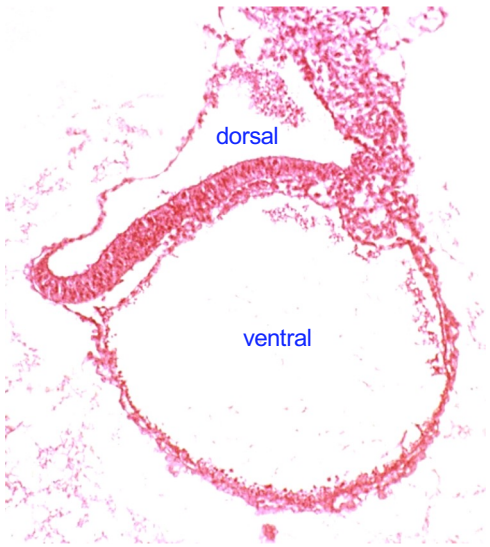
Viscera: ventral midline, brain–gut axis

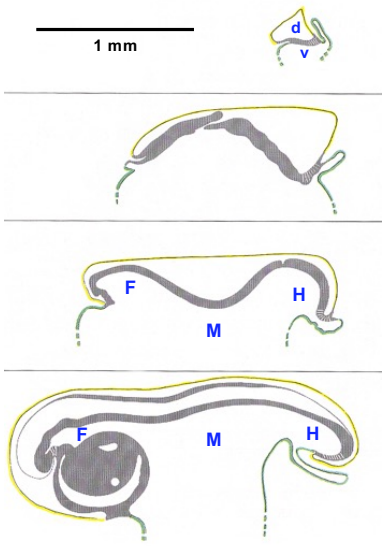
Brian Freeman
Oct 2023

references: *www.drawingonanatomy.com.au*

PRIME MOVER = Motor: growth movements in brain → viscera, in conformity (based on lectures: Bath 2012, Milan 2013, Berlin 2014).



CS 6/7; Nishimura & Okamoto (1976)



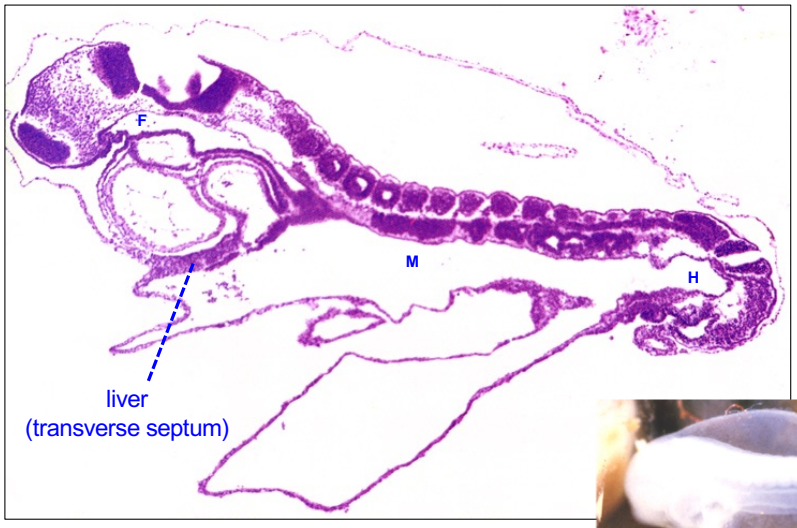
from: Blechschmidt (1969)

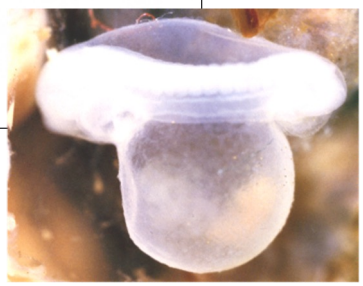
Embryo grows on its navel: Foregut (F) // Hindgut (H) // Midgut (M). NB. MOUTH MEMBRANE & CLOCAL MEMBRANE WHERE ECTODERM & ENDODERM ARE ADJACENT.

Entocyst (CS 6) with connecting stalk of mesoblast (Kyoto Collection) [courtesy Prof. K. Shiota, Kyoto University].

Nishimura H & Okamoto N. *Sequential Atlas of Human Congenital Malformations*. Baltimore: University Park Press, 1976

Blechschmidt E. *Vom Ei zum Embryo. Die Gestaltungskraft des Menschlichen Keims*. Stuttgart: Deutscher Bücherbund, 1969



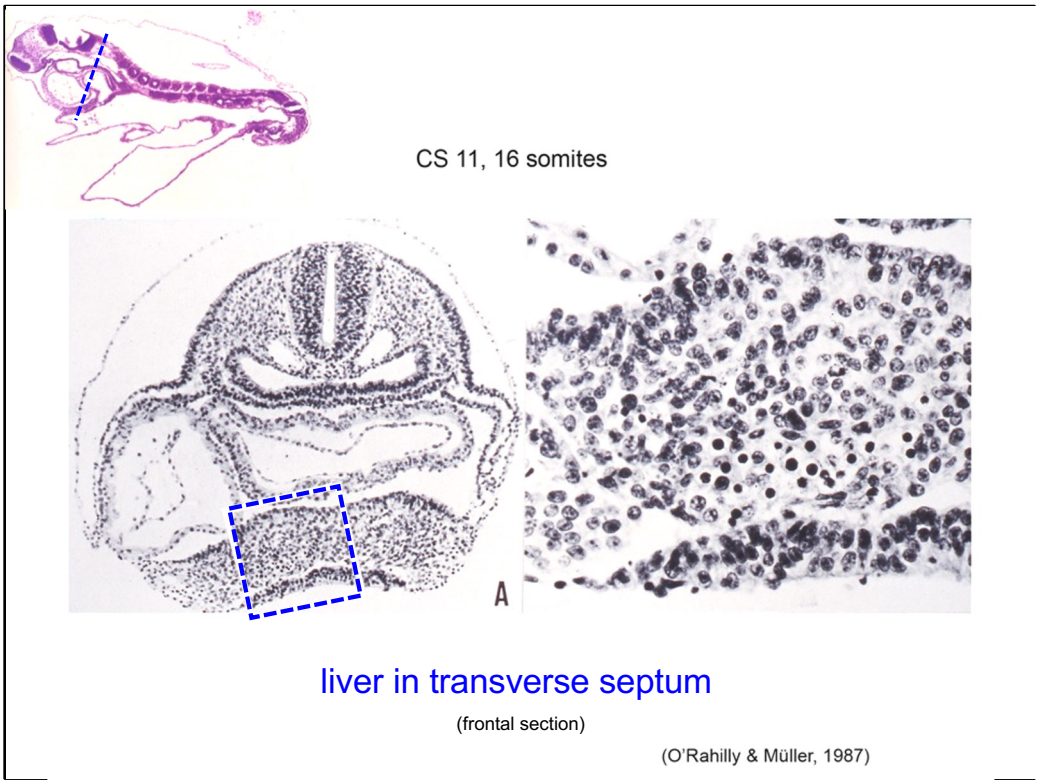


3 mm, 14 somite pairs, 24–25 days, CS 11
(ovarian ectopic pregnancy) Exalto et al. (1980, 1983)

Transverse septum in 3 mm, CS 11, 14 somites, 24–25 days; ovarian ectopic pregnancy; connecting stalk at right background; left umbilical vein along flank of embryo.

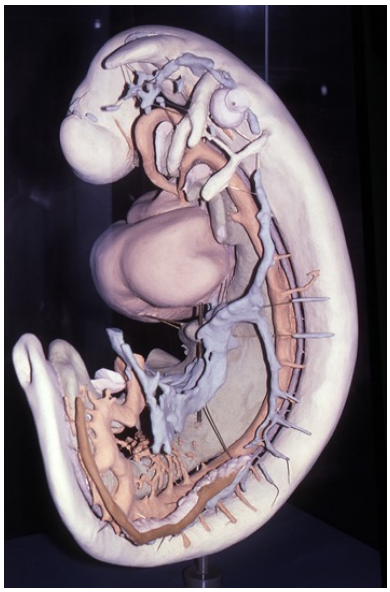
Exalto N, Vooys, GP, Meyer JWR, Lange WPH (1980) Ovarian pregnancy: a morphologic description. Europ. J. Obstet. Gynec. reprod. Biol. 11: 179-187

Exalto N, Rolland R, Eskes TKAB, Voojis GP. *Early Pregnancy.* Boehringer Ingelheim: Postgrad Med Services, 1983



LIVER in transverse septum; blood ISLAND; also DIAPHRAGM + PARIETAL PERICARDIUM.
(CS 11, 16 somites; frontal section at low and high magnification). Inset shows approximate plane of frontal section in a similar embryo.

O'Rahilly R, Müller F. *Developmental Stages in Human Embryos*. Washington: Carnegie Institution Publication 637, 1987



model

2.5 mm embryo

CS 12

Blechschmidt Museum
Univ. Göttingen

Importance of enlarged models to known scale; viscera partly hidden from view by vessels.

2.5 mm, CS 12

neural tube
& cranial gangia

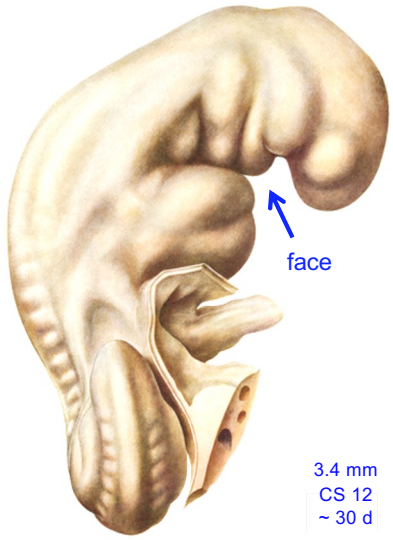
endoderm:
fore-, mid-, hindgut

somites & serosa
(lining of coelom)

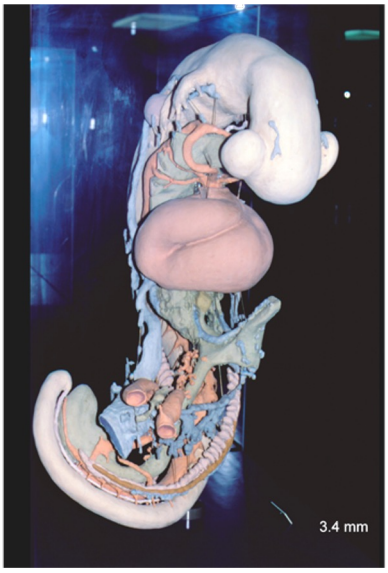
Blechschmidt (1982)

Sequence: Brain // Viscera // somites & serosa. Accurate drawings from models: 2.5 mm, CS 12: endoderm – green.

Blechschmidt E (1982) Vom Ei zum Embryo. In: *Kindlers Encyklopädie Der Mensch*, Bd 4, 80–116



Blechschmidt, *The Human Embryo. Documentations on Kinetic Anatomy* (1963)



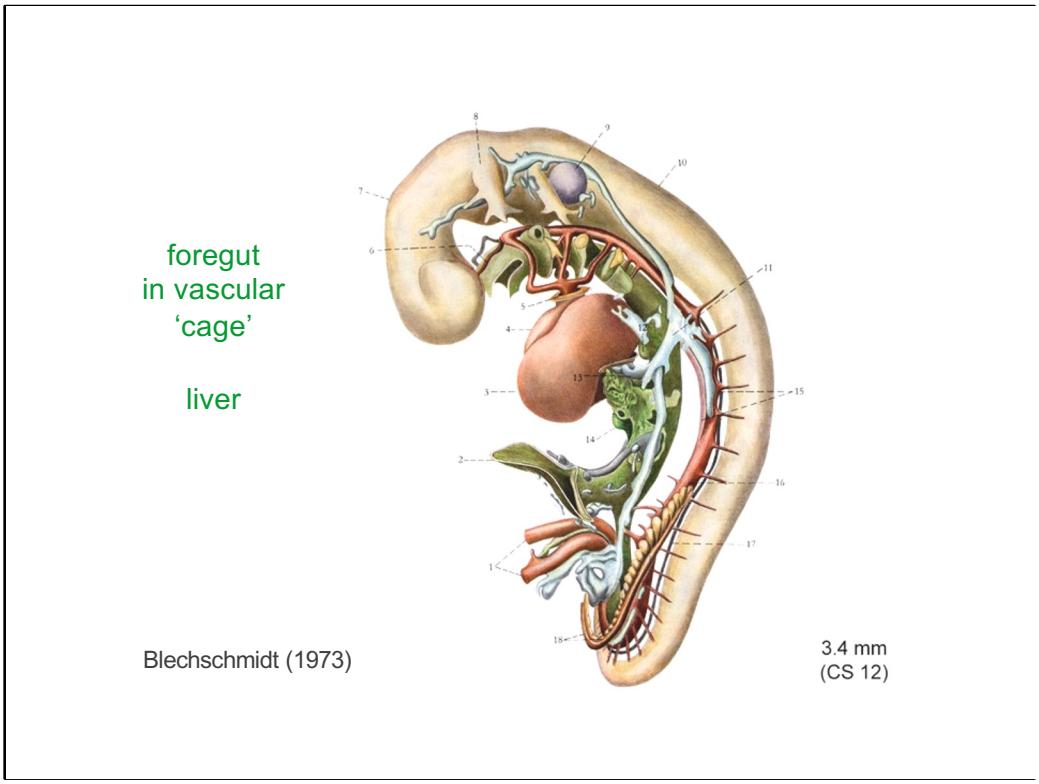
Blechschmidt Museum
Univ. Göttingen

3.4 mm: brain development – folds seen from side; face hidden from view.

FACE: MANDIBULAR ARCH, HYOID ARCH, 3rd = LARYNGEAL ARCH. Foregut compressed between brain and heart. ¾ front view shows compression of foregut with vascular cage from truncus arteriosus. FACING FACTS: overview of pharyngeal arches & face development; also nasal gubernaculum, nasal placode & pit.

Blechschmidt, E. *The Human Embryo. Documentations on Kinetic Anatomy*. Stuttgart: Schattauer, 1963

3.4 mm museum model/reconstruction - The Blechschmidt Collection and Museum of Human Embryos (University of Göttingen, Germany)



VASCULAR 'CAGE' & THYROID. 3.4 mm reconstruction; endoderm green; viewed from left.

