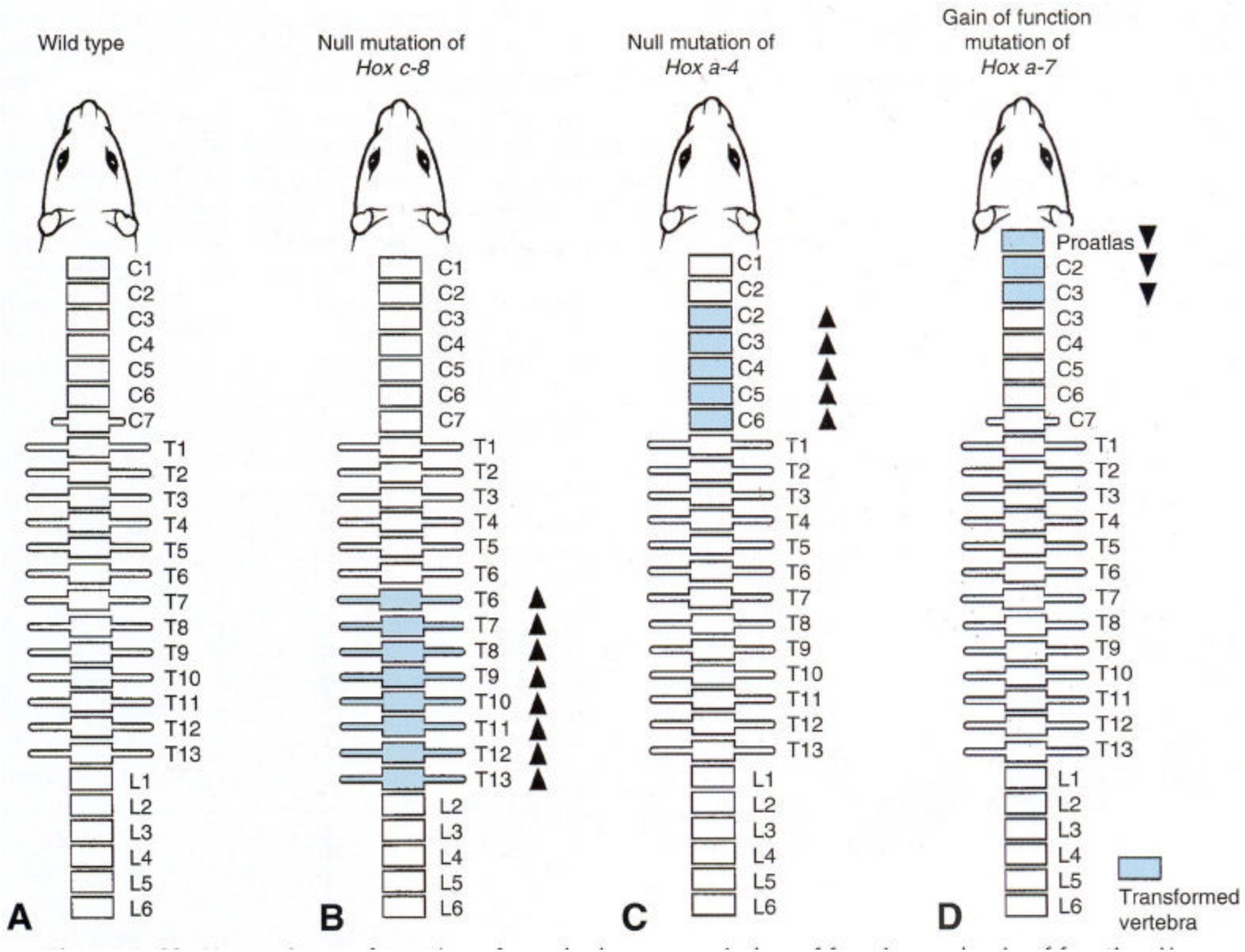
Migration of dermamytomone cells. All skeletal muscle arises from the myotome.




A
Dermomyotome
Dermotome
Dermotome
Sclerotome
Myotome
Sclerotome
Sclerotome
Myotome
Syndetome
B
Dermomyotome
Myotome
Sclerotome
Syndetome
FGF8
FREK
Pax1
FGF8
FREK
Pax1
C
Muscle
Cartilage
Tendon
Axial Tendon
Cartilage Progenitors
Muscle Progenitors
Tendon Progenitors
Epaxial Muscle
Vertebra

