

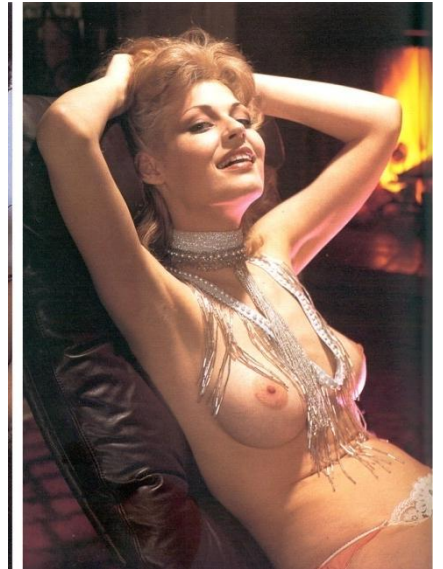
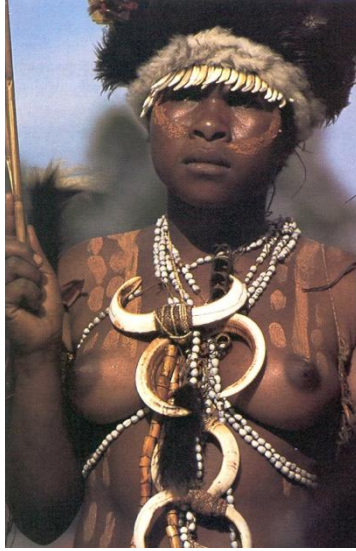
Development and functional anatomy of the breast, lactation

Dr. Andrea D.Székely

Semmelweis University

Department of Anatomy, Histology and Embryology





Typical for mammals, paired apocrine gland
Organ of lactation

Both sexes (male, female) express it
*(in males the size equals to the diameter of the areola,
Only the female breast produces milk)*

Maturation starts with the onset of puberty

Secondary sexual organ (trait)
*(enlargement /protrusion of the breast from the thoracic wall
is the sign of female sexual maturity and fertility (??))*

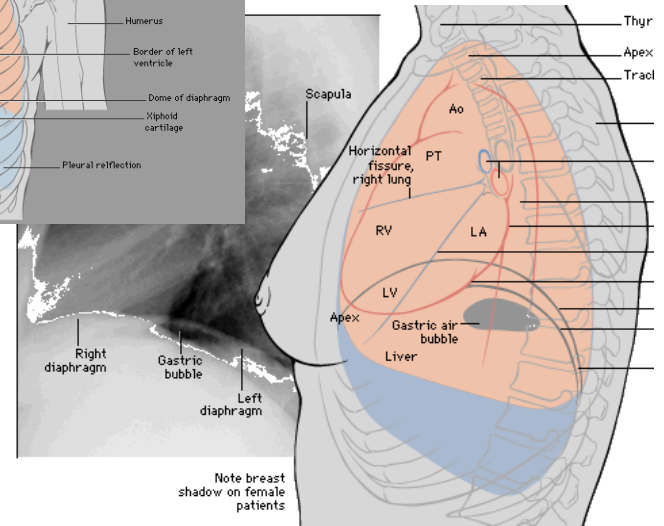
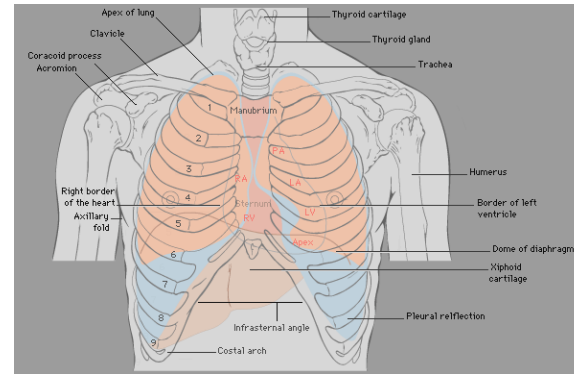
**Human breasts are relatively large
when compared to those in other apes**



Structure of the thorax

Regio mammalis

VENTRAL THORACIC SURFACE



THORACIC CAVITY:

- superior thoracic aperture (Th2)

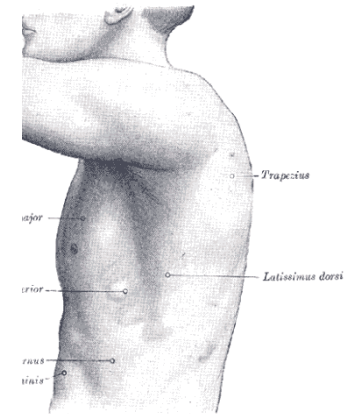
Borders: Th1, 1st ribs, sternum, pleura,

- inferior thoracic aperture (Th10)

Borders: Th12, 11-12th ribs, costal arch, xiphoid process

SUPERIOR – „open” (inflammations!)

INFERIOR - diaphragma



BLOOD SUPPLY OF THE THORACIC WALL

SUBCLAVIAN A.

- INTERNAL THORACIC A.

ANT. INTERCOSTAL RAMI

Perforator branches (!!)

AXILLARY A.

SUPREME THORACIC A. (2)

THORACOACROMIAL

LATERAL THORACIC A. (3)

DESCENDING AORTA

INTERCOSTAL AA (4)

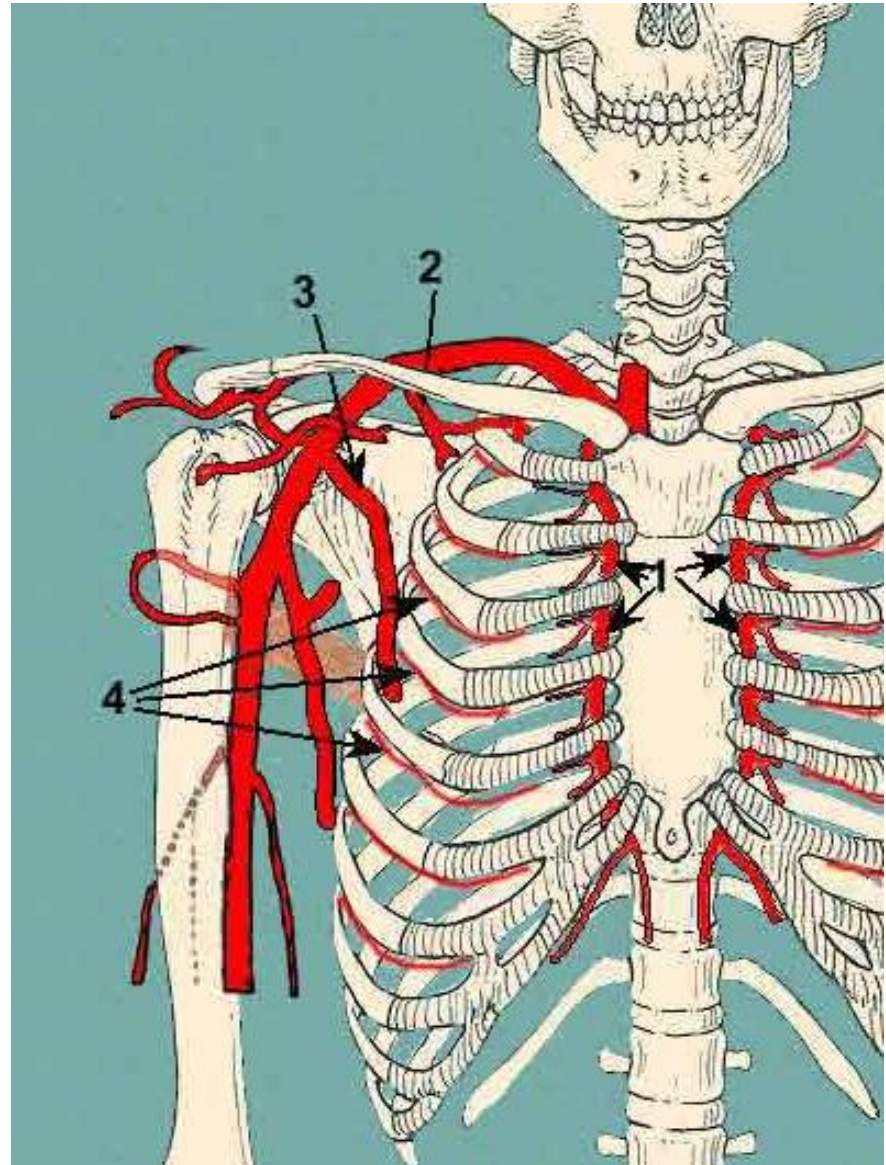
**SIMILAR VENOUS DRAINAGE
TOWARDS THE
SUPERIOR V CAVA**