Blechschmidt E. *Die präatalen Organsysteme des Menschen*. Stuttgart: Hippokrates, 1973

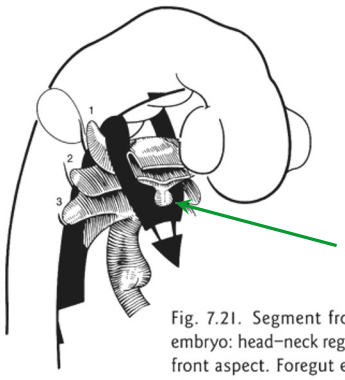
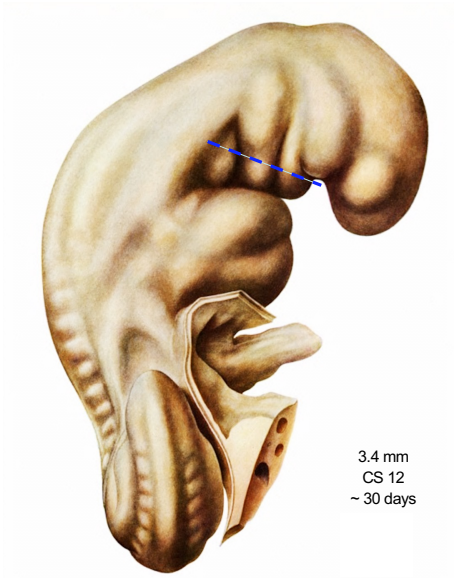


Fig. 7.21. Segment from serial section reconstruction of 3.4 mm long embryo: head–neck region (ectoderm removed) viewed obliquely from right front aspect. Foregut endoderm in head and neck is hatched. Pair of 1st visceral arch arteries black. 1, 2, 3 indicate 1st, 2nd, and 3rd pharyngeal pouches. Broad arrow denotes descent of heart. The angle between the left and right 1st visceral arch artery decreases during the constant pull of heart descent, and the endoderm at the floor of the pharynx is "worked off" to form the anlage of the thyroid gland (seen above the arrow).

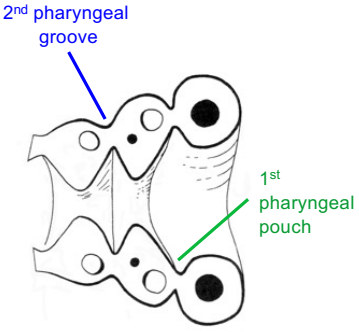
Blechschmidt (2004)

DIGRESSION: Thyroid gland development from the floor of the pharynx.

Blechschmidt E. (trans./ed. Freeman B) *The Ontogenetic Basis of Human Anatomy. A Biodynamic Approach to Development from Conception to Birth*. Berkeley: North Atlantic, 2004



Blechschmidt (1963)



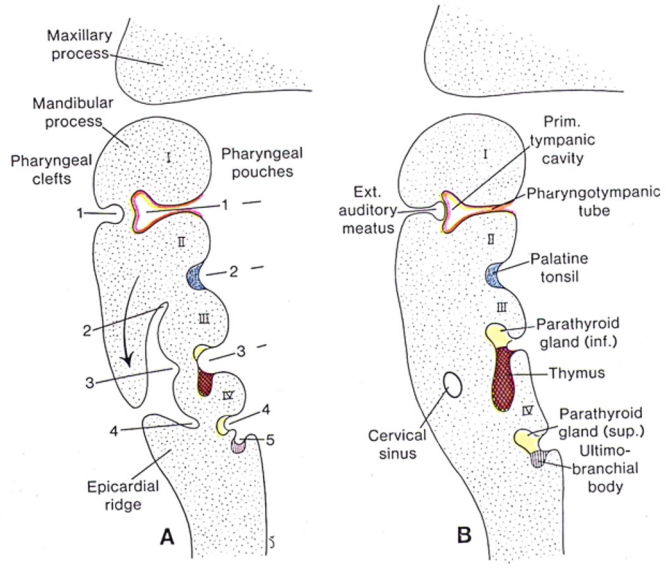
floor of pharynx

Blechschmidt (2004)

Pharyngeal arches at 3.4 mm, CS 12: TEACH HOW TO MODEL ARCHES WITH FINGERS & THUMBS – highly curved thick SINGLE SURFACE epithelium → SPECIAL ORGANS.

Blechschmidt, E. *The Human Embryo. Documentations on Kinetic Anatomy,* 1963 Stuttgart: Schattauer

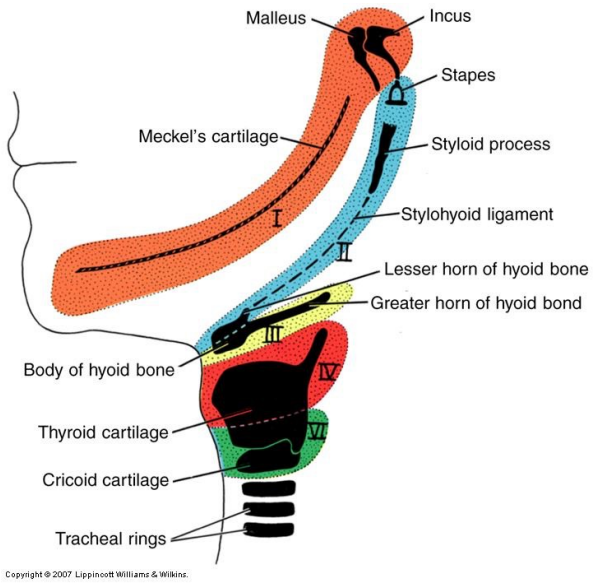
Blechschmidt E. (trans./ed. Freeman B) *The Ontogenetic Basis of Human Anatomy. A Biodynamic Approach to Development from Conception to Birth*. Berkeley: North Atlantic, 2004



Sadler, *Langman's Medical Embryology* (1985)

Pharyngeal pouches (endodermal derivatives): THYMUS grows from highly wedge-shaped surface – becomes anchored to blood vessels and stays in neck/thorax region region.

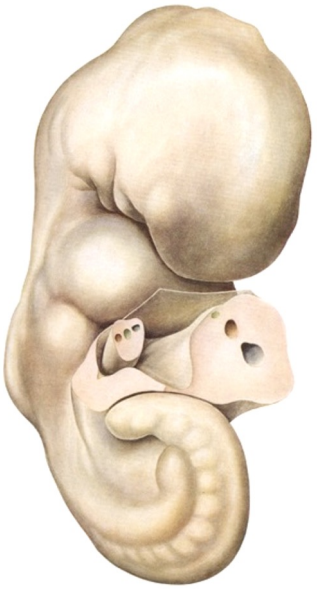
Sadler TW. *Langman's Medical Embryology*. Baltimore: Lippincott, 1985



Sadler, *Langman's Medical Embryology* (2007)

CONNECTIVE TISSUE DERIVATIVES: Derivatives (conventional) of pharyngeal arches, made to conform to "fish pattern".

Sadler, TW. *Langman's Medical Embryology*. Baltimore: Lippincott, 2007



‘shy’
embryo

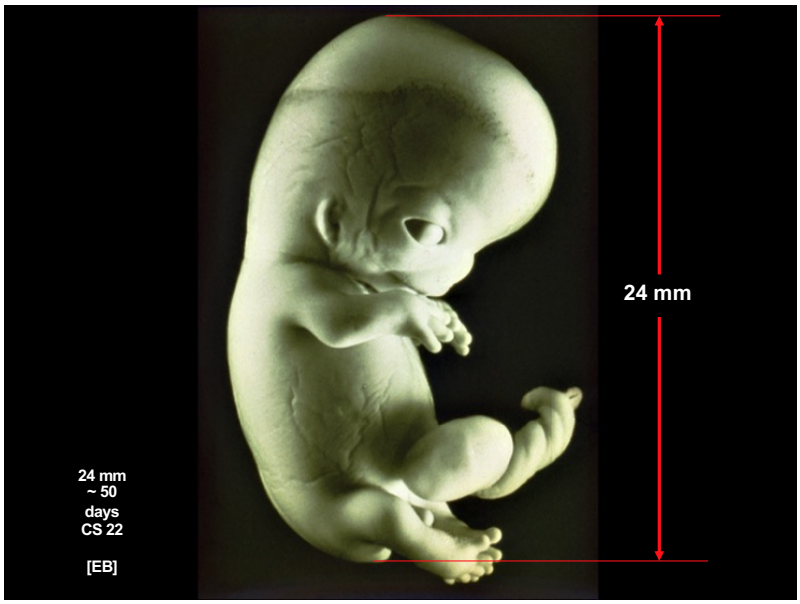
4.2 mm
CS 14

Blechschmidt (1963)

Watercolour drawing based on large model (total reconstruction) of 4.2 mm embryo, CS 14.

Note single umbilical artery and vein, cf. Benirschke (*Pathology of the Fetus and the Infant*, 3. ed. 1976, p.54) – single umbilical artery occurs in 0.45–1.2% of placentas.

Blechschmidt, E. *The Human Embryo. Documentations on Kinetic Anatomy*. Stuttgart: Schattauer, 1963



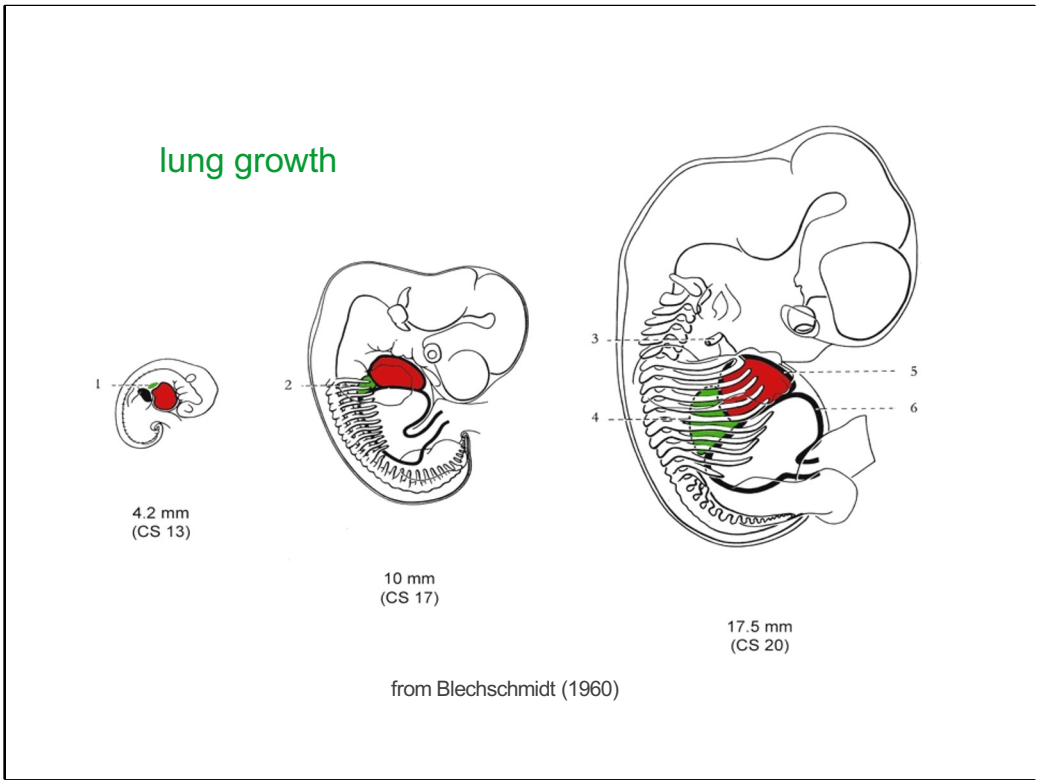
Human embryo: ca. 24 mm (crown-rump length), CS 22 (Carnegie Stage 22), ca. 50 days after fertilization. Carnegie Stages 1 to 23, then fetal development

[original photograph by Erich Blechschmidt] [Weight at 8 weeks is less than 15 g; 35 g at 10 weeks]

Fetus head 50 mm

Fetus: 50 mm. [original photograph by Erich Blechschmidt]

VECTORS OF FACE DEVELOPMENT in Fetus: 50 mm.
CONSEQUENCES OF ERECTION OF HEAD FOR VISCERA. [original photograph by Erich Blechschmidt]

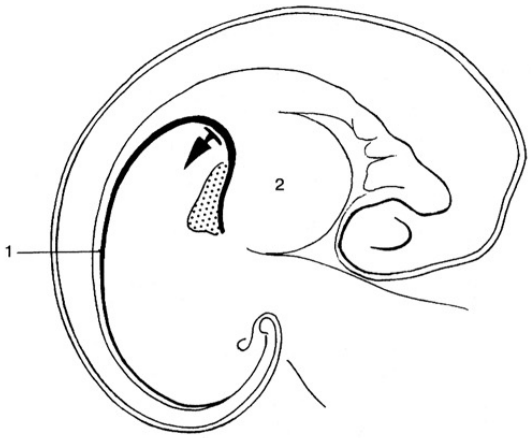


2023: OVERVIEW OF LUNG DEVELOPMENT. Ascent of brain and descent of viscera: comparison of 4.2 / 10 / 17.5 mm embryos.

Diaphragm will arise in part, here, opposite cervical segments 3 and 4 and during the relative movement of ascent or descent, the diaphragm and these segments separate = move apart, so the motor neurites and sensory dendrites in the phrenic nerve to the tissue trapped here get carried along with the descent (to here).

University–Kindergarten: “C3, C4 and sometimes 5 keeps the diaphragm alive”.