Generation of form and diversity: homeotic transformations

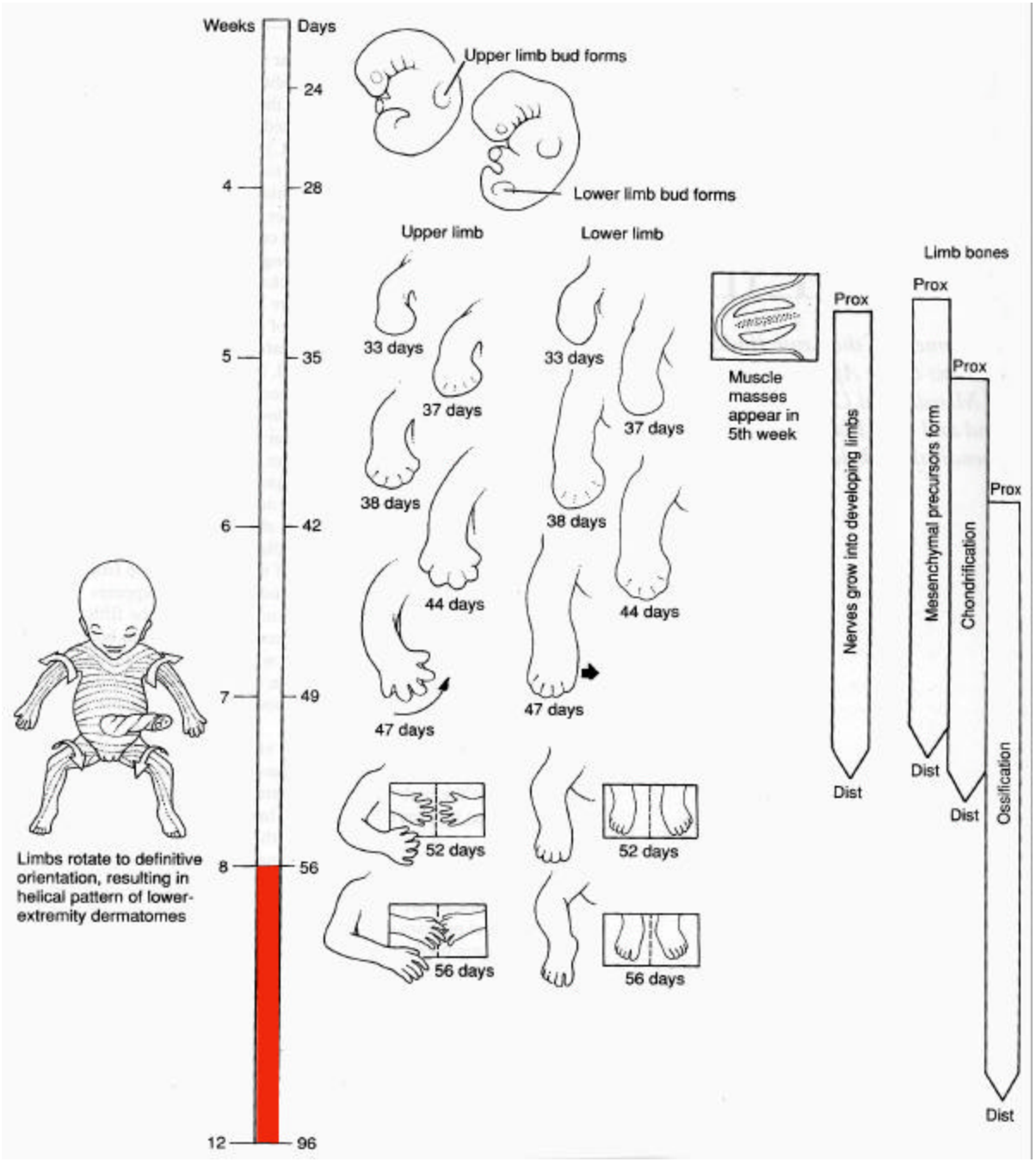

Occipital
Cervical
Thoracic
Lumbar
Sacral
Caudal
1 2 3 4
1 2 3 4 5 6 7
1 2 3 4 5 6 7 8 9 10 11 12 13
1 2 3 4 5 6
1 2 3 4
1 2 3 4
b 2
a 2
b 3
a 3
d 4
b 4
a 4
b 5
a 5
c 5
b 6
c 6
a 6
b 7
a 7
c 8
d 8
b 9
c 9
d 9
a 10
d 10
a 11
d 11
d 12
d 13


Wild type
Null mutation of
Hox c-8
Null mutation of
Hox a-4
Gain of function
mutation of
Hox a-7
Proatlas
C1
C2
C3
C4
C5
C6
C7
T1
T2
T3
T4
T5
T6
T7
T8
T9
T10
T11
T12
T13
L1
L2
L3
L4
L5
L6
A
B
C
D
Transformed
vertebra

Positional information: Transplantation of somites

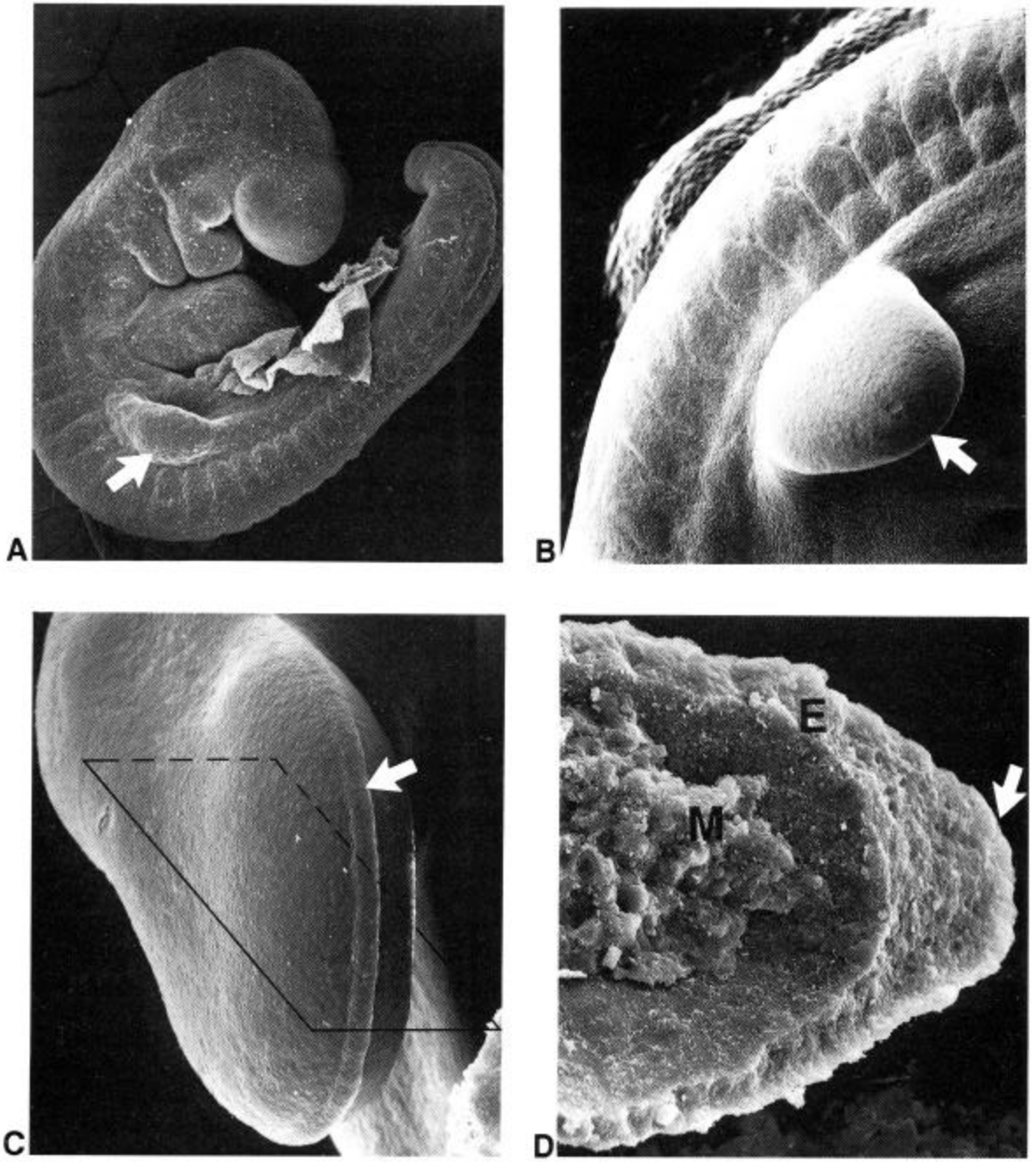
Summary:

1. Somites establish body segmentation.
2. Somite has 3 separate compartments.
3. Differential A/P properties of the somite result in segmentation of vertebral column and peripheral nervous system.
4. Overlapping patterns of HOX gene expression result in somites with individual characteristics.
5. Positional information is present in somites prior to epithelial-mesenchymal transformation.

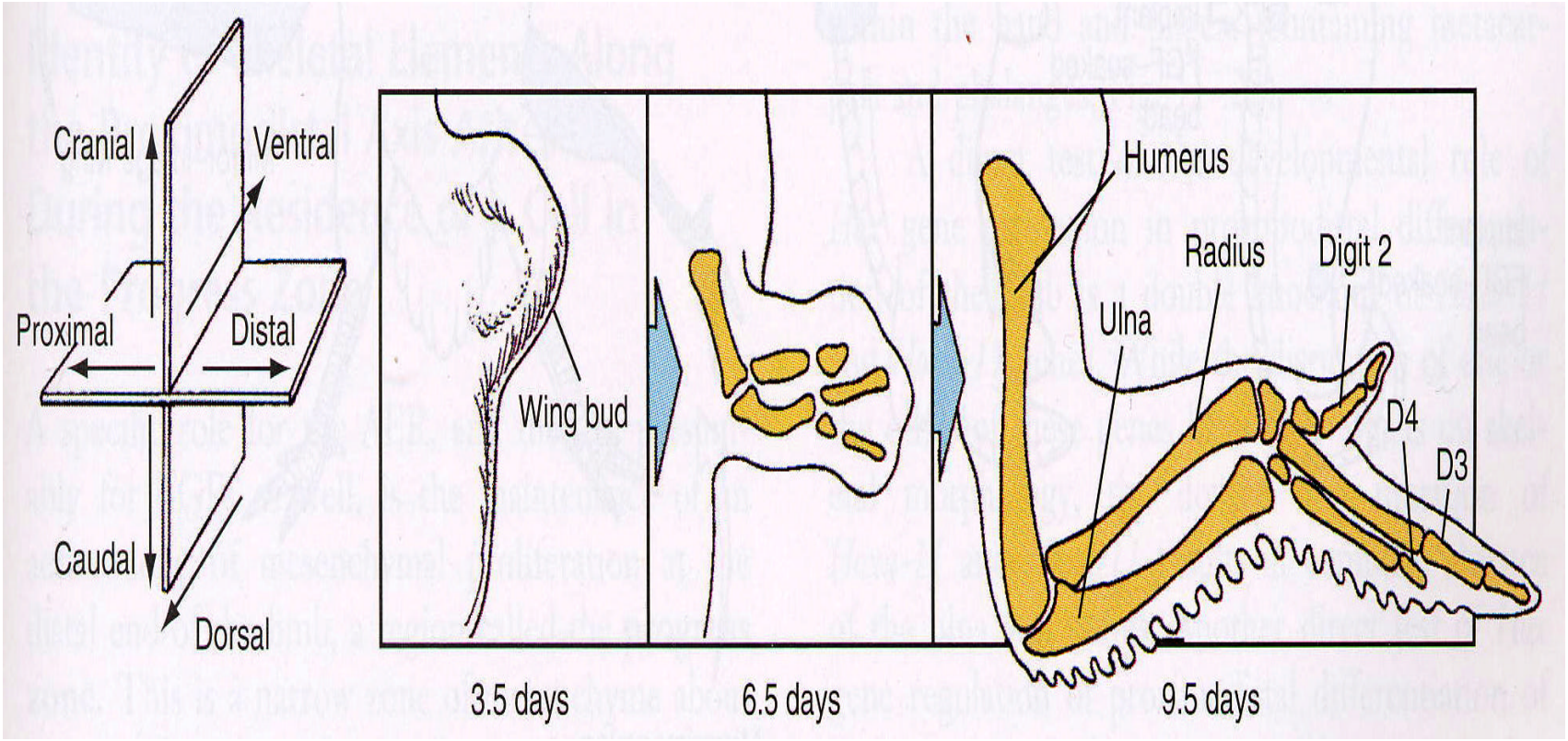

Weeks
Days
4
5
6
7
8
12
24
28
35
42
49
56
96
Upper limb bud forms
Lower limb bud forms
Upper limb
Lower limb
33 days
37 days
38 days
44 days
47 days
52 days
56 days
Muscle masses appear in 5th week
Prox
Dist
Nerves grow into developing limbs
Limb bones
Mesenchymal precursors form
Chondrification
Ossification
Limbs rotate to definitive orientation, resulting in helical pattern of lower-extremity dermatomes