MAJOR VEINS:

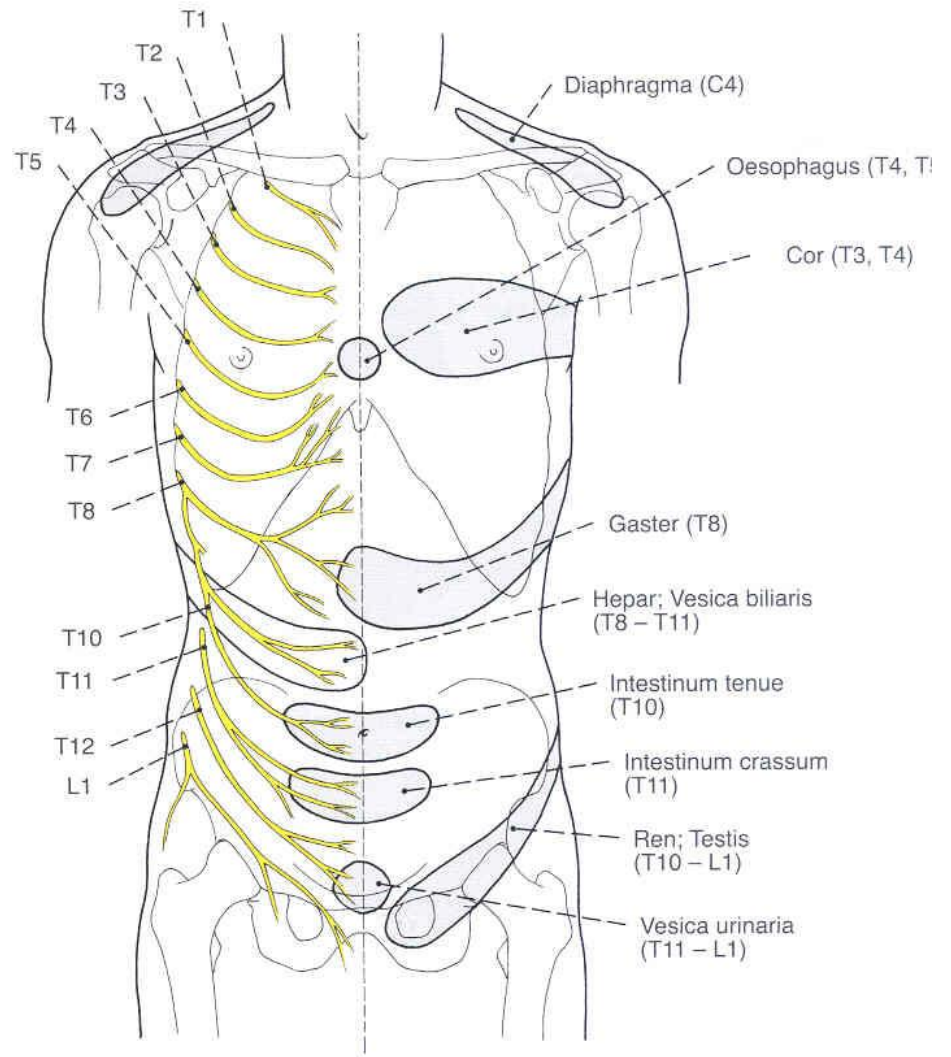
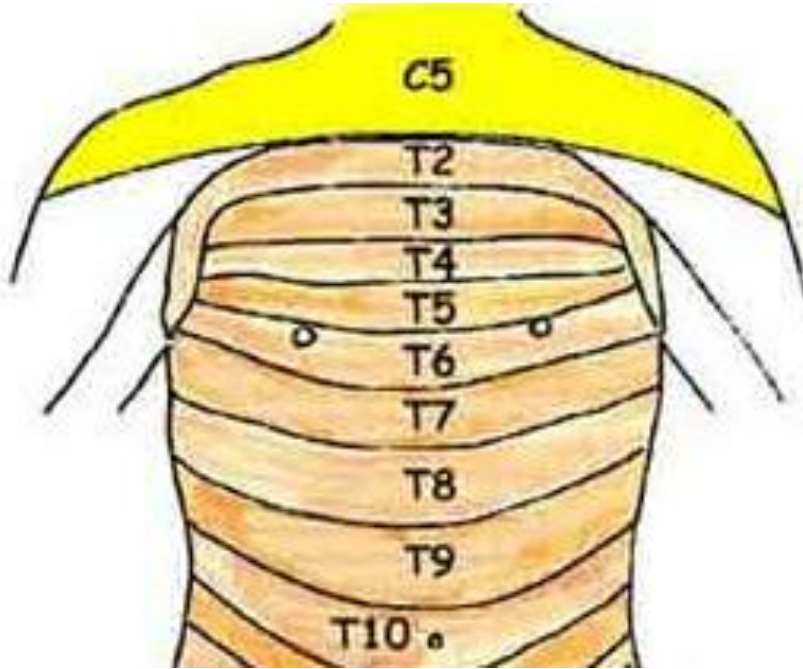
AXILLARY V.

SUBCLAVIAN V.

AZYGOS & HEMIAZYGOS V.



SEGMENTAL INNERVATION OF THE THORAX



Cutivisceral reflexes !!!