Blechschmidt E. *The Stages of Human Development Before Birth*. Basel: Karger, 1960



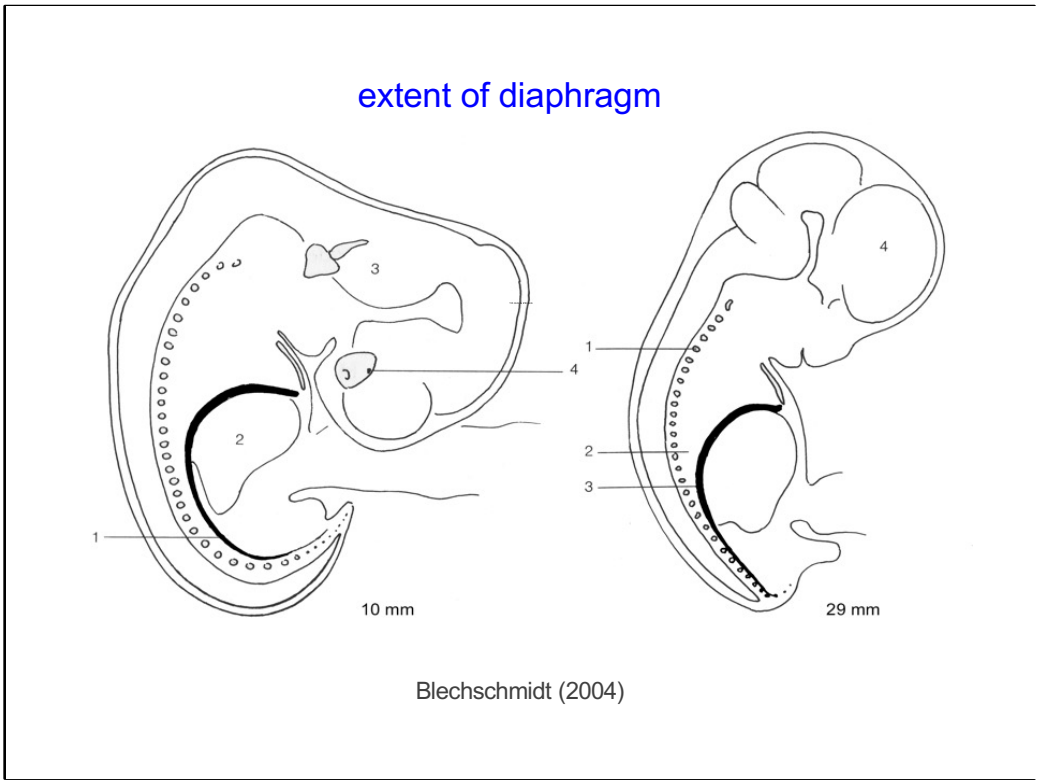
descent of diaphragm

Fig. 7.13. Human embryo 4.2 mm long (Carnegie Stage 13). Start of descent of diaphragm (arrow). Liver (stippled) still high in neck region. Diaphragm black. 1) inferiorly attached part of diaphragm, 2) heart bulge.

Blechschmidt (2004)

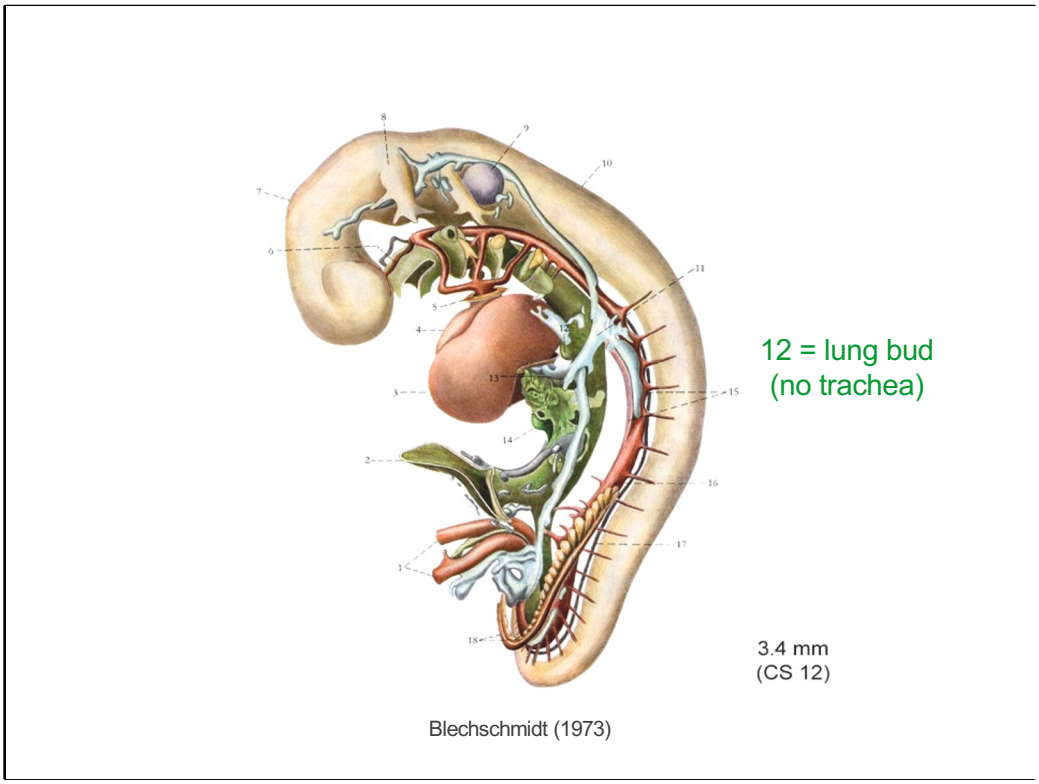
Early diaphragm and its descent (4.2 mm).

Blechschmidt E. (trans./ed. Freeman, B) *The Ontogenetic Basis of Human Anatomy. A Biodynamic Approach to Development from Conception to Birth*. Berkeley: North Atlantic, 2004



Descent of diaphragm in 10 mm & 29 mm – extends to COCCYX and then via anococcygeal fascia to linea alba and back to STERNUM then to OCCCIPUT via sternomastoid fascia, etc. etc. Some fibres from the right crus surround oesophageal hiatus, acting as physiological sphincter and preventing reflux of gastric contents into oesophagus.

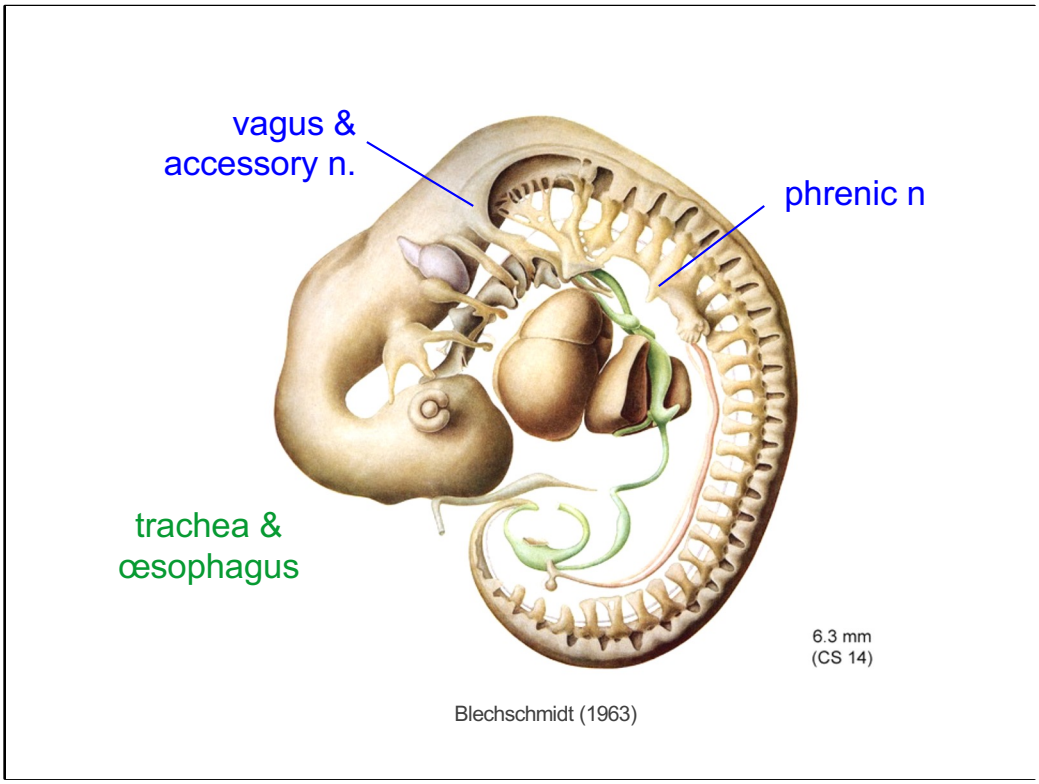
Blechschmidt E. (trans./ed. Freeman, B) *The Ontogenetic Basis of Human Anatomy. A Biodynamic Approach to Development from Conception to Birth*. Berkeley: North Atlantic, 2004



Foregut and lung bud in 3.4 mm reconstruction drawing (viewed from left)

Blechschmidt E. *Die pränatalen Organsysteme des Menschen*. Stuttgart: Hippokrates, 1973

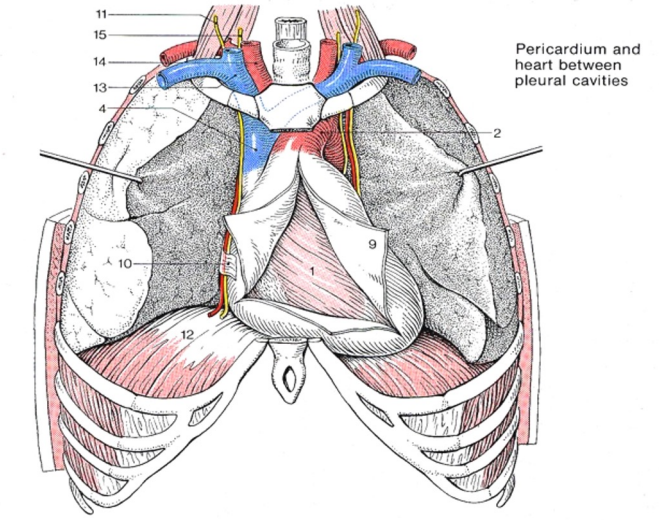
6.3 mm embryo: peripheral nerves



6.3 mm embryo: peripheral nerves, especially X & XI; with rami from X already between trachea & esophagus' (no obvious sympathetic division). PHRENIC n. just fraction of mm (300 mu) from surface of liver = at diaphragm.

Blechschmidt, E. *The Human Embryo. Documentations on Kinetic Anatomy*. Stuttgart: Schattauer, 1963

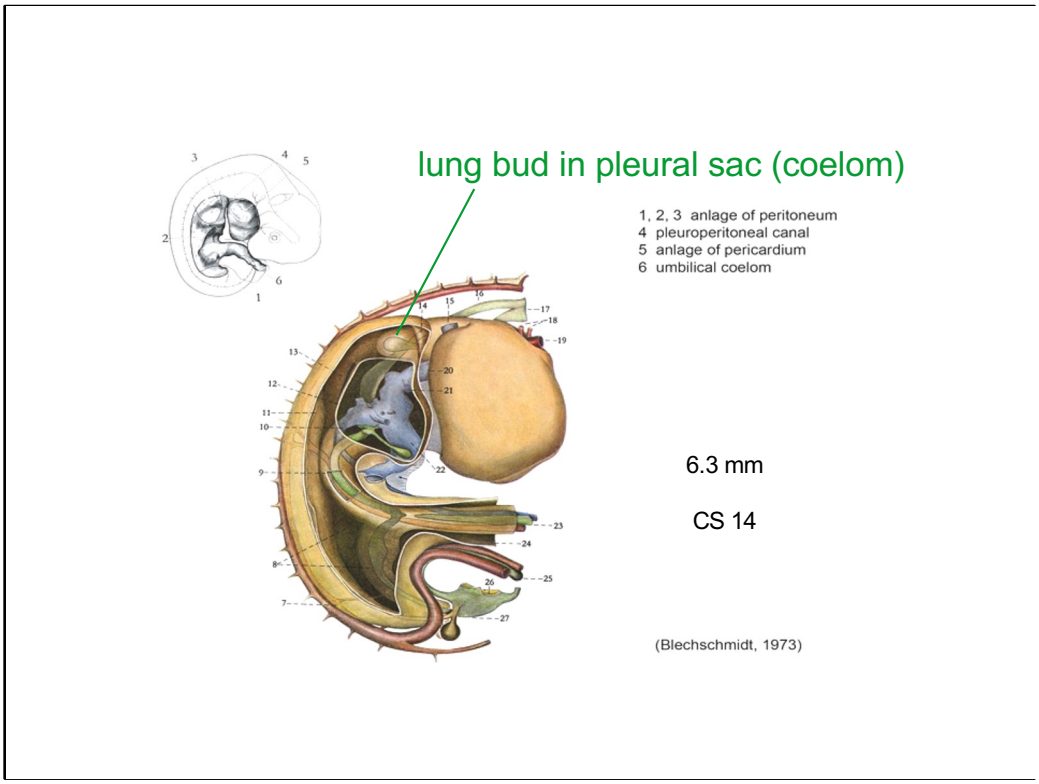
phrenic nn.



Kahle et al. (1984)

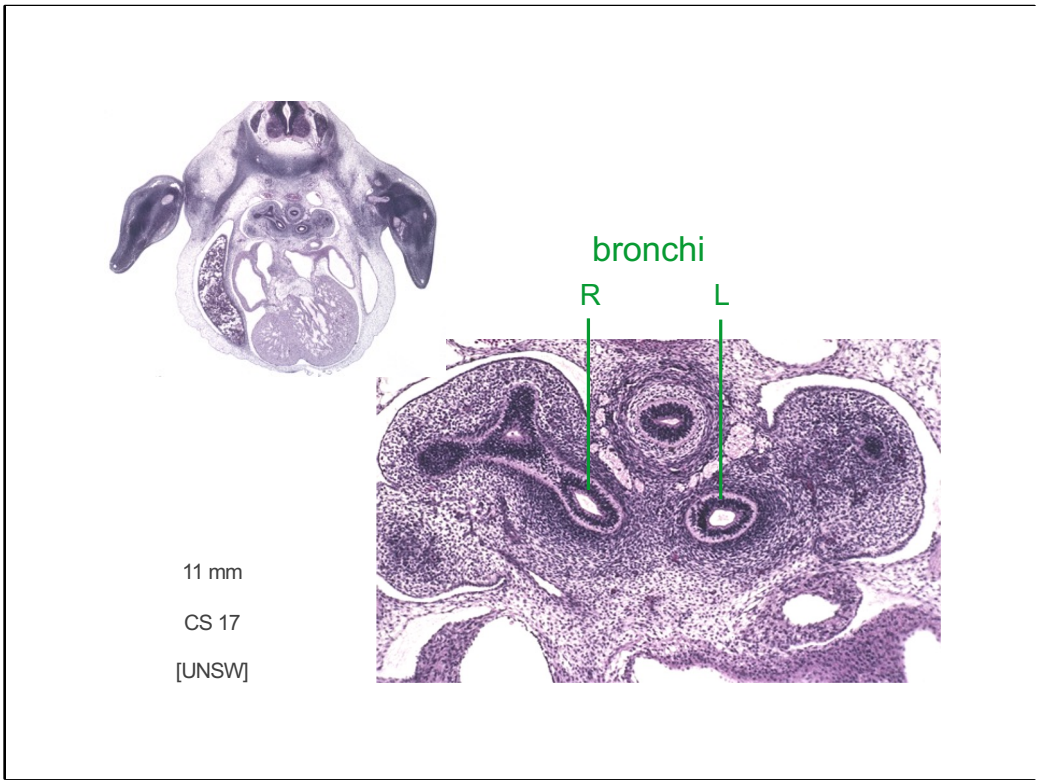
Phrenic nerves (yellow).