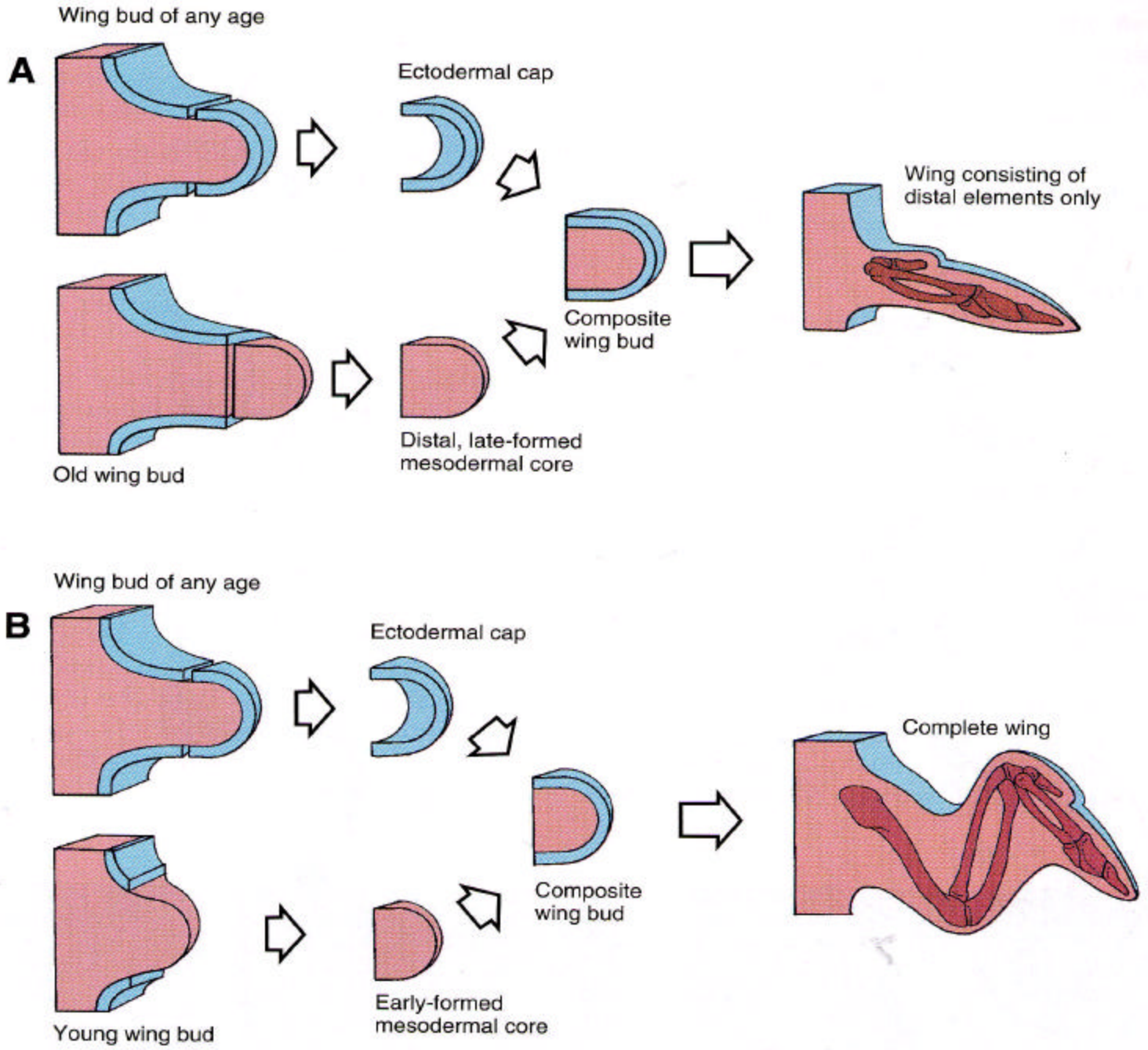
White arrow
To limb bud

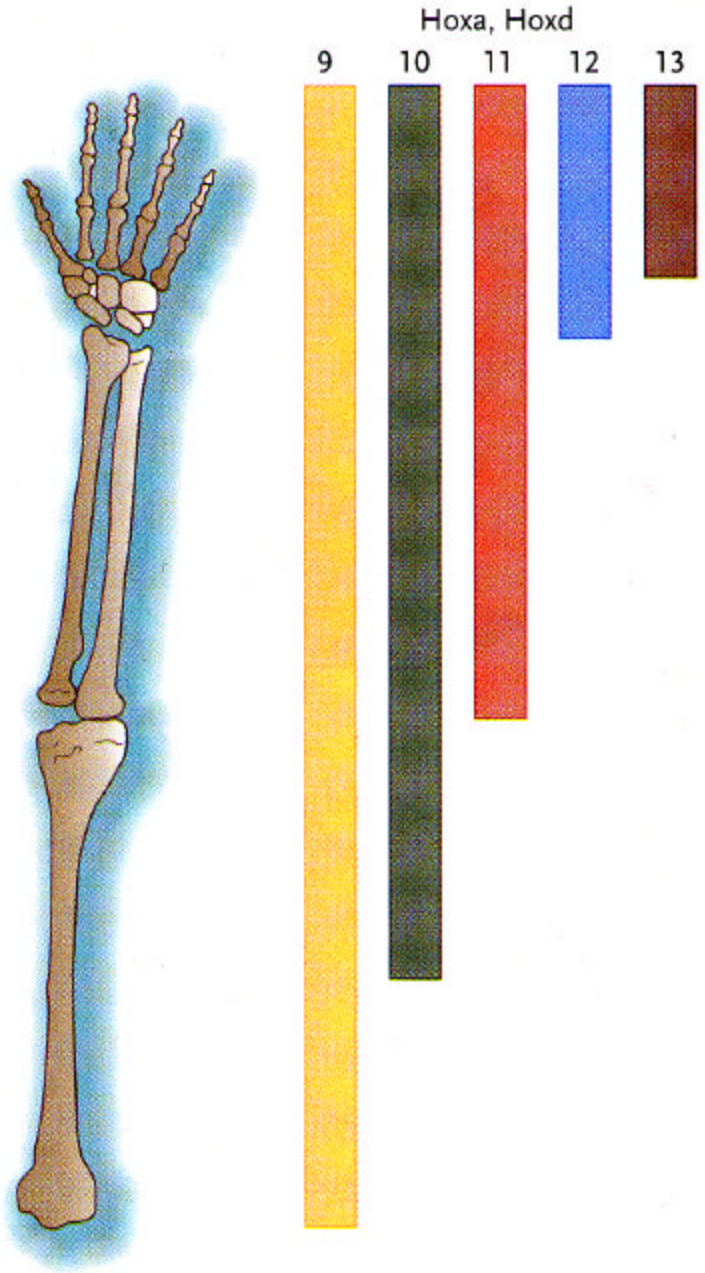
White arrow
to apical ecto-
dermal ridge.
M=mesoderm
of progress
zone