Referred pain

Converging afferentation on the same ganglionic cell in the DRG

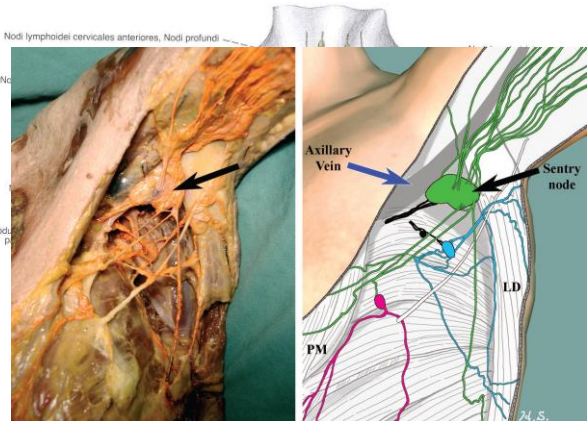
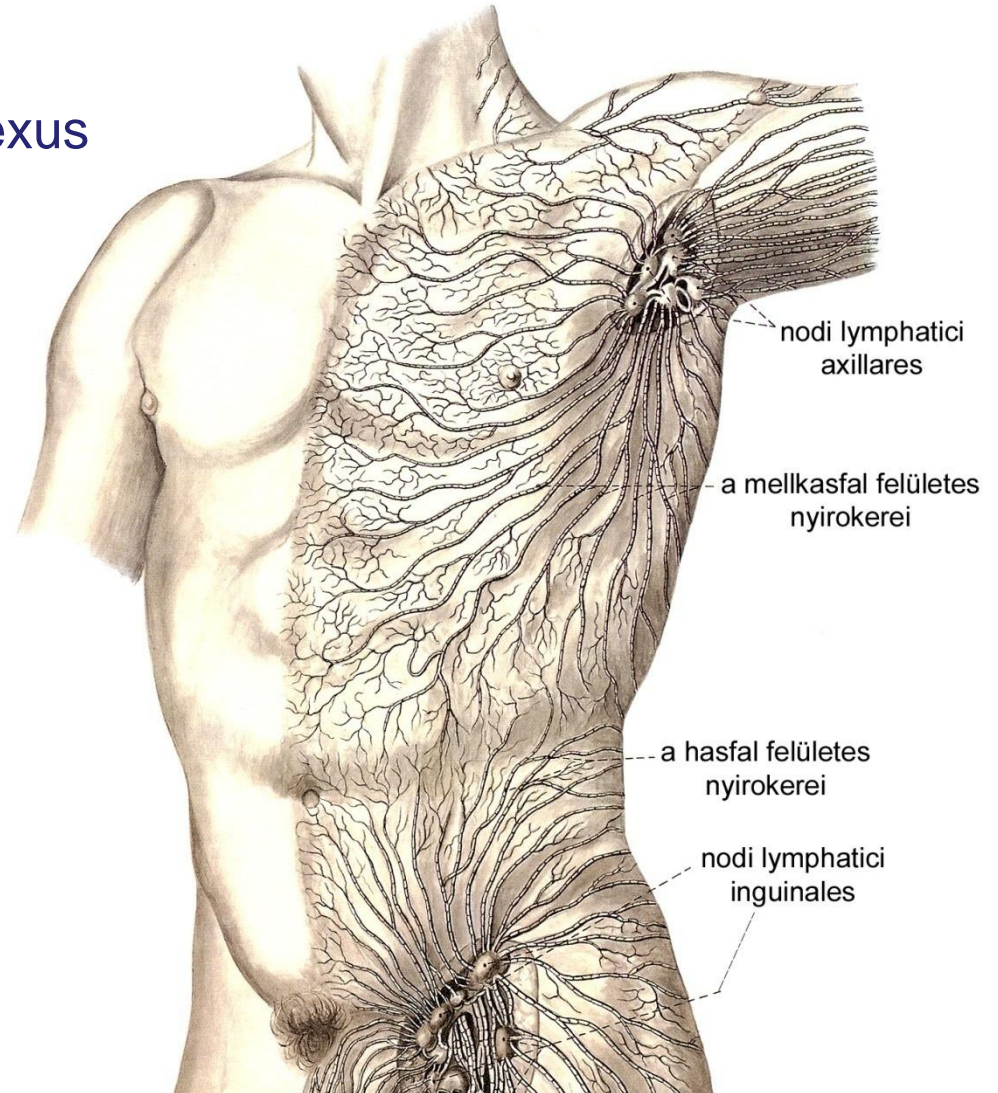
LYMPHATIC DRAINAGE OF THE BODY WALL

Lymphatic vessels

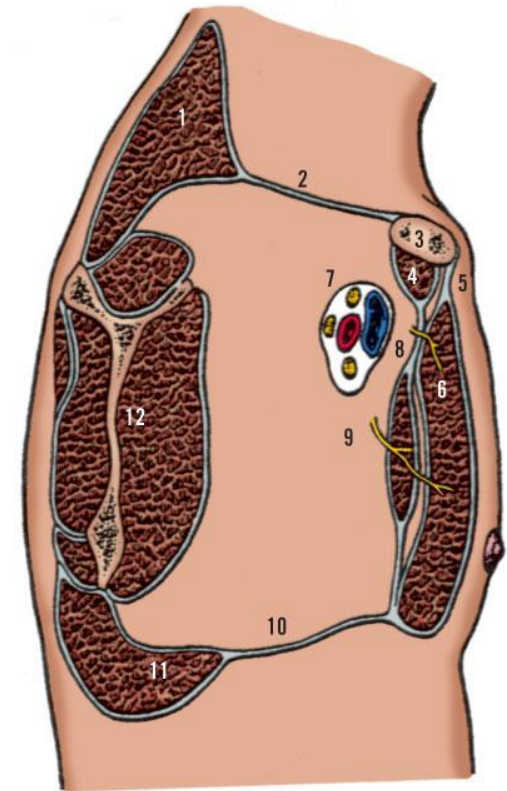
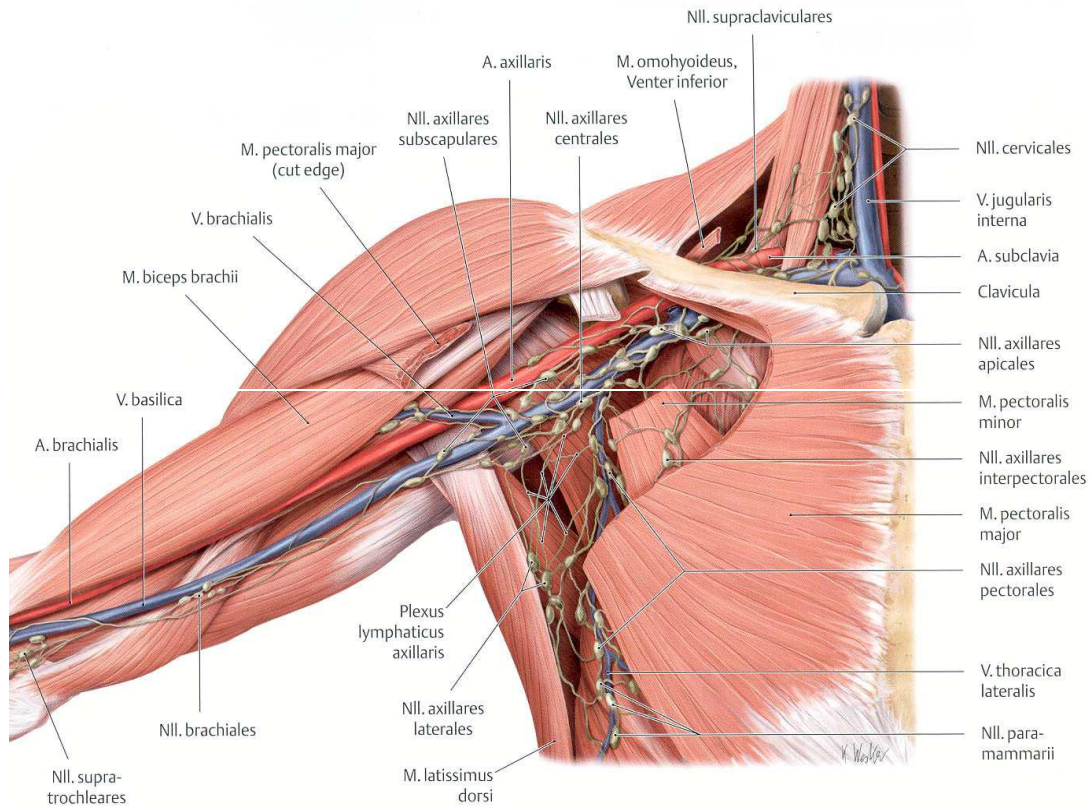
areolar and subareolar plexus