Kahle W. et al. *Color Atlas and Textbook of Human Anatomy*. Vol 2: Internal Organs. Stuttgart: Thieme, 1984



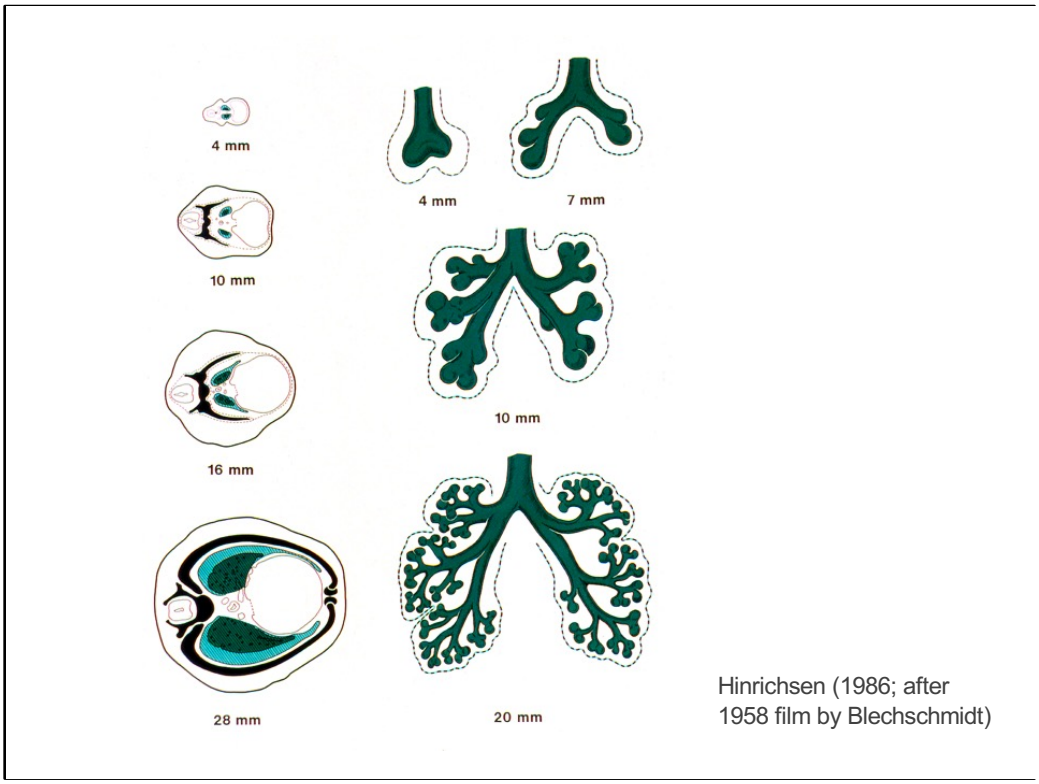
Lung bud in relation to body sac (coelom).

Blechschmidt E. *Die pränatalen Organsysteme des Menschen*. Stuttgart: Hippokrates, 1973



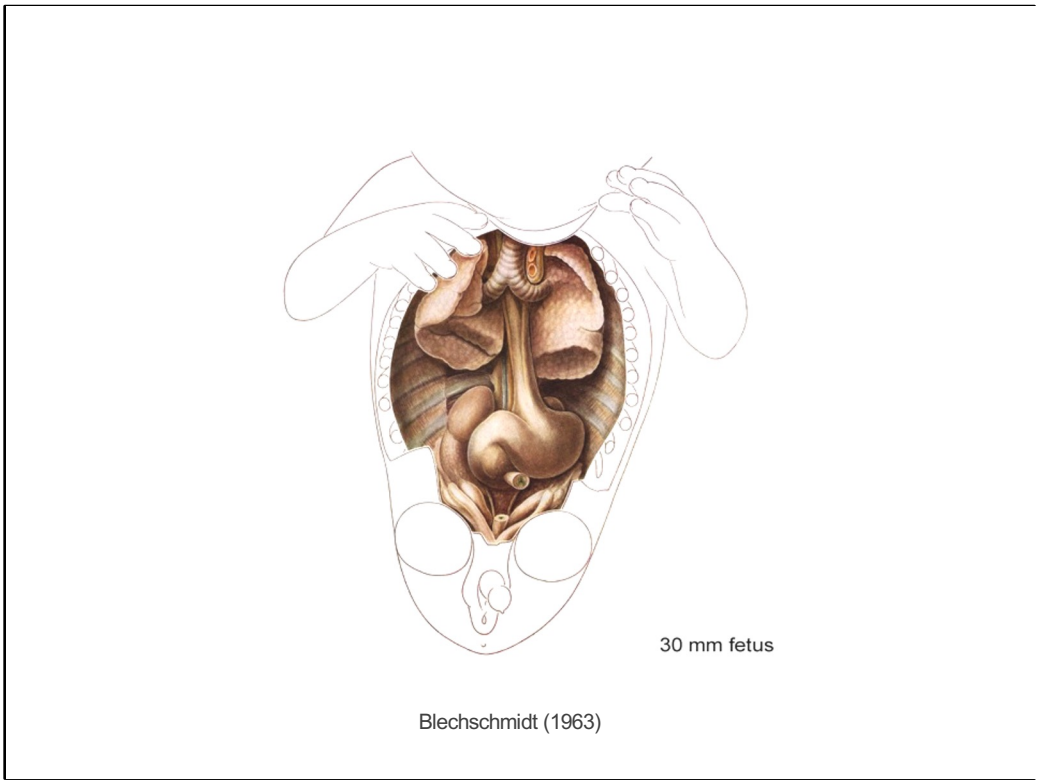
Pulmonary lobes and early division of bronchi (secondary bronchi on right) in 11 mm, CS 17 embryo. Suction field.

[BF, UNSW]



Lung development: based on 1958 film by Blechschmidt.

Hinrichsen KV. *Slides on Human Embryology*. Munich: Bergmann, 1986



Lungs, trachea, principal bronchi - 30 mm fetus. AUTONOMIC NERVES.

Blechschmidt E. *The Human Embryo. Documentations on Kinetic Anatomy*. Stuttgart: Schattauer, 1963

suction field

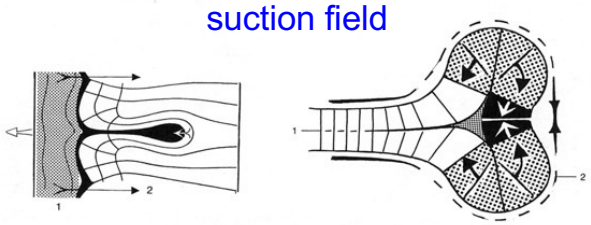


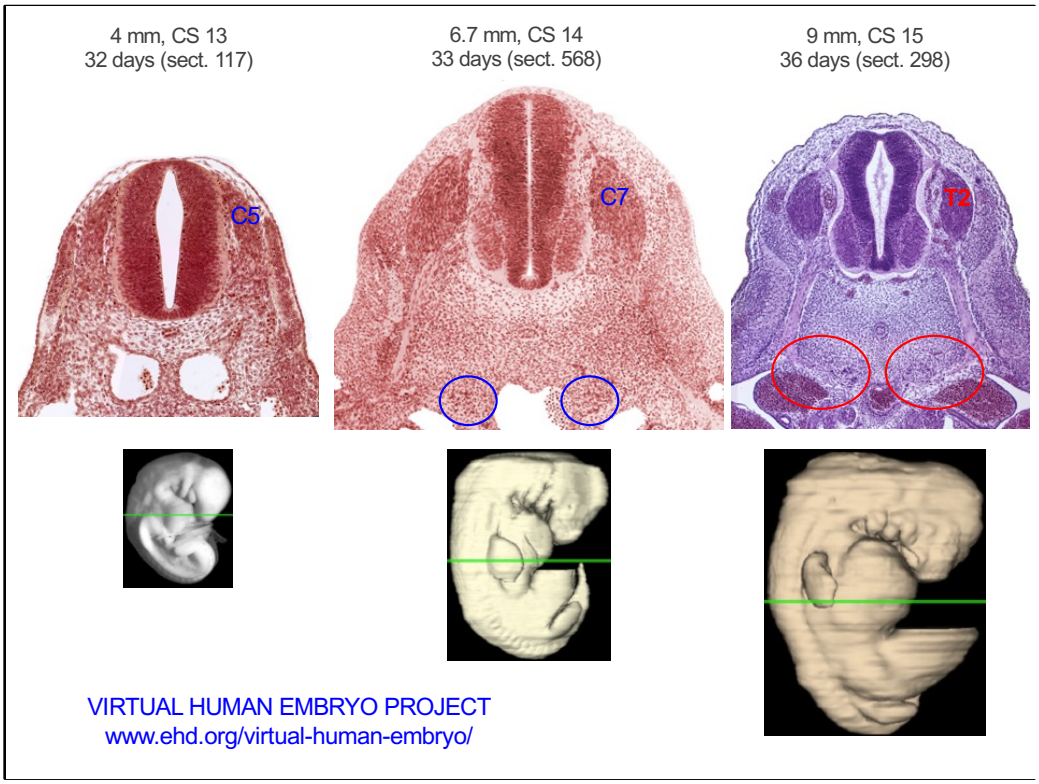
Fig. 3.16. Growth dynamics in a suction field. Formation of a mucosal gland of the lip (gland in longitudinal section). 1) mucosal epithelium, 2) stroma. Outlined arrow: developmental movement of epithelium relative to stroma during growth of the lip. Long tailed arrows: fluid influx into connective tissue, which therefore becomes a zone of loosening tissue. Black: deep layer of epithelium with a growing glandular anlage. Small tailed arrow: uptake of fluid substances through the sprouting region of the gland.

Fig. 3.17. Branching of an epithelial glandular anlage. Coarse stipple: growing wedge epithelium. Black: wedge epithelium hindered in growth. Close stipple: glandular lumen. Arrows with cross-tails: growth pressure of cells. 1) still solid part of gland, 2) arising connective tissue capsule with restraining function indicated by converging double arrow.

(Blechschmidt & Freeman, 2004)

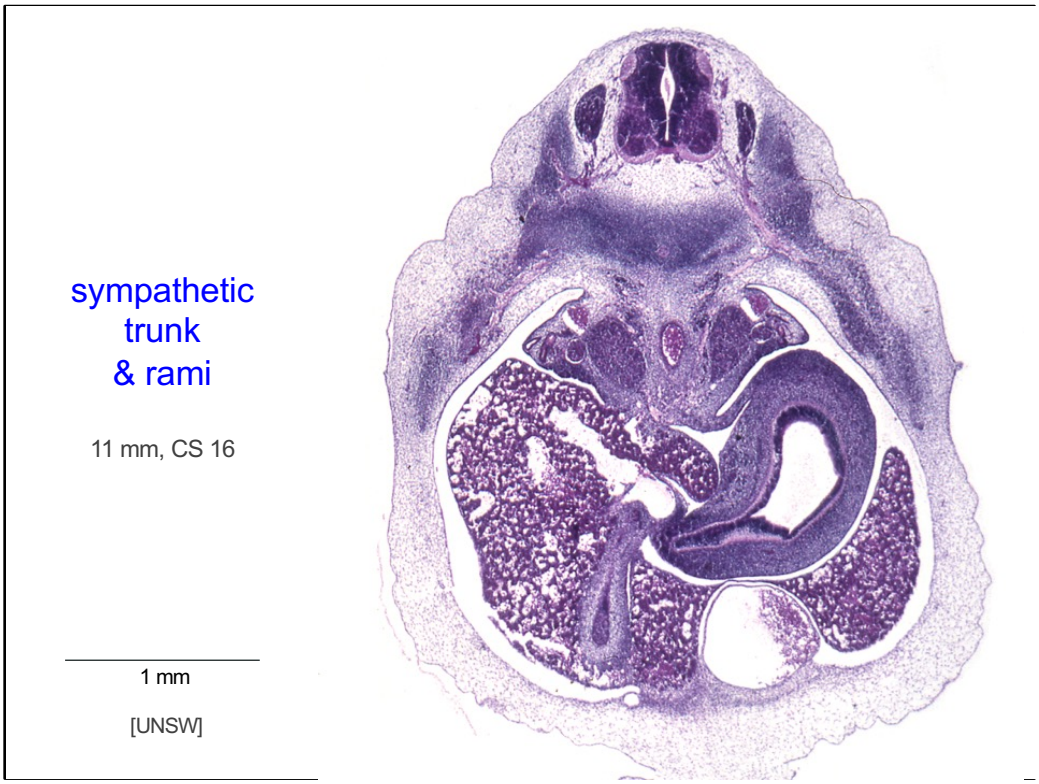
Suction field for gland development.