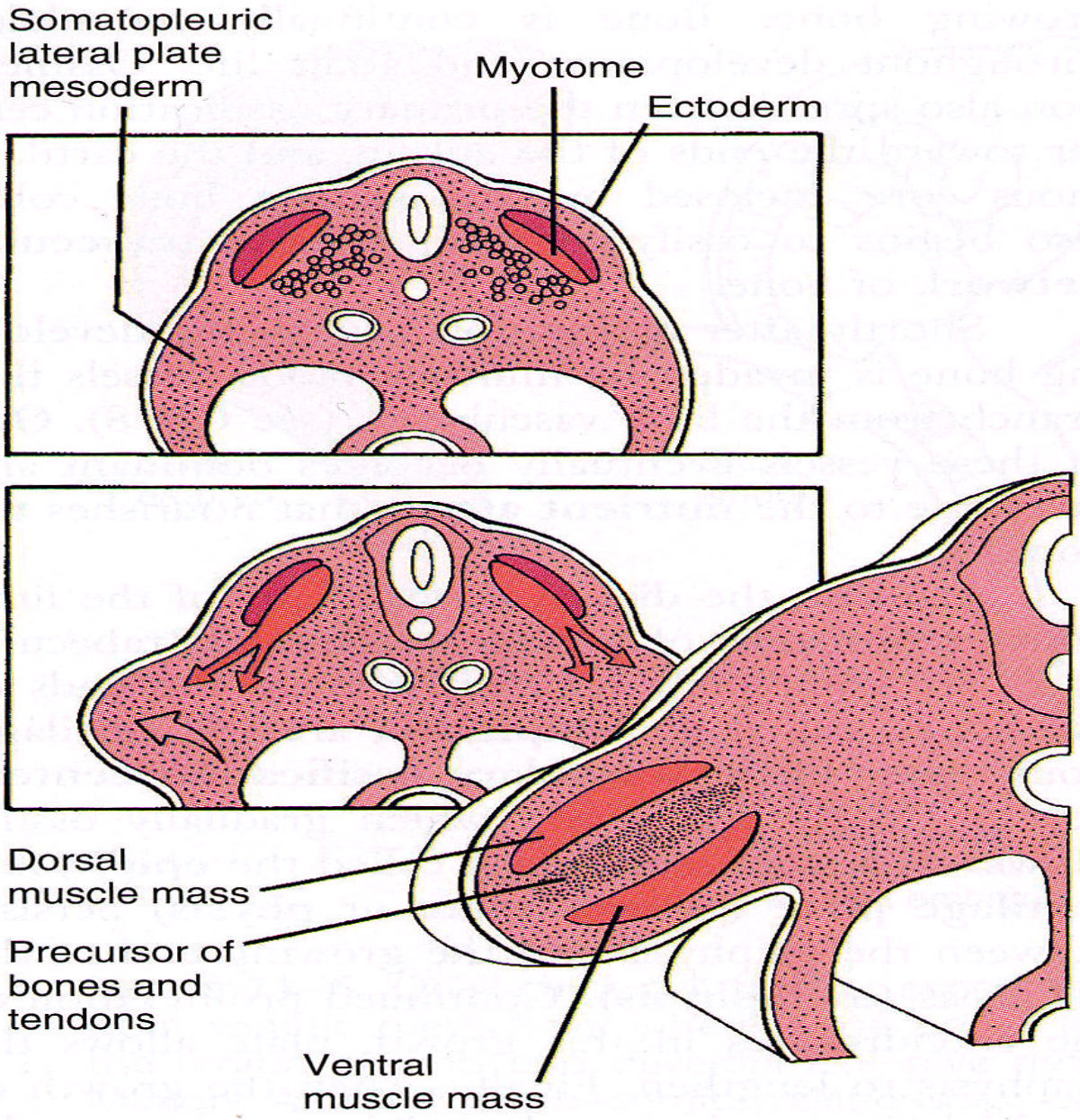
Limb segments are laid down proximal to distal