lymph nodes

- axillary
- pectoral
- parasternal
- interpectoral

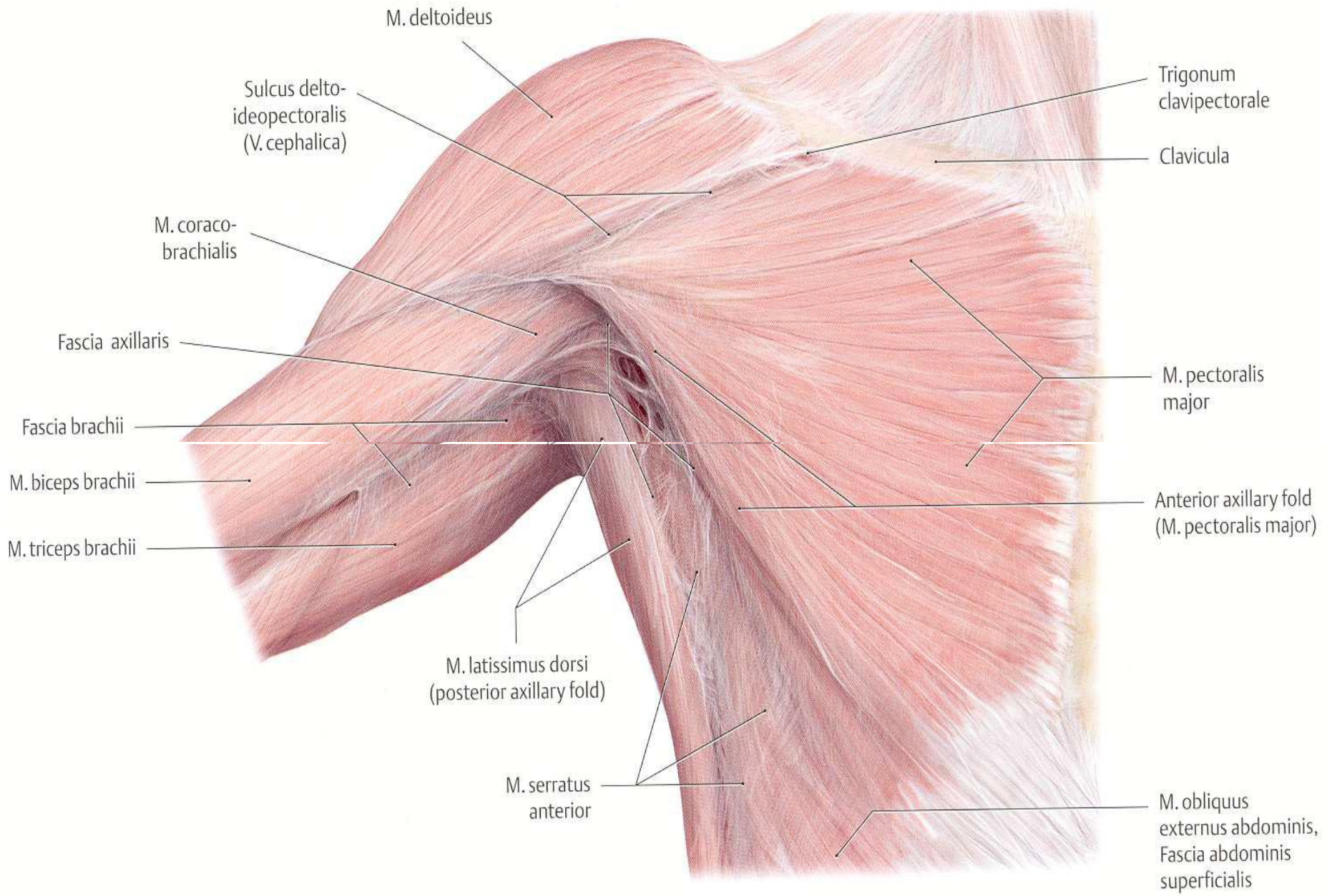


STRUCTURE OF THE AXILLA

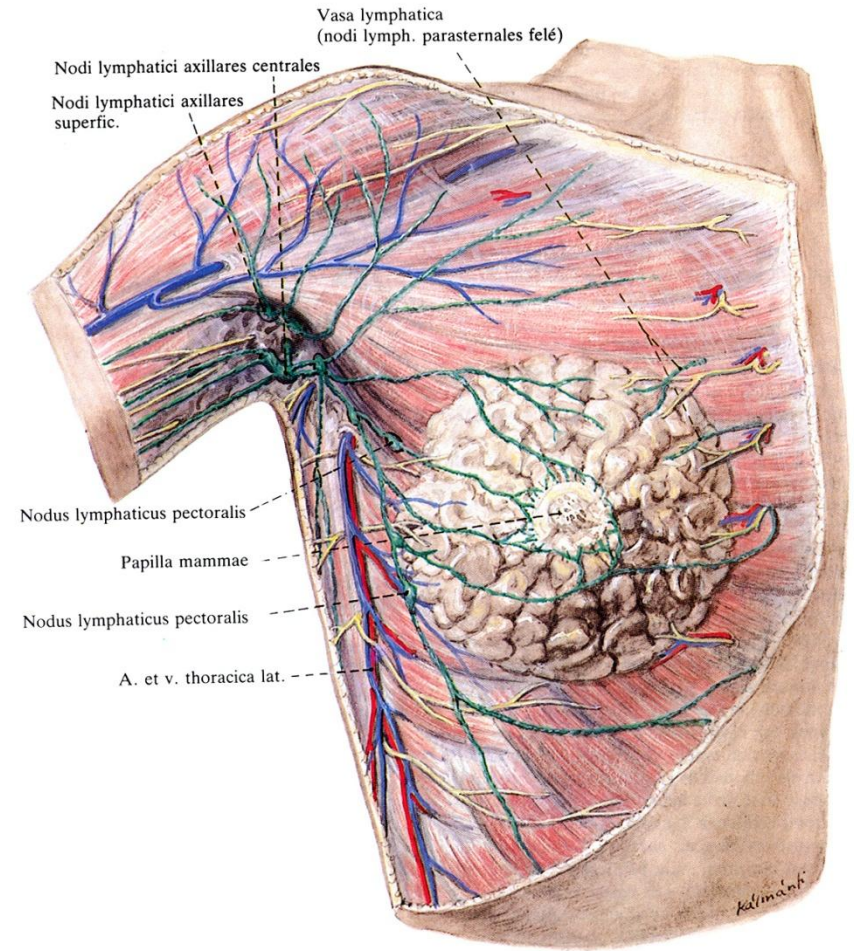


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Parasagittal section through the pectoral region. 1. Trapezius muscle. 2. Cervical investing fascia. 3. Clavicle. 4. Subclavius muscle. 5. Pectoral fascia. 6. Pectoralis major. 7. Axillary sheath. 8. Lateral pectoral nerve. 9. Medial pectoral nerve, entering pectoralis minor muscle. 10. Suspensory ligament of axilla. 11. Latissimus dorsi muscle. 12. Blade of scapula. (Modified from Colborn GL, Skandalakis JE. Clinical Gross Anatomy. Pearl River NY: Parthenon, 1993; with permission.)