Blechschmidt E. (trans./ed. Freeman, B) *The Ontogenetic Basis of Human Anatomy. A Biodynamic Approach to Development from Conception to Birth*. Berkeley: North Atlantic, 2004



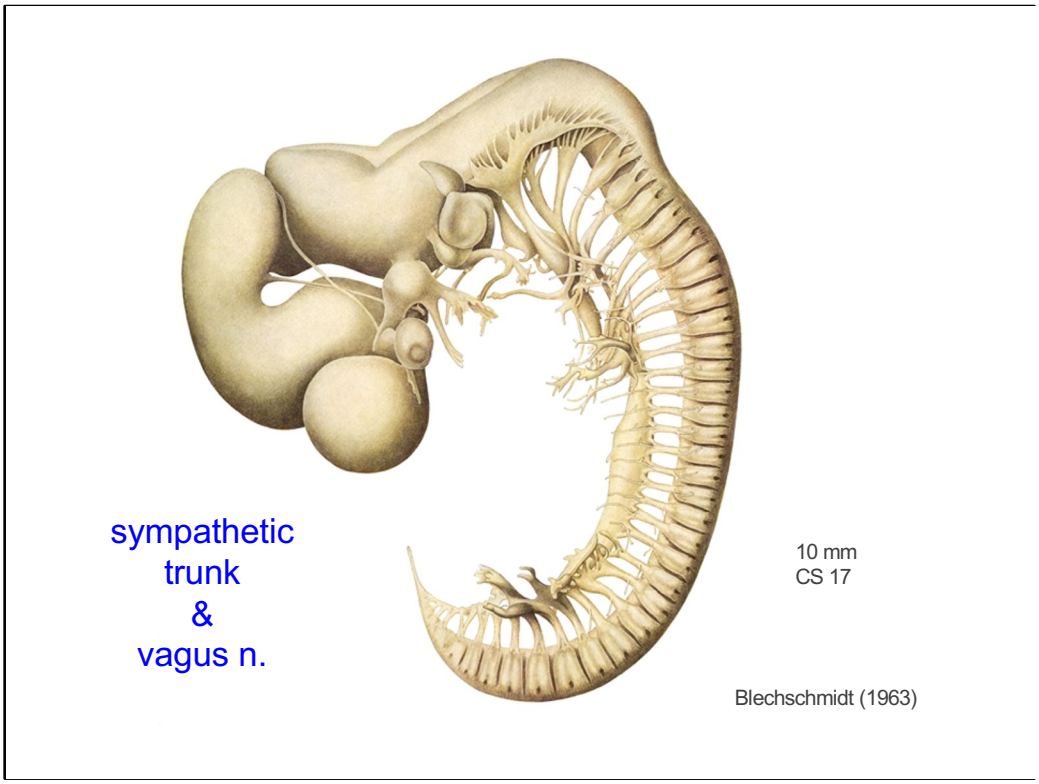
Sympathetic neurons arise from mesoderm in situ. CS 14 – C7 ganglion; CS 15 – T2 ganglion

VIRTUAL HUMAN EMBRYO PROJECT http://www.ehd.org/virtual-human-embryo/.



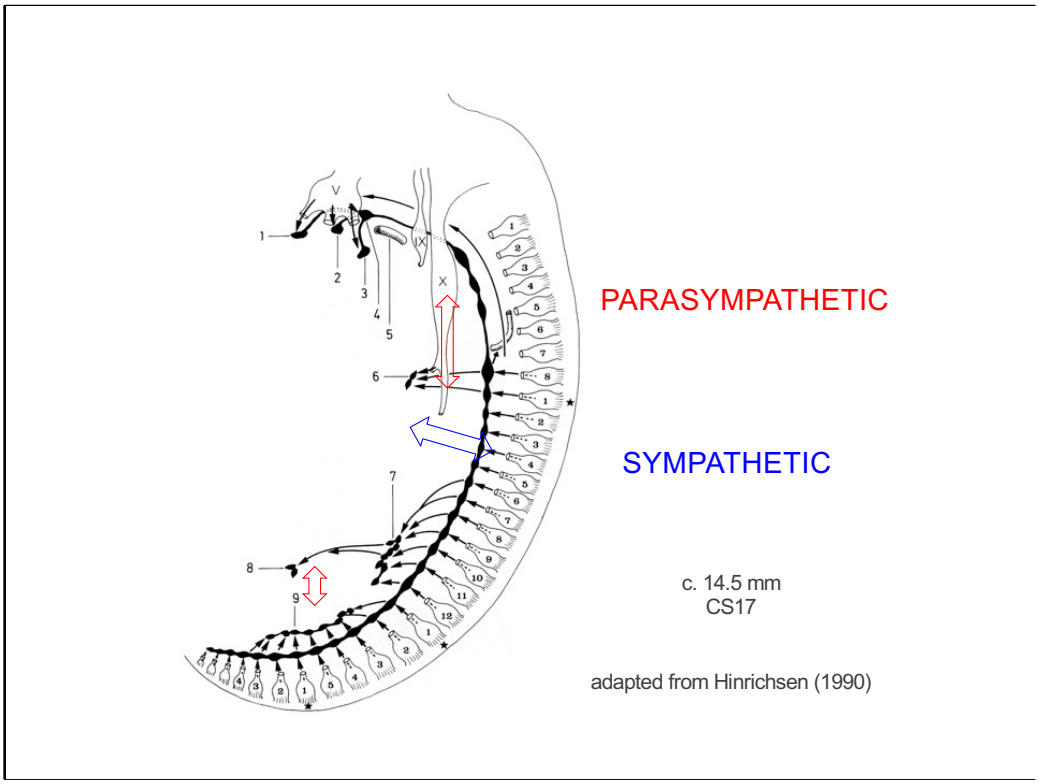
Slide showing well-developed rami to sympathetic ganglion.

Courtesy HZ-T: H45: 11 mm, 2779 (J, R3 C3 x5)

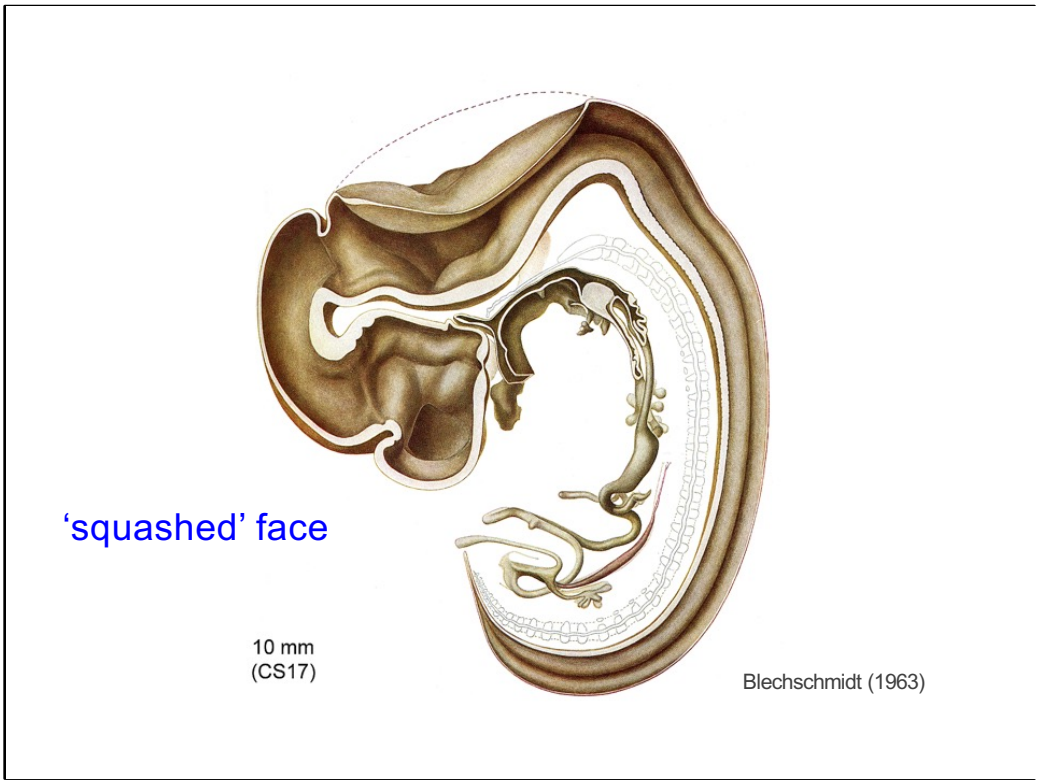


Peripheral nerves in 10 mm embryo.

Blechschmidt E. *The Human Embryo. Documentations on Kinetic Anatomy*. Stuttgart: Schattauer, 1963



Hinrichsen (1990), illustrating almost orthogonal vectors of parasympathetic & sympathetic innervation.



Median section through model of 10 mm, CS 17 embryo showing neural and endodermal structures.

Blechschmidt E. *The Human Embryo. Documentations on Kinetic Anatomy*. Stuttgart: Schattauer, 1963

Human face 16.2 mm

Human face 16.2 mm: NOSTRILS ALMOST CLOSED [original photograph by Erich Blechschmidt].

Blechschmidt, 2004

conchae
&
palate
at
24 mm

3 conchae; palatal process; 24 mm.

Blechschmidt E. (trans./ed. Freeman B) *The Ontogenetic Basis of Human Anatomy. A Biodynamic Approach to Development from Conception to Birth*. Berkeley: North Atlantic, 2004

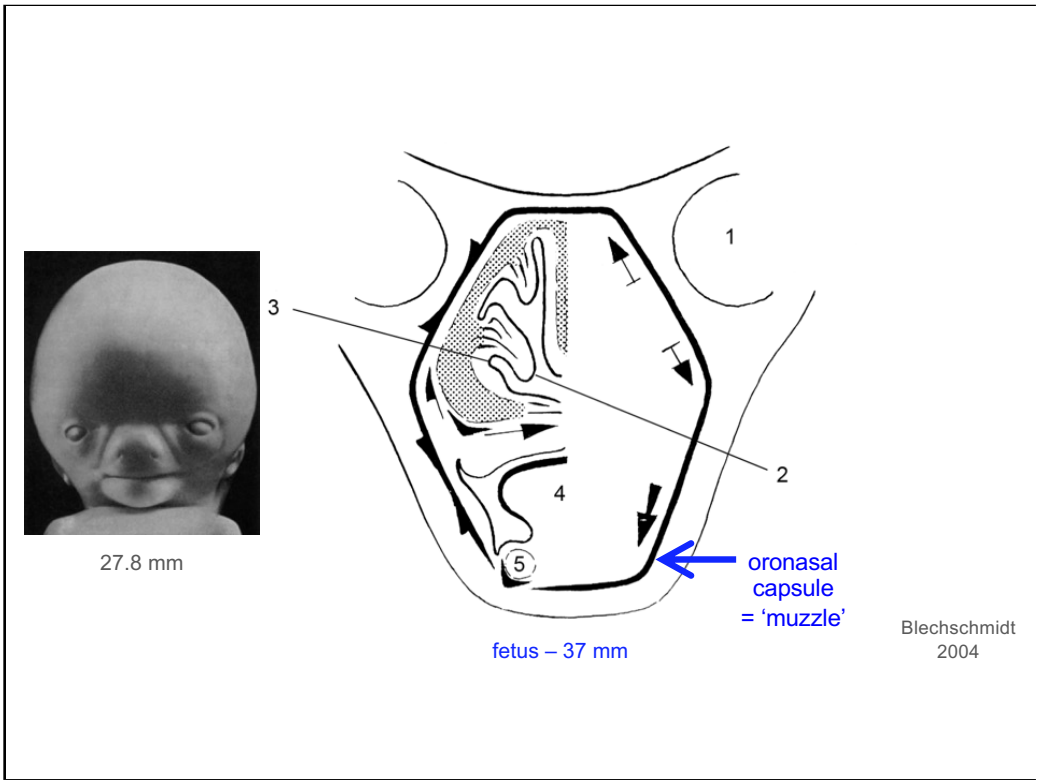
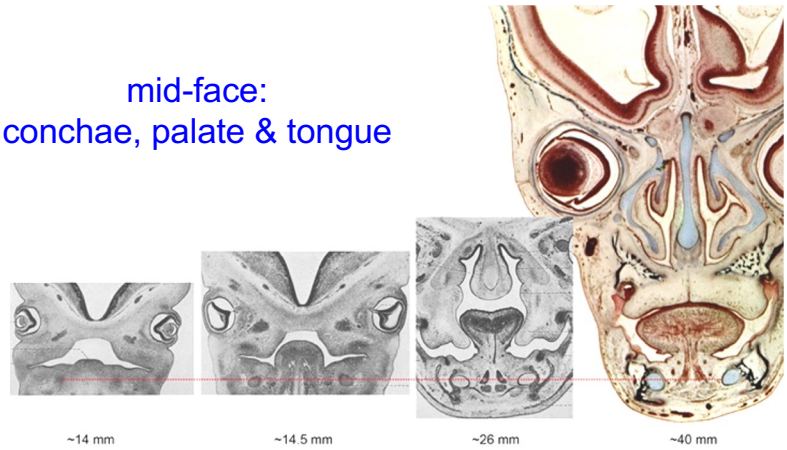


Fig. 19. Frontal section through facial region of 37 mm long fetus. Formation of long face with stretching of connective tissue of nasal capsule ('muzzle, thick black line, external to nasal cartilage (stippled). Converging half-headed arrows: restraining function of stretched connective tissue. Diverging arrows: piston-like growth and growth expansion of nasal cartilage. 1 eye, 2 middle concha, 3 middle nasal meatus (site of growth of maxillary sinus), 4 tongue, 5 Meckel's cartilage with bone formation on lateral aspect.

(modified from ref. 2).