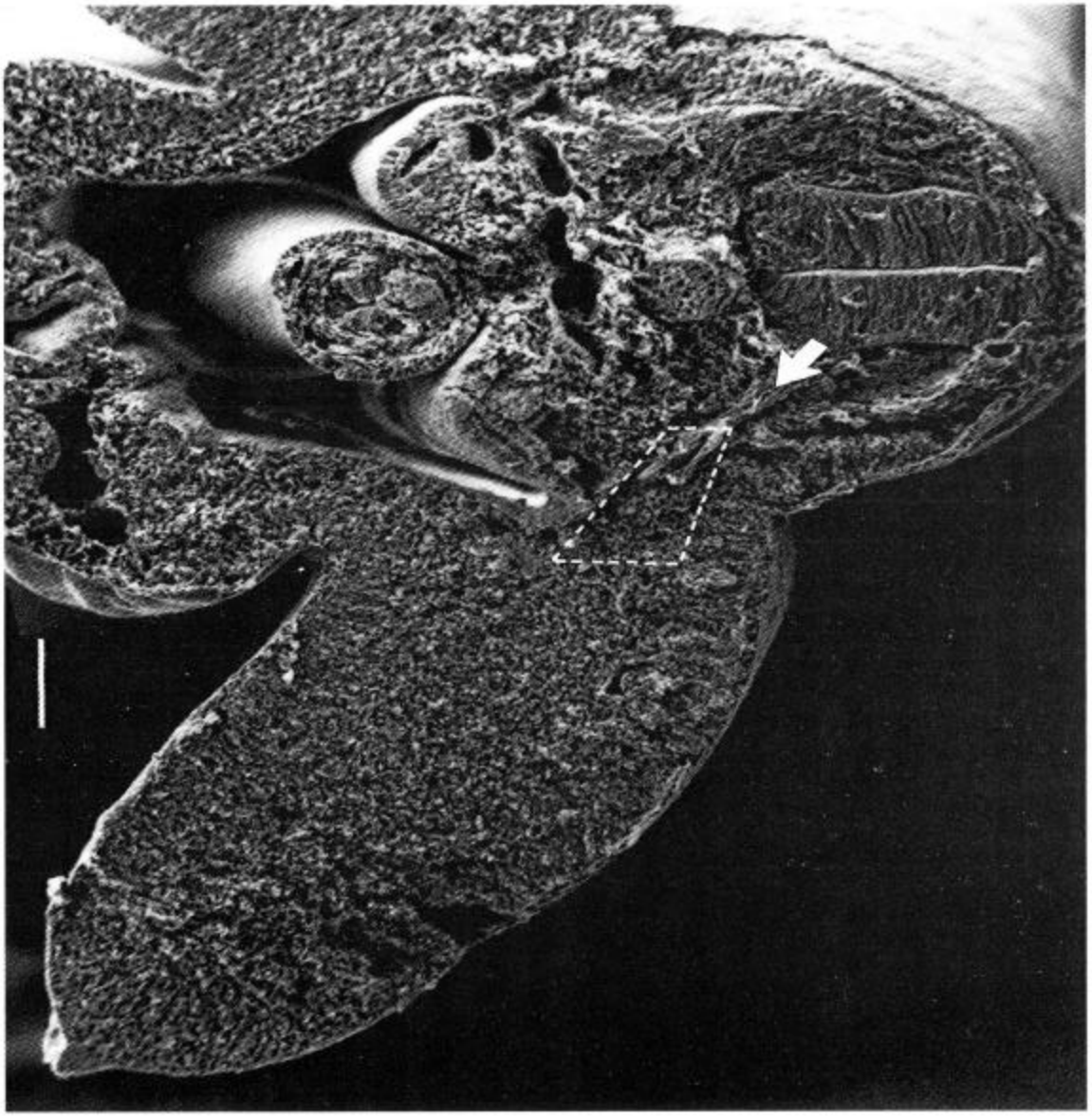


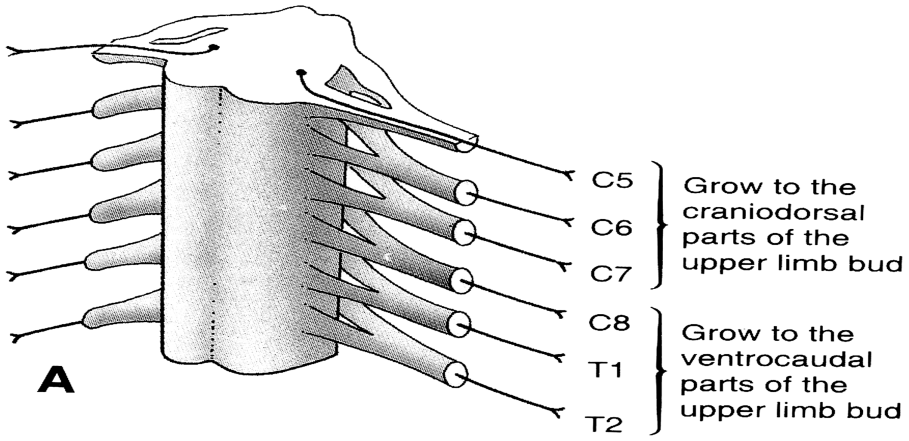

A
Wing bud of any age
Ectodermal cap
Wing consisting of distal elements only
Composite wing bud
Distal, late-formed mesodermal core
Old wing bud
B
Wing bud of any age
Ectodermal cap
Complete wing
Composite wing bud
Early-formed mesodermal core
Young wing bud

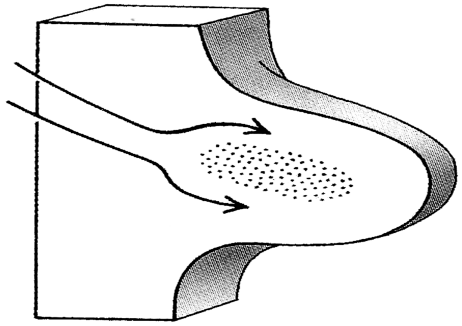


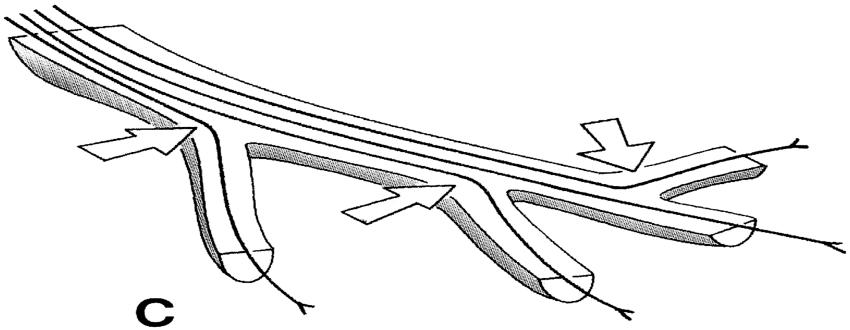
Hox gene expression is also important in patterning limb as with vertebral column


Somatopleuric
lateral plate
mesoderm
Myotome
Ectoderm
Dorsal
muscle mass
Precursor of
bones and
tendons
Ventral
muscle mass