MAMMARY REGION



Borders:

- parasternal line
- plica axillaris anterior
- between 2-3 – 6-7. ribs
- nipple reflects to the 4th IC space

Borders of the breast

2. rib

6. rib

parasternal line

Anterior axillary fold

Submammary fold

Runs to the 5. rib
from the superficial
fascia

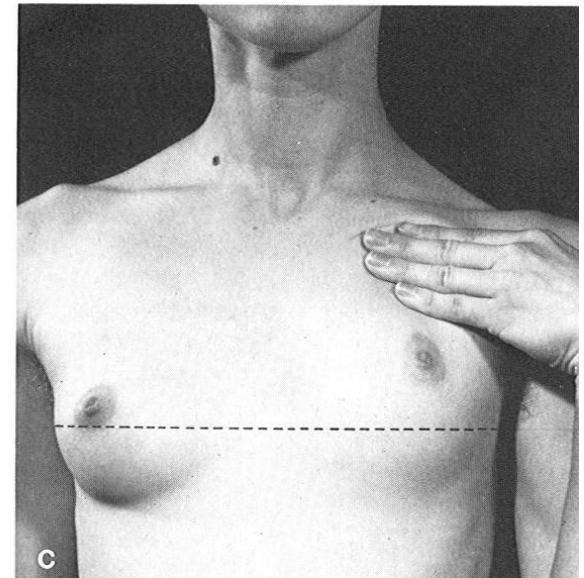
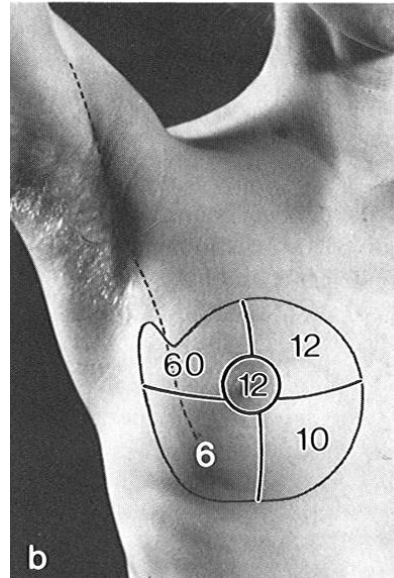
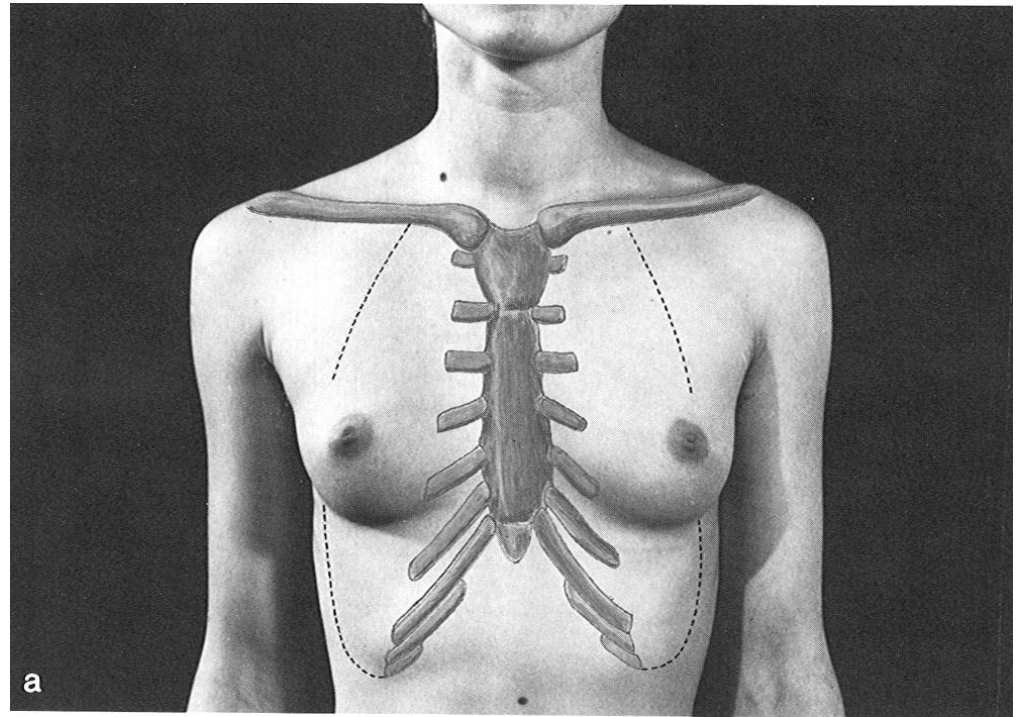
Muscular base