RETENSION FIELD: GREEK: PHIMOS = muzzle. NB. discuss bone formation within retension field.

mid-face:
conchae, palate & tongue



frontal sections; same scale

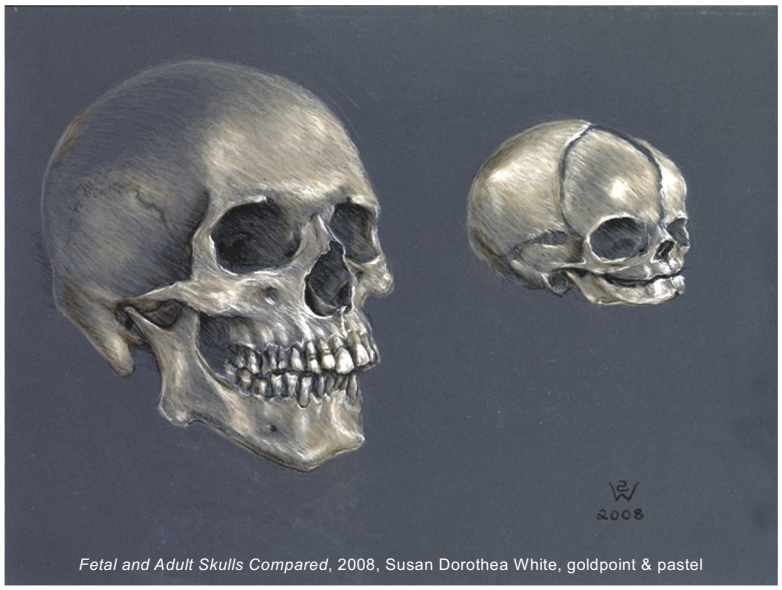
reference: Meckel's cartilage → mandible

from: Blechschmidt (1960, 1969)

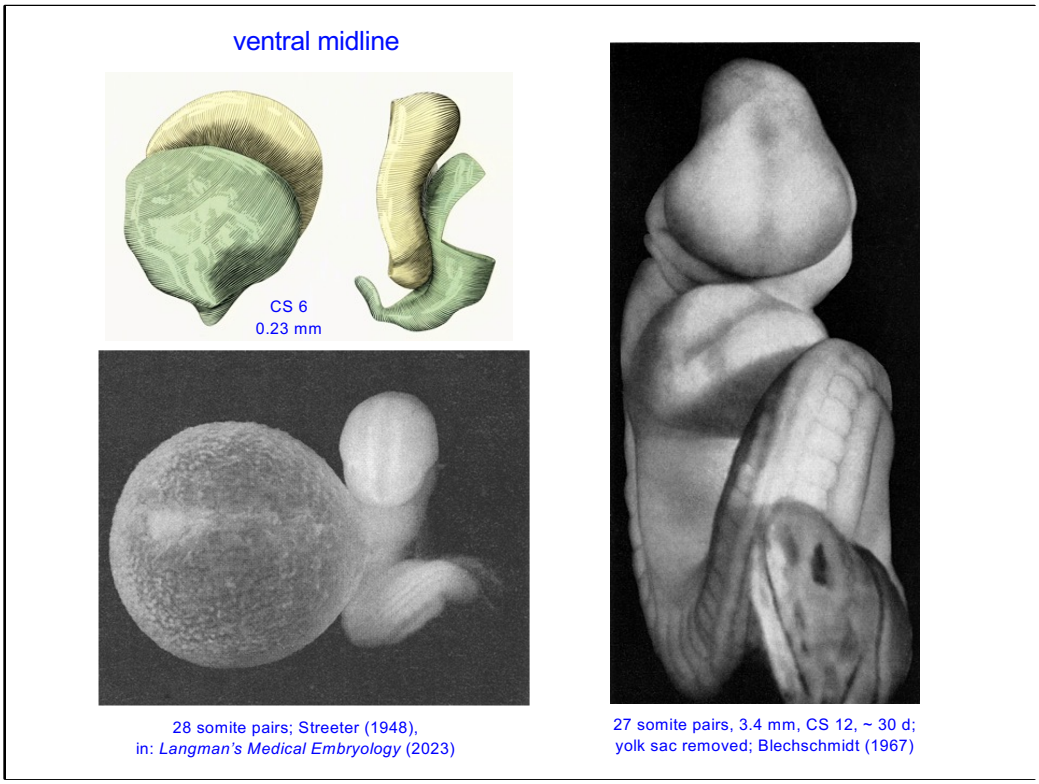
Growth movements of conchae, palate & tongue (reference line: Meckel's cartilage; frontal sections): ALL DUE TO HEAD ERECTION.

Blechschmidt E. *The Stages of Human Development Before Birth*. Basel: Karger, 1960

Blechschmidt E. *Vom Ei zum Embryo. Die Gestaltungskraft des Menschlichen Keims*. Stuttgart: Deutscher Bücherbund, 1969



Fetal and Adult Skulls Compared, 2008, Susan Dorothea White, goldpoint & pastel



Ventral views: face (hidden), heart, liver, ventral (yolk) vesicle, connecting stalk. NB. ECTODERMAL RING crosses midline.

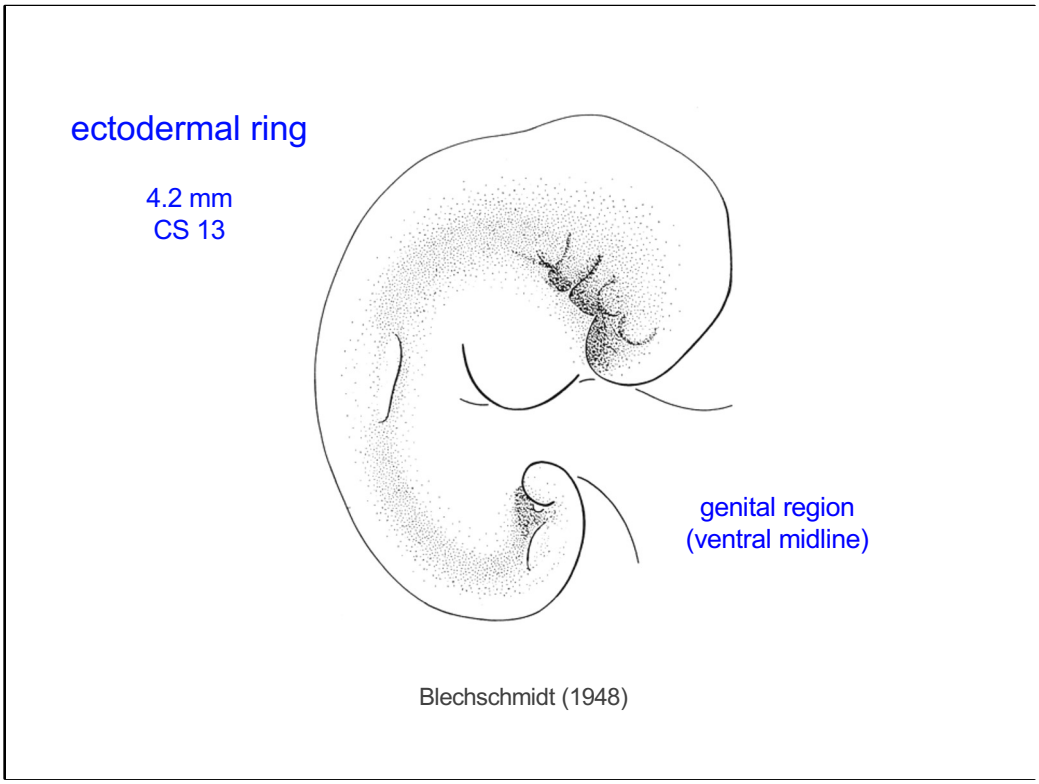
Top left: Wojtowicz *et al.* (2023)

Right: 27 somite, 3.4 mm embryo, CS 12 ~ 30 days // YOLK SAC REMOVED.

Blechschmidt E (1967) Die Bedeutung der interzellulären Flüssigkeit für die Herzentwicklung (Flüssigkeitsstauungen als allgemeine Vorbedingungen für Differenzierungen). In: Heilmeyer L, Mazzei ES, Holtmeier HJ, Marongiu F (eds) *Diureseforschung*. Fortschr Gebiete Inn Med, IV. Symp, Freiburg 1966, Thieme, Stuttgart, pp. 60–85

Bottom left: 'yolk' sac in a 28 somite embryo (Streeter/Langman). NOTE TORSION IN EMBRYO. Sadler, TW. *Langman's Medical Embryology*. Baltimore: Lippincott, 1985.

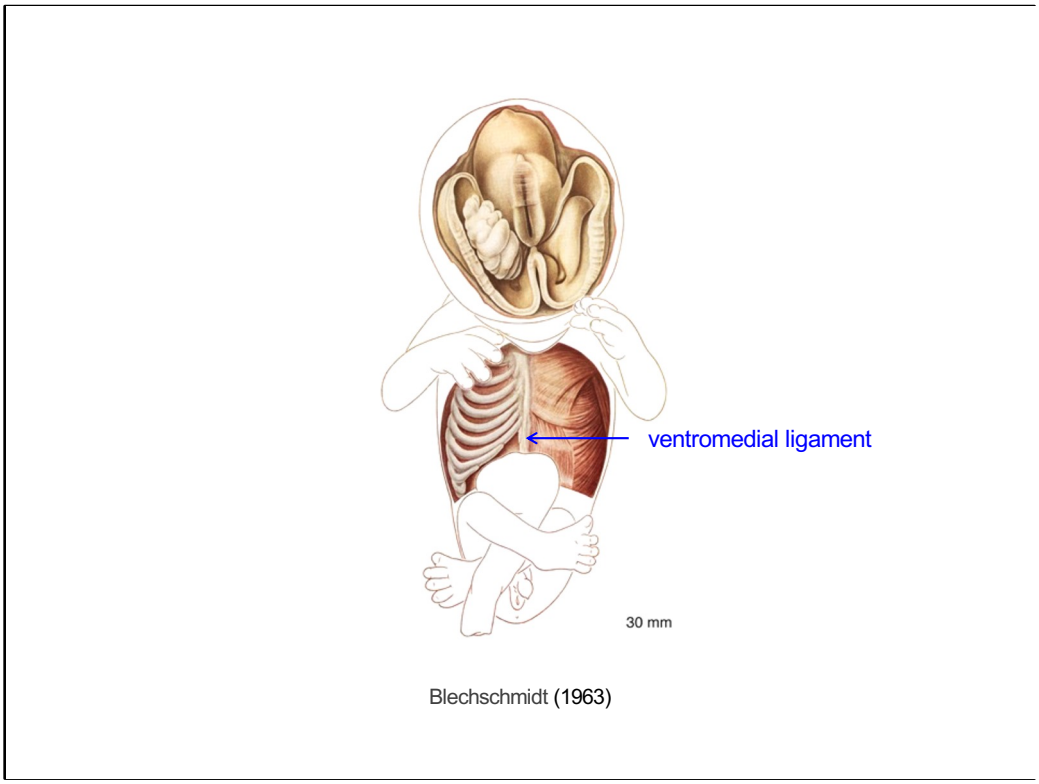
[Langman has lateral and ventral views of same 28 somite embryo; perhaps photo B was taken first, then 'yolk' sac cut off, then re-photographed, but negative reversed to make photo A?; from Streeter (1948); images still appearing in latest version 2023!]



Ectodermal Ring (4.2 mm: CS 13) 2 different representations. BRIEF HISTORY OF ECTODERMAL RING; GENITAL REGION: in VENTRAL MIDLINE.

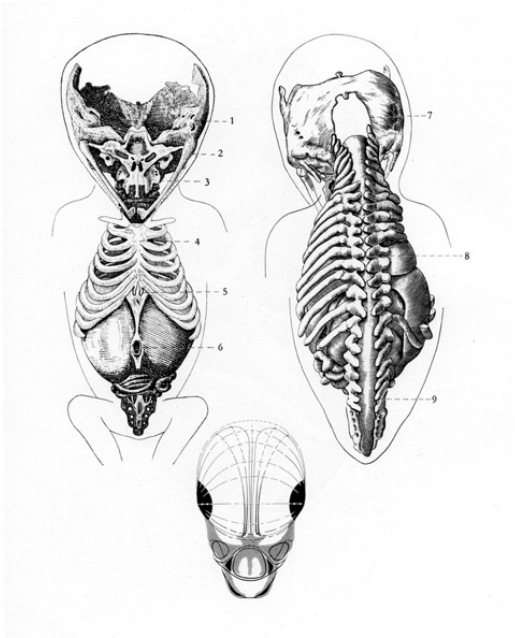
Heinrich Schmitt (Freiburg) 1898; Blechschmidt E. *Mechanische Genwirkungen*. Göttingen: Musterschmidt, 1948 (redrawn in: Blechschmidt E, Gasser RF. *Biokinetics and Biodynamics of Human Differentiation*. Springfield: Thomas, 1978); O'Rahilly R, Gardner E (1975) The timing and sequence of events in the development of the limbs in the human embryo. Anat Embryol 148: 1–23.

From O'Rahilly (1956): "Blechschmidt (1948, 1951) believed that the band of thickened head ectoderm is continuous with those located on the upper limbs, and that these latter are in turn continuous with those found on the lower limbs. Thus he illustrated a ring of thickened ectoderm, *Ektodermring,* part of which is found on the ventral aspects of the limb buds. Blechschmidt reproduced photomicrographs of later stages which show the *Ektodermkappe* or *Randreifen.* In Blechschmidt's laboratory Strube (1950) made a detailed study of the thickness of the surface epithelium of a 7-5-mm. human embryo. He found that the ectodermal ring ranged from 7 to 24 *um* in thickness, and that the ectodermal ridges of the upper and lower limbs ranged from 13 to 24 *um.* With the exception of the olfactory pit (25-54 *um),* the epithelium of the ectodermal ring and ridges was the thickest on the surface of the body. The writers wish to thank Professor E. Blechschmidt, of Gottingen, for the loan of Dr. Strube's dissertation."



Ventromedial ligament (fetus - 30 mm).

Blechschmidt E. *The Human Embryo. Documentations on Kinetic Anatomy*. Stuttgart: Schattauer, 1963



4 sternum
5 xiphoid process
6 ventromedial ligament

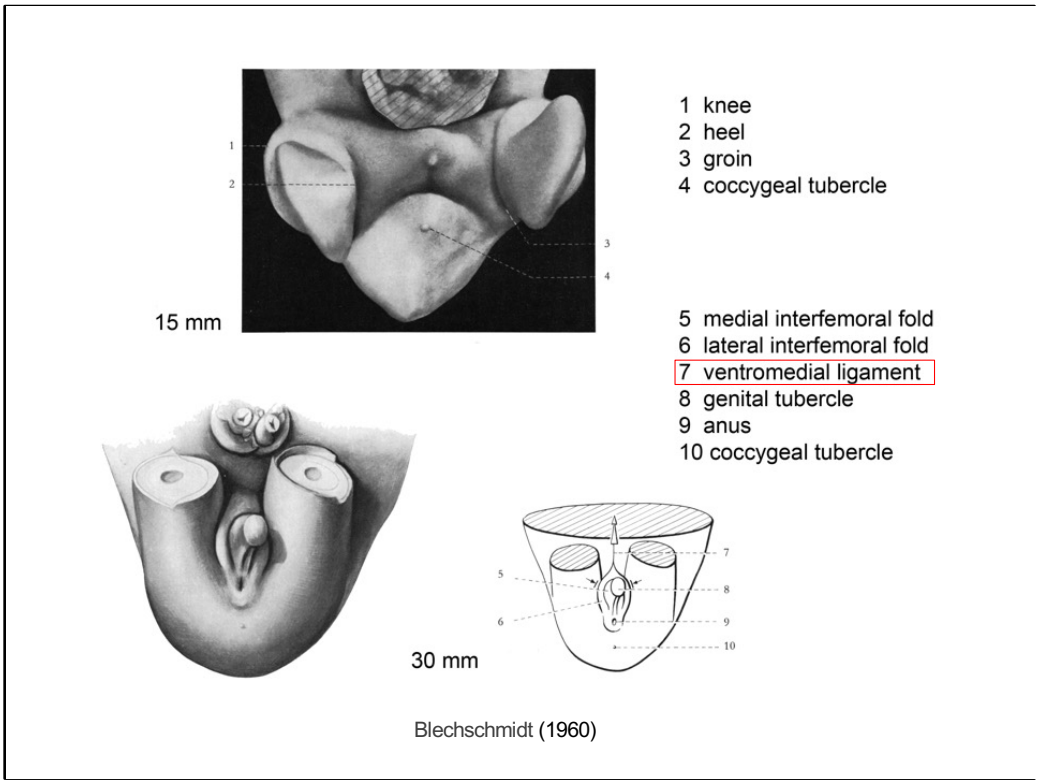
Ventromedial lg. continues into interfemoral region