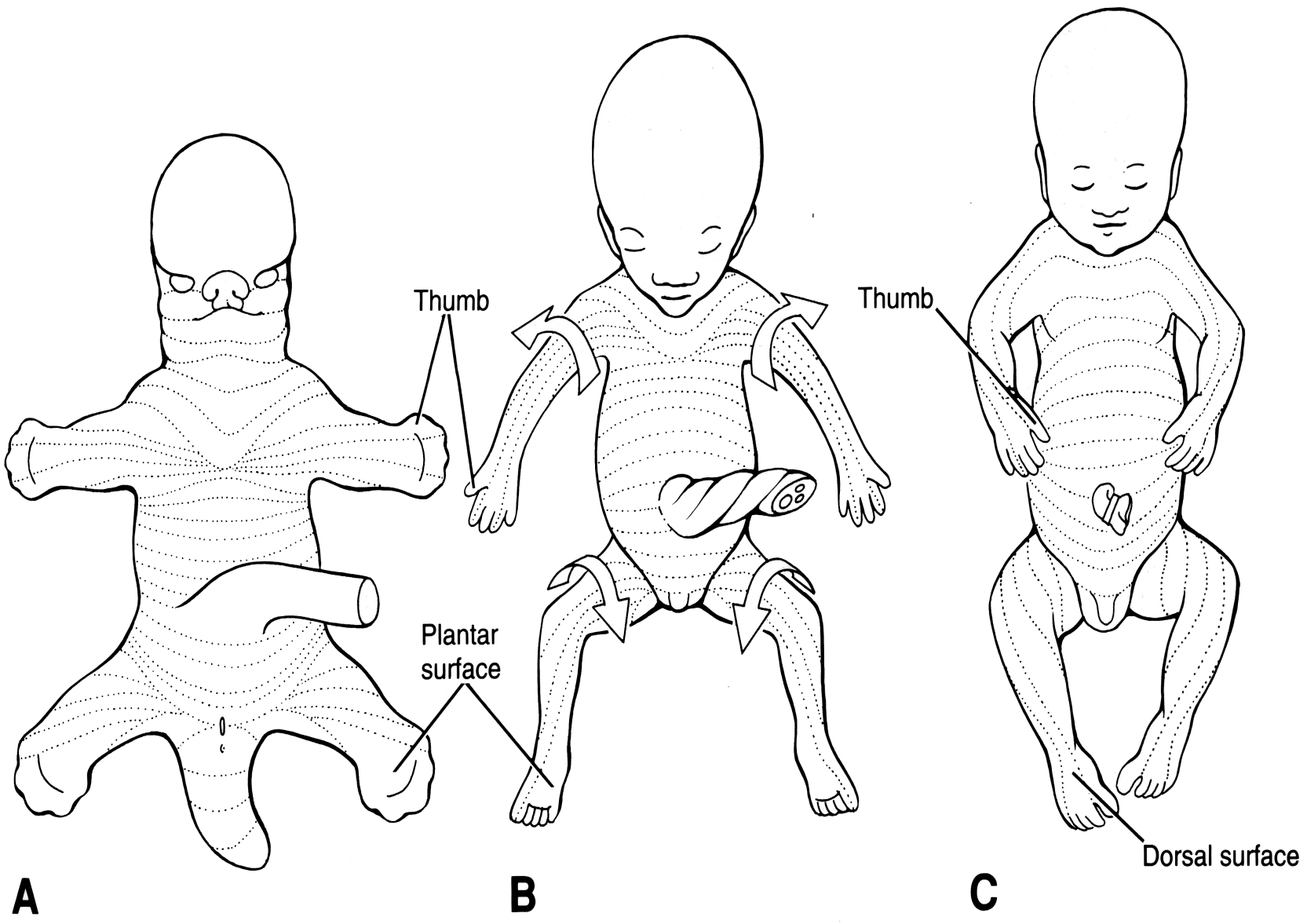



C5
C6
C7
Grow to the craniodorsal parts of the upper limb bud
C8
T1
T2
Grow to the ventrocaudal parts of the upper limb bud
A