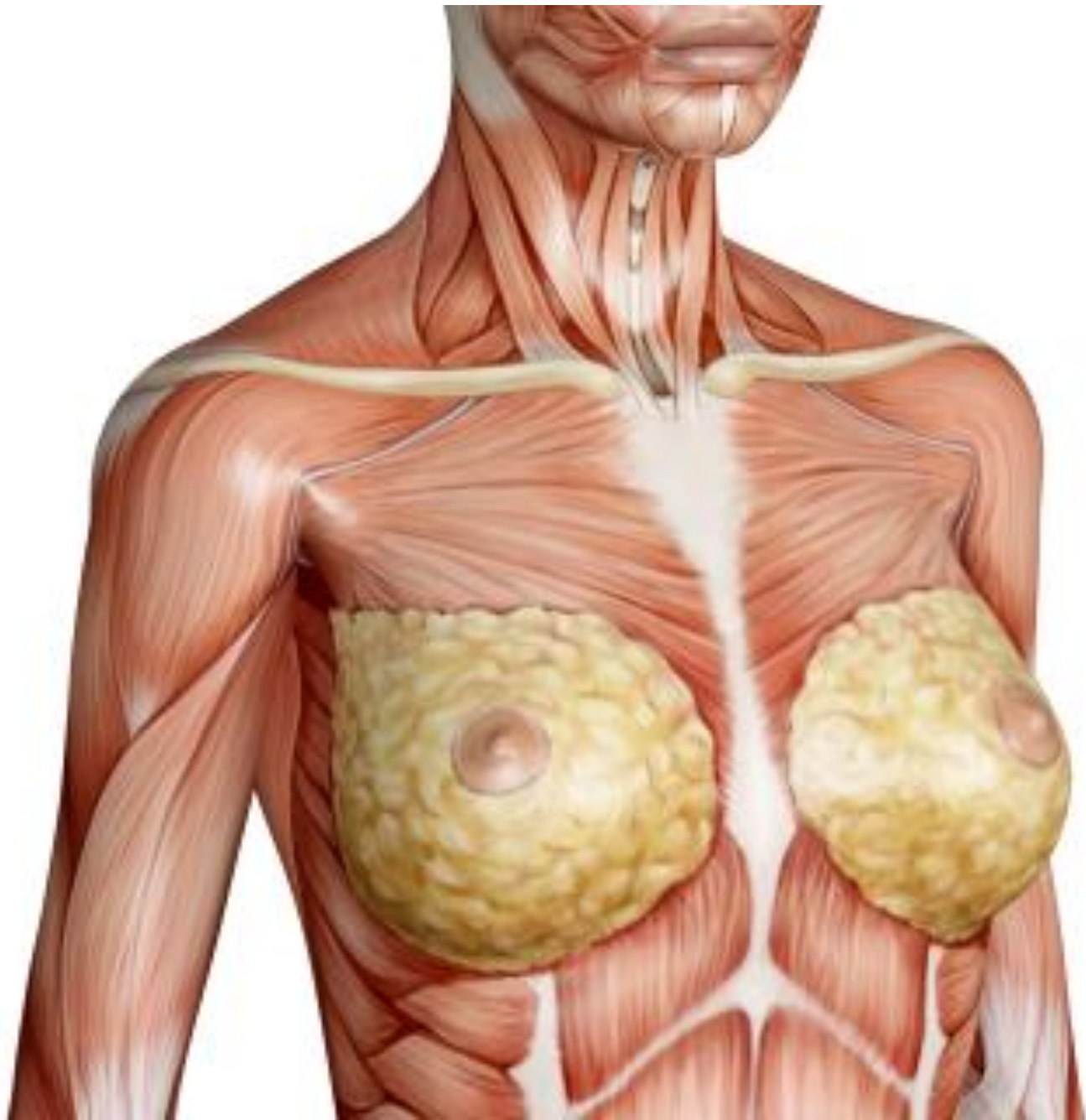
pectoralis major

latissimus dorsi

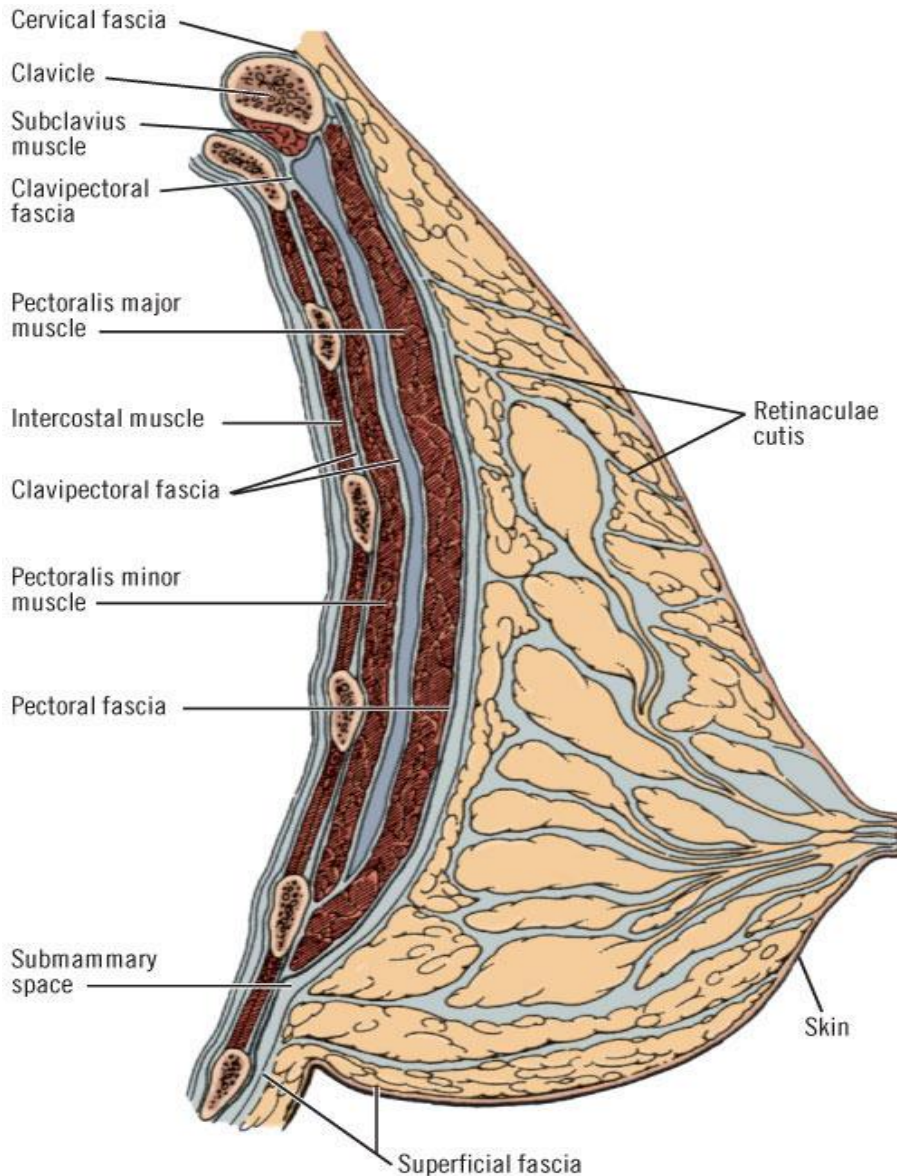
rectus abdominis

obliquus abd. externus





LAYERS OF THE MAMMARY REGION



Skin

Subcutis

Fascia superficialis (lamina ext)

Glandula mammaria
and the Cooper - ligaments
(*retinacula mammae*)

Fascia superficialis (lam. Int.)
(*continuous with the fascia
cervicalis*)

Submammary space

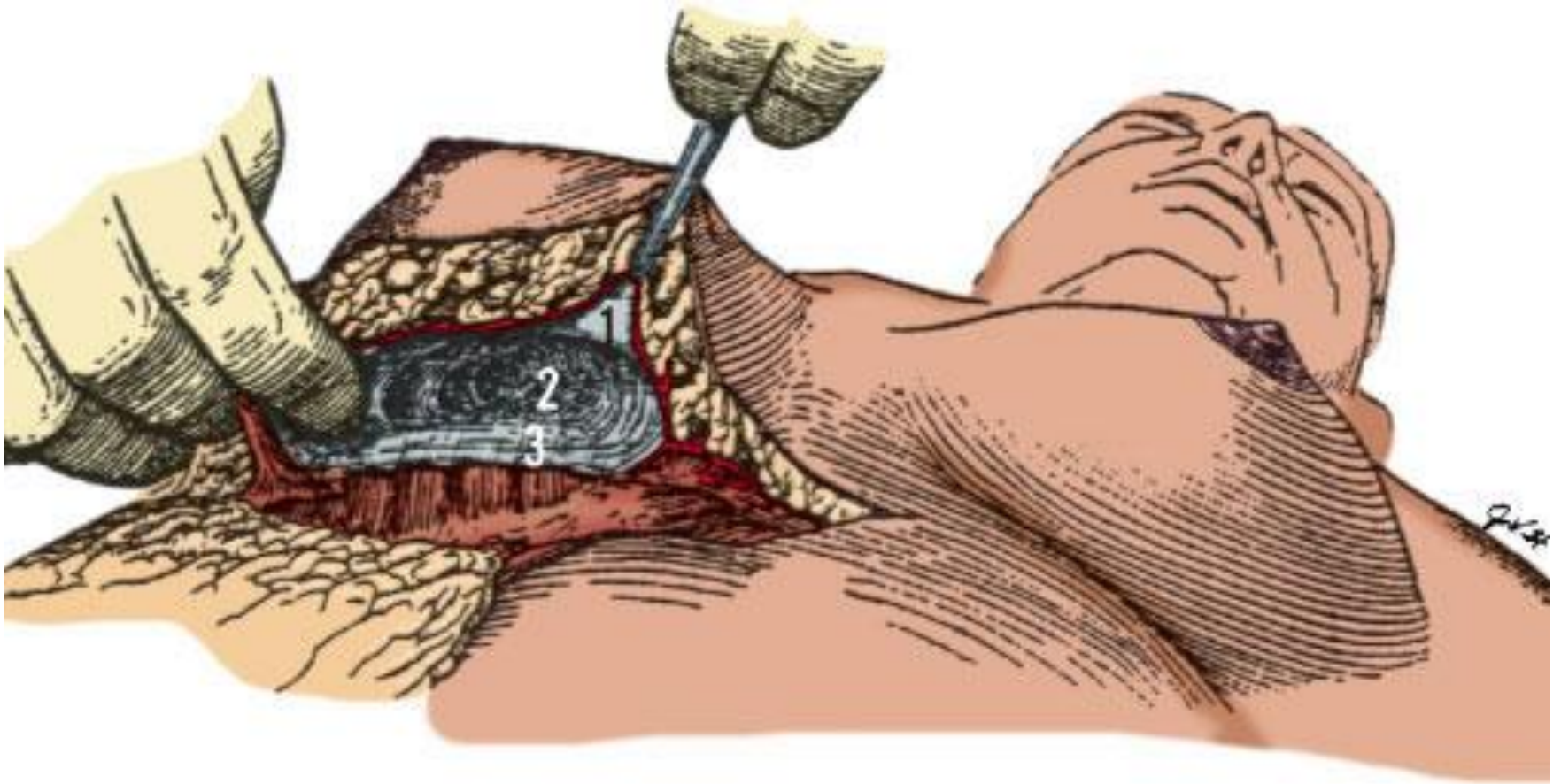
Fascia pectoralis (f. profunda =
deep)