FETUS
(4 cm; 3rd month)

Blechschmidt (1960)

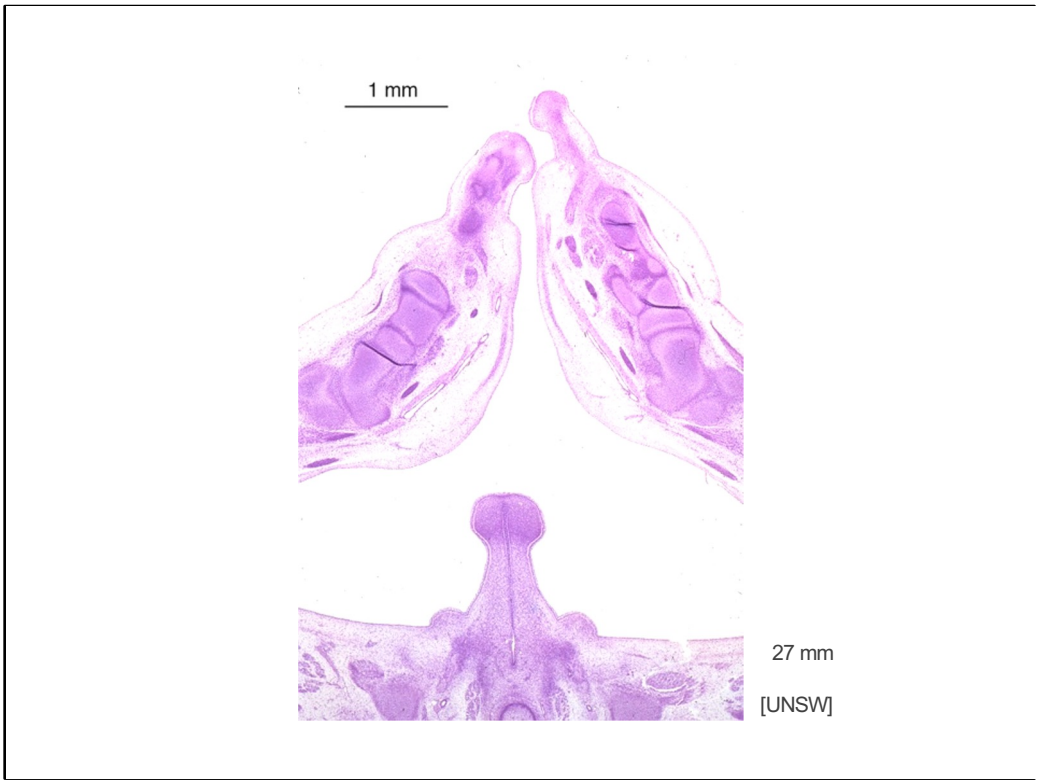
Myofascia of sternomastoid follows alignment of mandible, also hyoid bone and stylohyoid ligament.

Blechschmidt E. *The Stages of Human Development Before Birth*. Basel: Karger, 1960



Ventromedial ligament (7) and development of external genitalia.

Blechschmidt E. *The Stages of Human Development Before Birth*. Basel: Karger, 1960



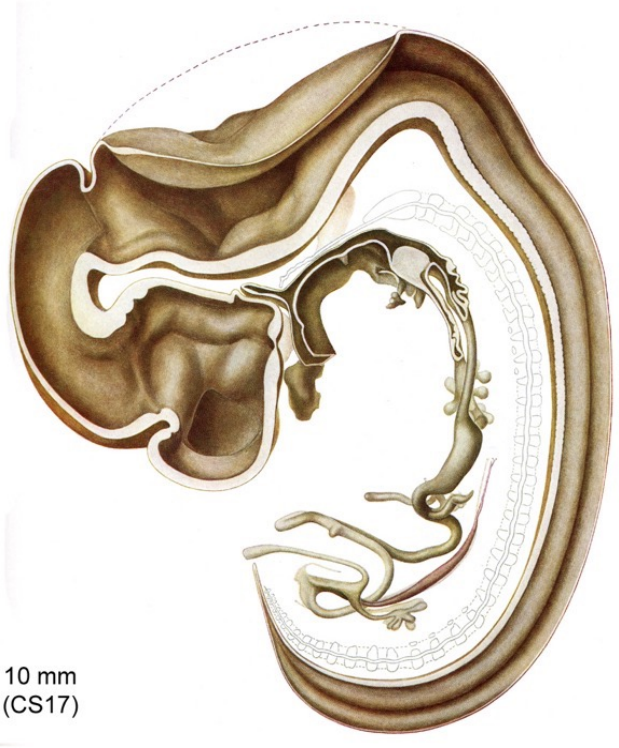
Section through inverted feet of 27 mm embryo, approximately along plane of upper dashed blue line on LHS of previous slide (scale: 1 mm). [BF, UNSW]

10 mm endoderm

internal genitalia

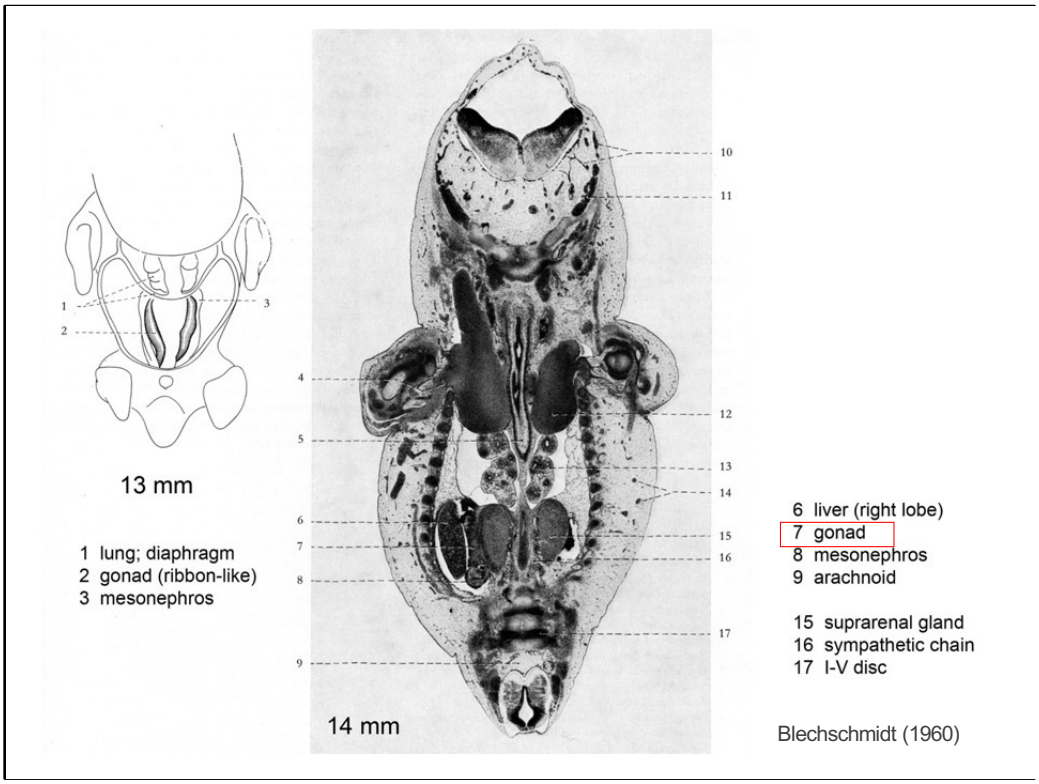
mesonephros

Blechschmidt (1963)



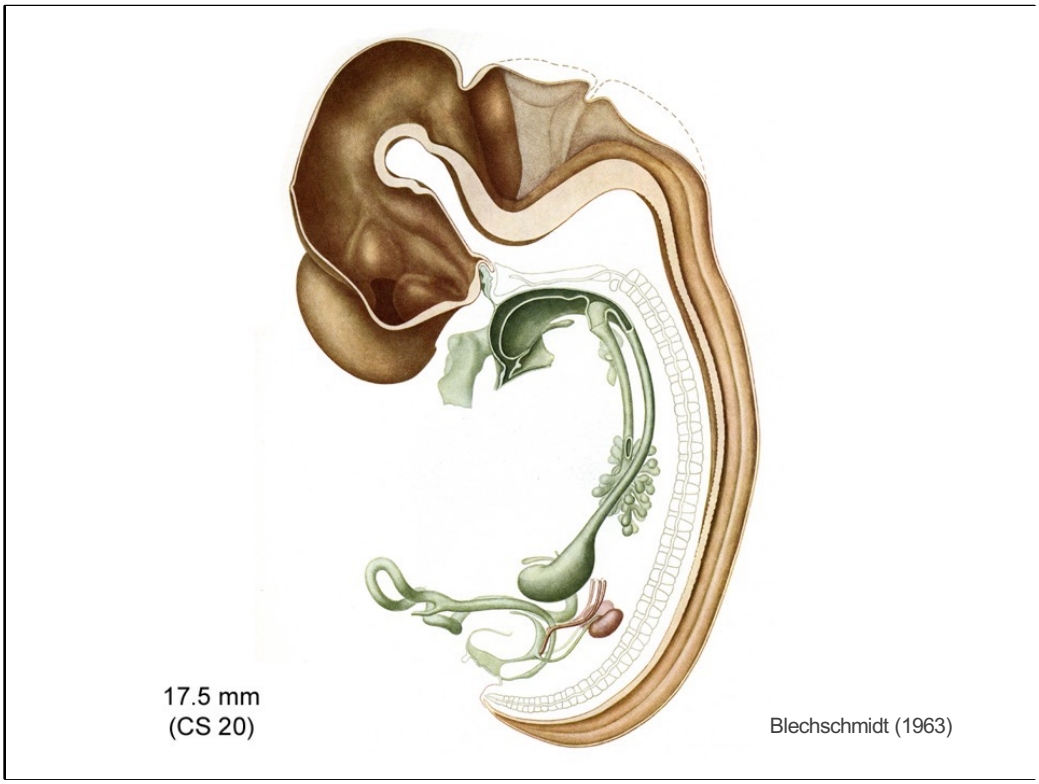
10 mm
(CS17)

Blechschmidt E. *The Human Embryo. Documentations on Kinetic Anatomy*. Stuttgart: Schattauer, 1963

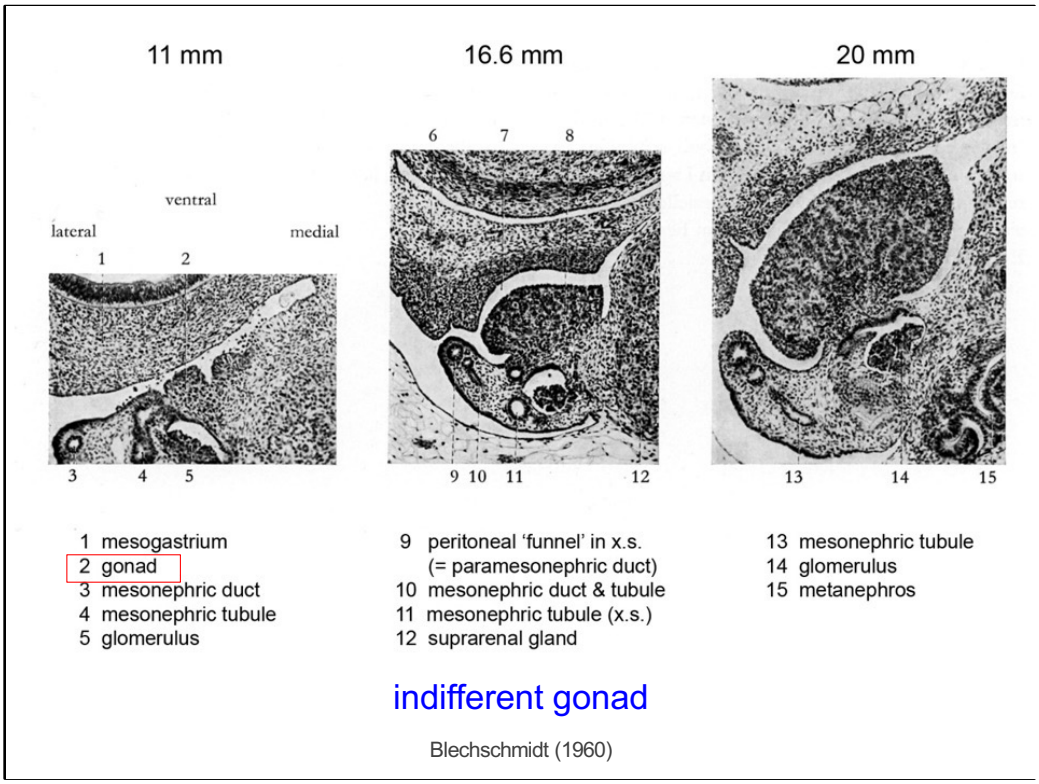


Blechschmidt E. *The Stages of Human Development Before Birth*. Basel: Karger, 1960