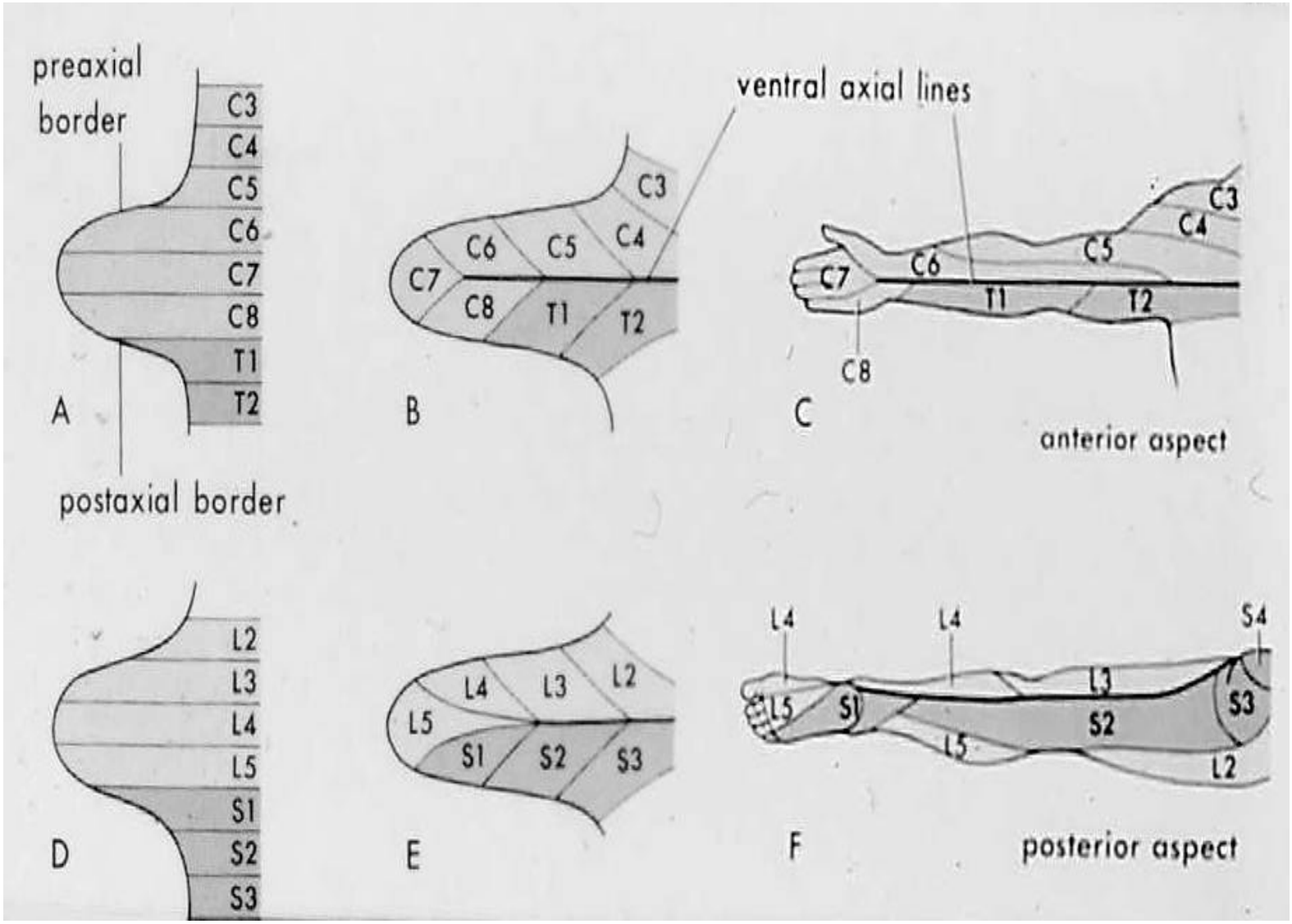

Nerves diverge after leaving the plexus to enter the craniodorsal or ventrocaudal part of the limb bud
B


Axons diverge to specific muscles in the limb bud
C

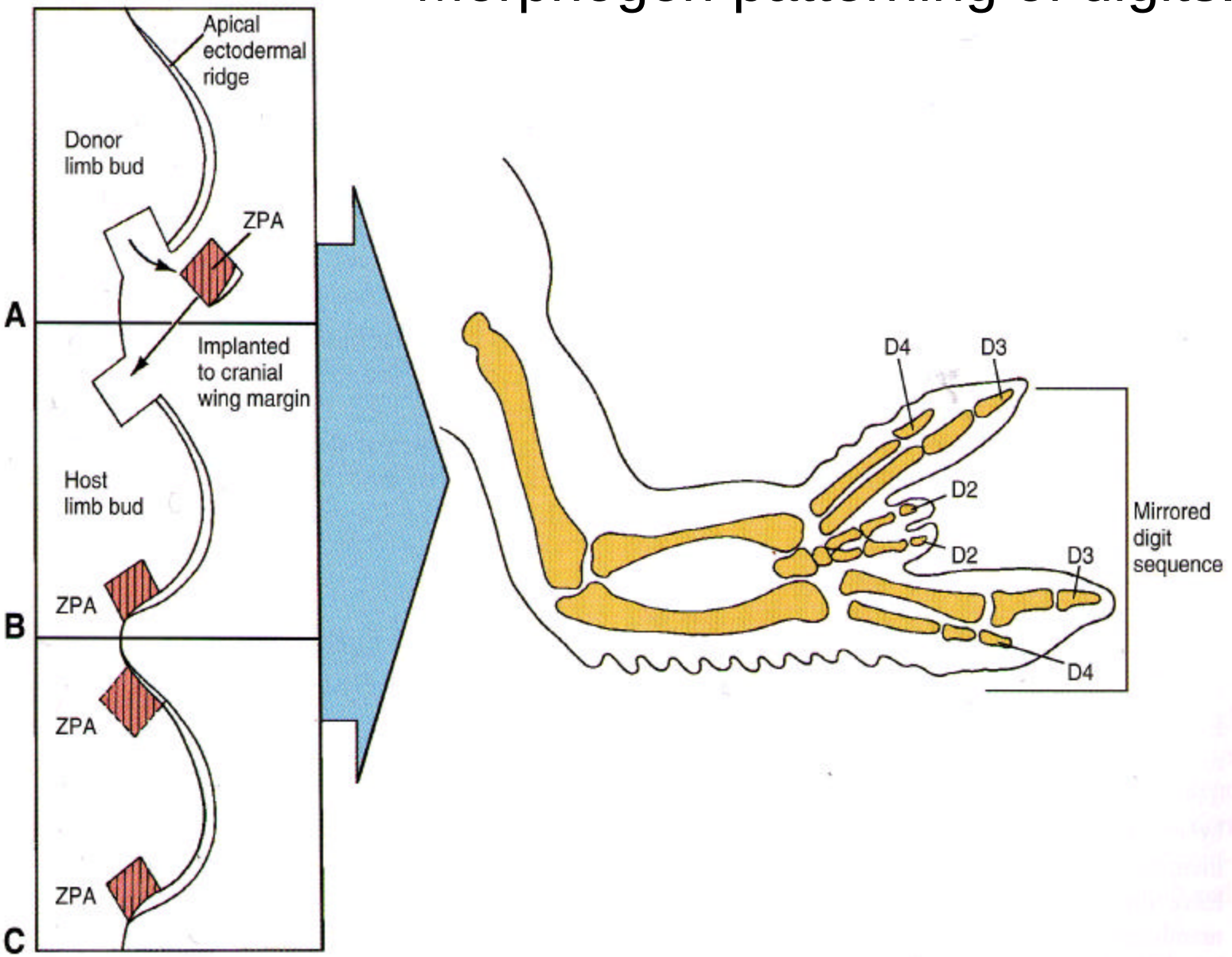
Limb rotation.



Consequences of limb rotation on innervation



Morphogen patterning of digits.



Limb summary

1. Two sources of mesoderm limb: lateral plate forming cartilage and bone; somite derived cells forming muscle.
2. The trunk level of the lateral plate mesoderm determines whether it becomes forelimb or hind limb.
3. The ectoderm is a signaling center regulating growth and it participates in patterning this outgrowth.
4. Because innervation of the limb arrives just as the muscle masses are forming, the segmental pattern of this innervation will be altered as limb rotate.