M. pectoralis major

Fascia clavipectoralis
(*contains the lig. susp. axillae*)

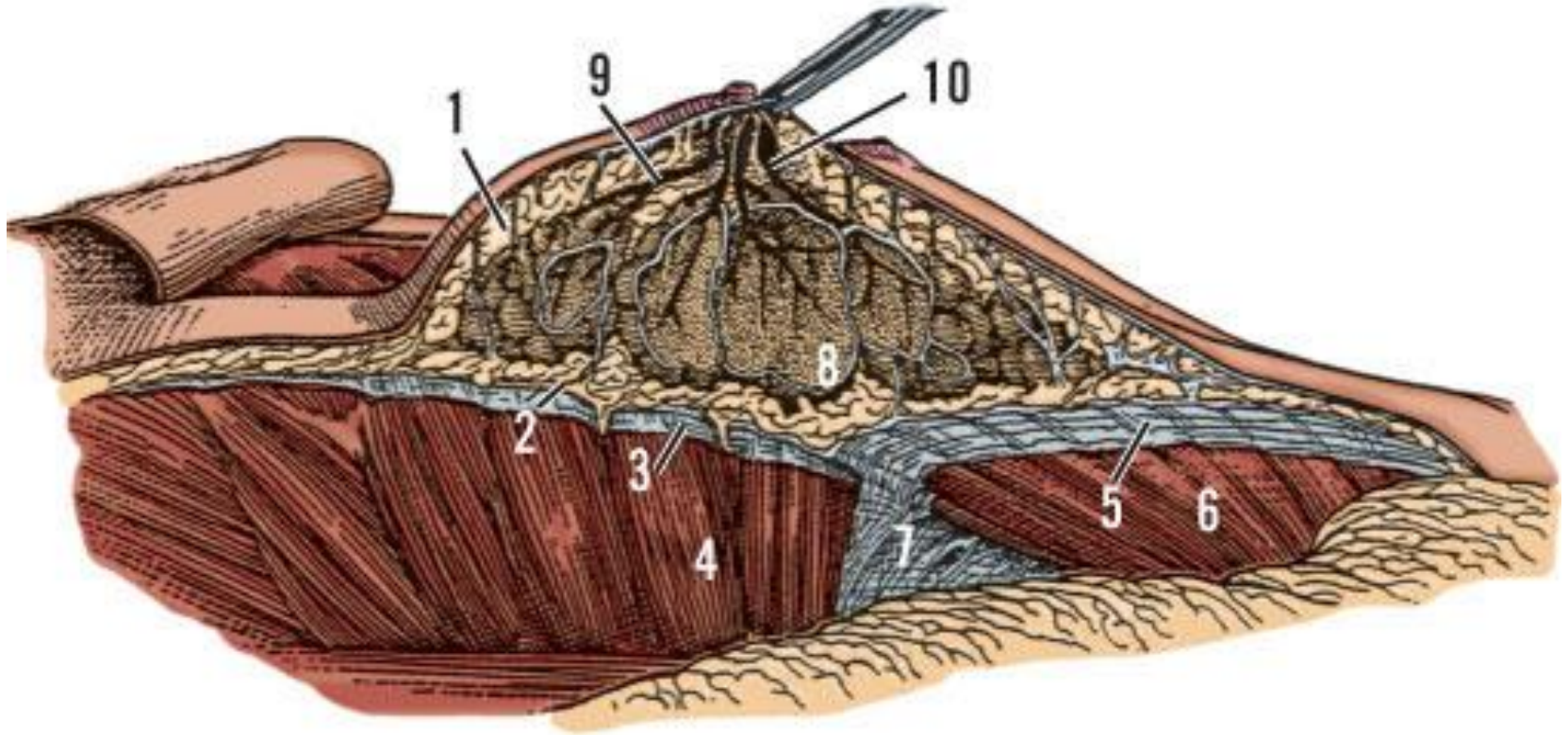
M. pectoralis minor

RETROMAMMARY SPACE



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RETROMAMMARY SPACE

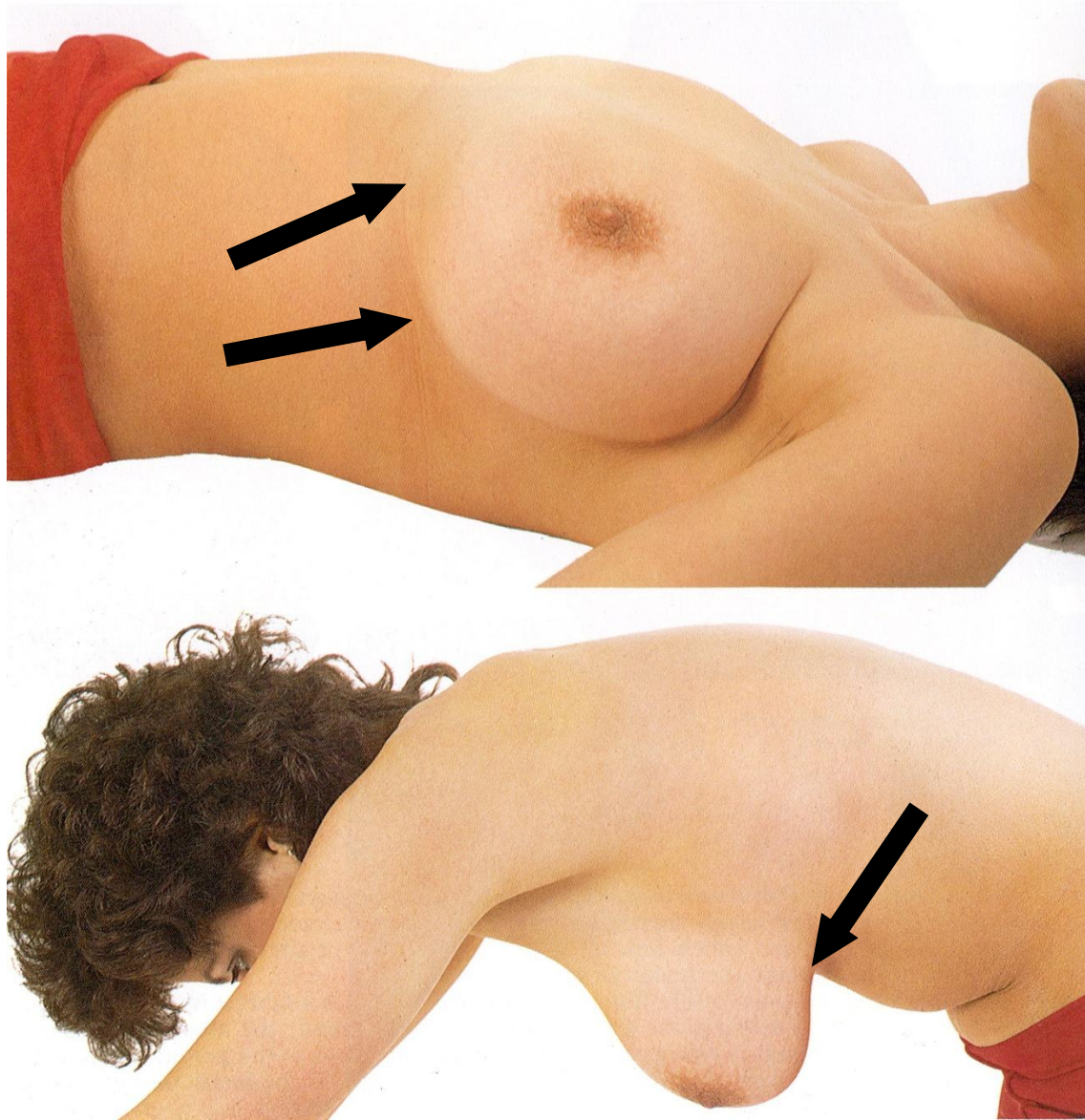


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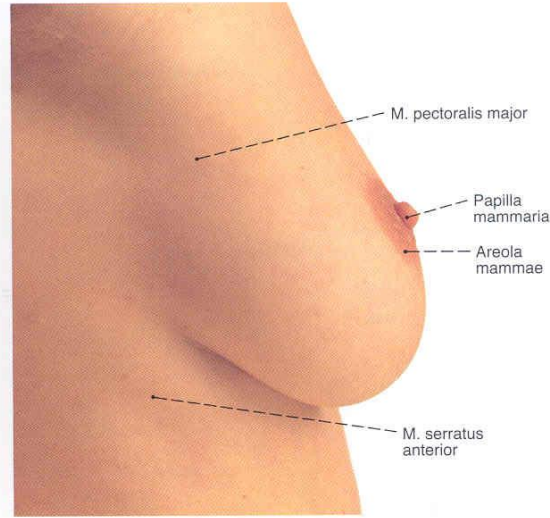
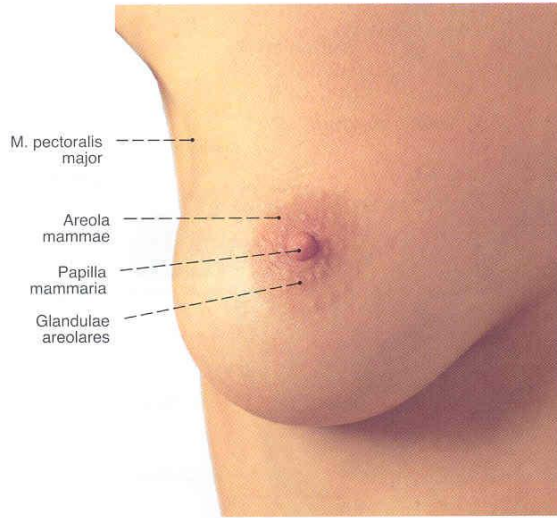
1. Retinacula cutis. **2.** Membranous layer. **3.** Serratus anterior fascia. **4.** Serratus anterior muscle. **5.** Pectoral fascia. **6.