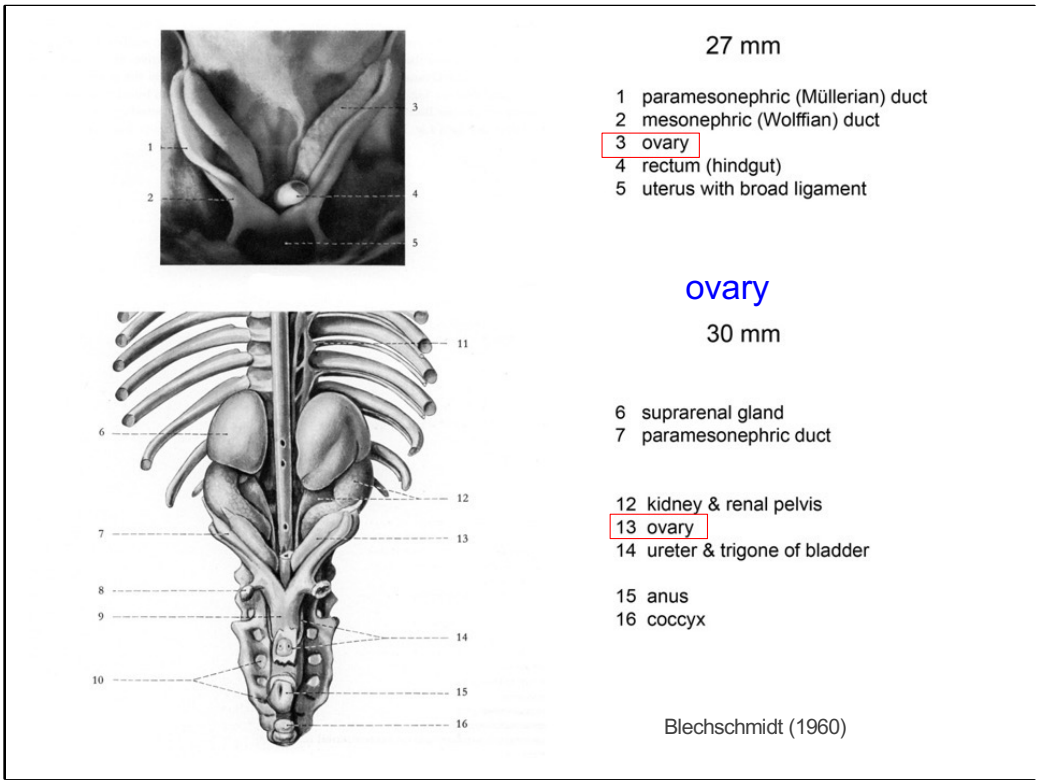
17.5 mm endoderm



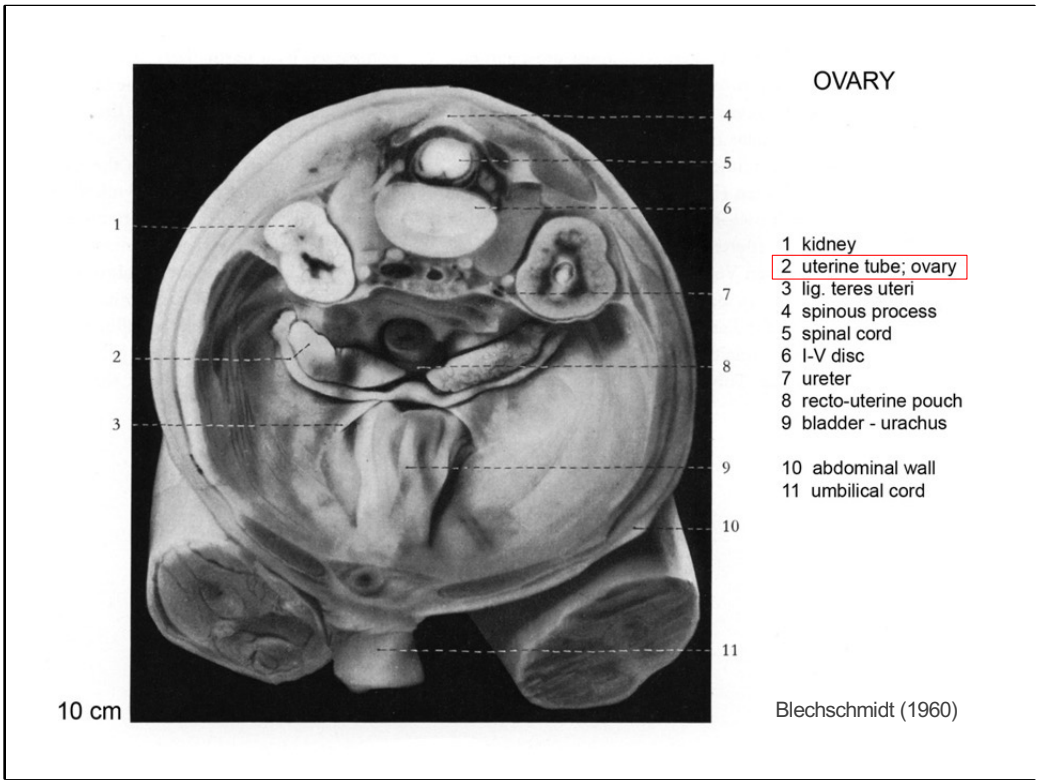
Blechschmidt E. *The Human Embryo. Documentations on Kinetic Anatomy*. Stuttgart: Schattauer, 1963



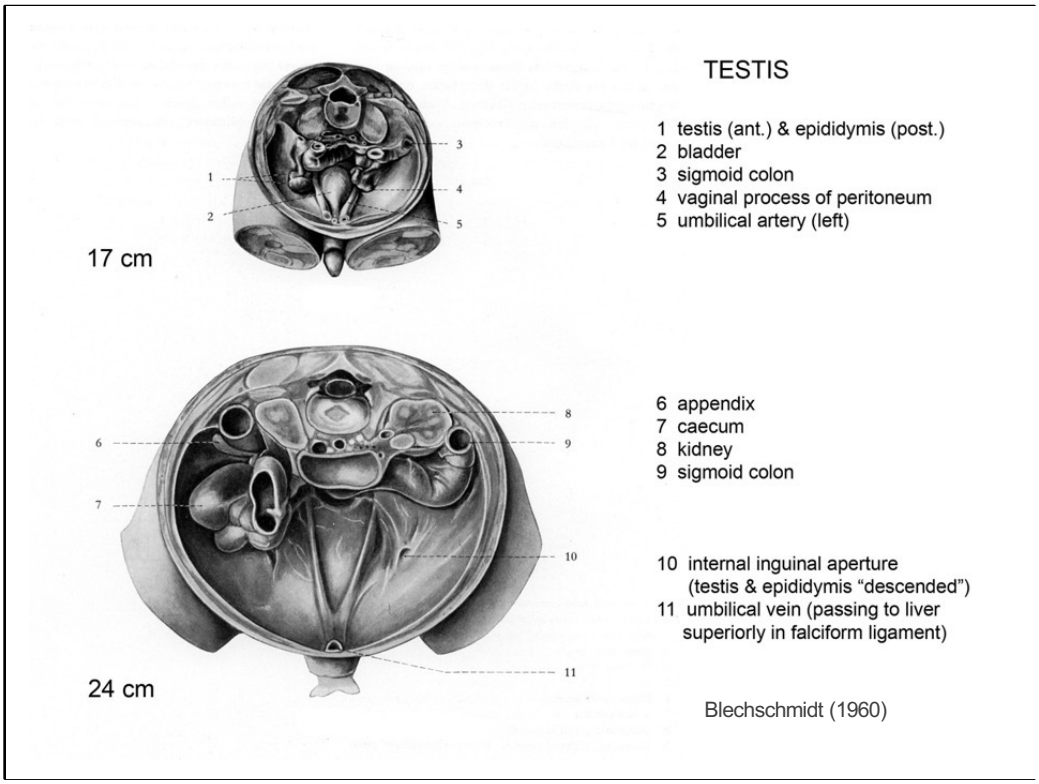
Blechschmidt E. *The Stages of Human Development Before Birth*. Basel: Karger, 1960



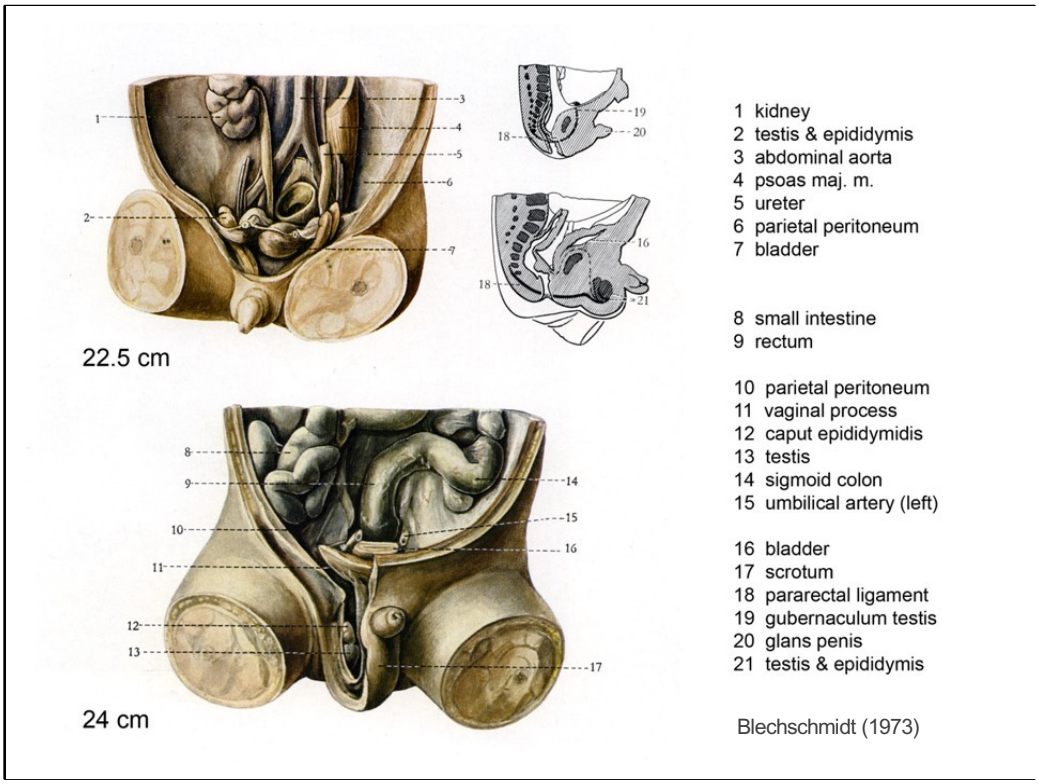
Blechschmidt E. *The Stages of Human Development Before Birth*. Basel: Karger, 1960



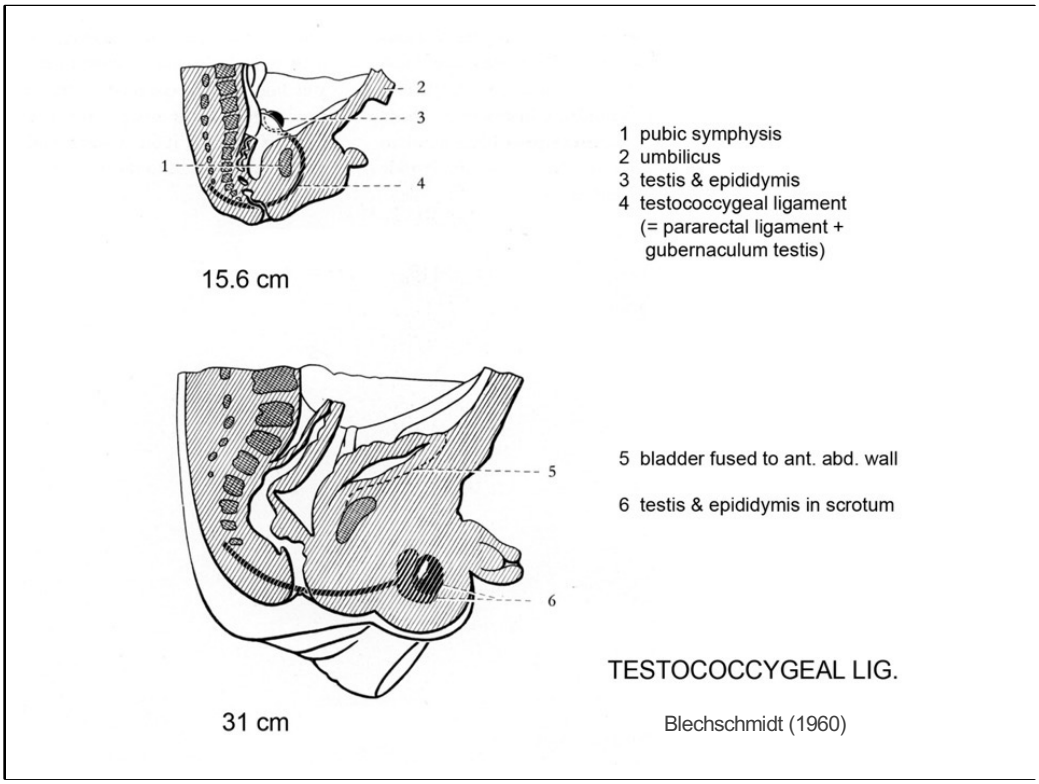
Blechschmidt E. *The Stages of Human Development Before Birth*. Basel: Karger, 1960



Blechschmidt E. *The Stages of Human Development Before Birth*. Basel: Karger, 1960



Blechschmidt E. *Die präatalen Organsysteme des Menschen*. Stuttgart: Hippokrates, 1973



Blechschmidt E. *The Stages of Human Development Before Birth*. Basel: Karger, 1960

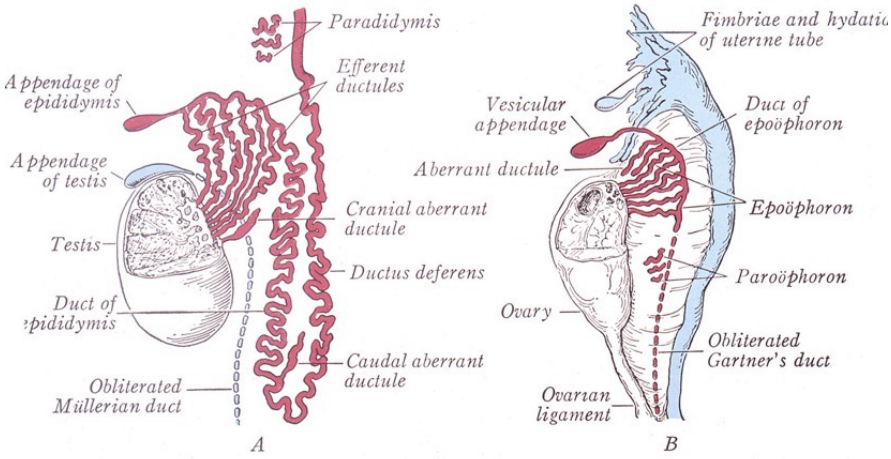


Fig. 288. Diagrams illustrating the diverse fates of the mesonephric tubules and t mesonephric and Müllerian ducts in the two sexes. *A*, Male; *B*, female.

Arey, *Developmental Anatomy* (1947)

The End