** Pectoralis major muscle. **7.** Suspensory ligament of axilla. **8.** Lobe of breast parenchyma. **9.** Lactiferous duct. **10.** Ampulla. (*Modified from Colborn GL, Skandalakis JE. Clinical Gross Anatomy. Pearl River NY: Parthenon, 1993; with permission.*)

***The anatomical
description of the mamma***

INFRAMAMMARY SULCUS



STRUCTURE OF THE MAMMA



Covered in skin

**Shape:
combination of a
cone and a sphere**

Areola

Papilla (nipple)

Areolar glands

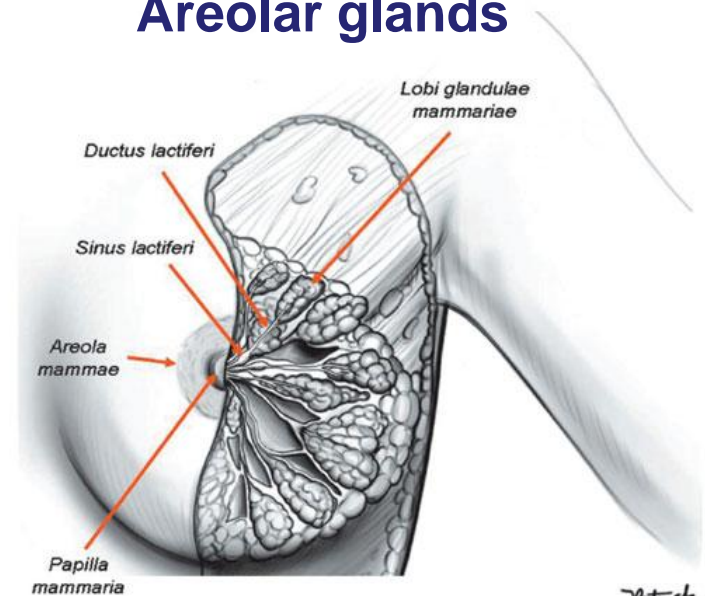
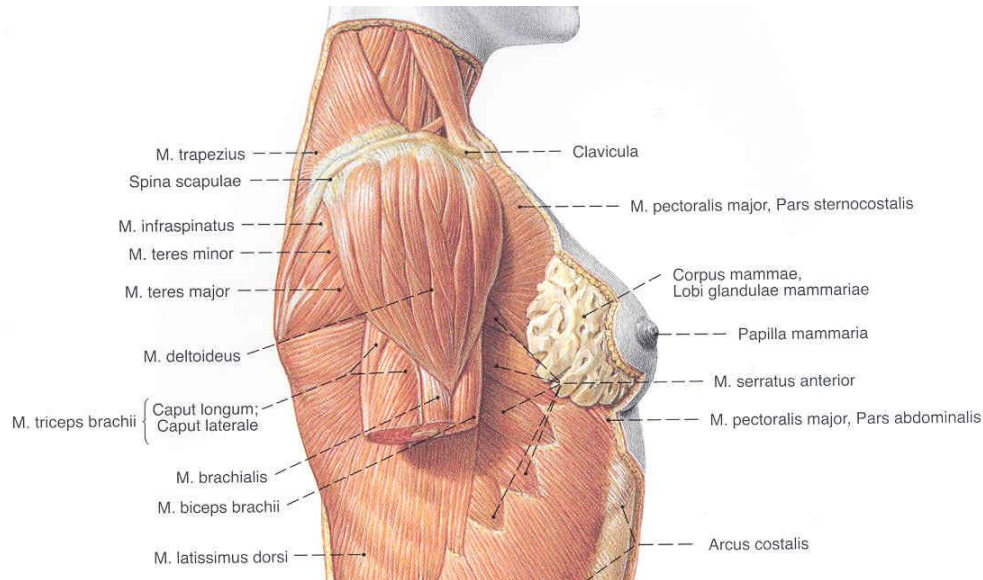
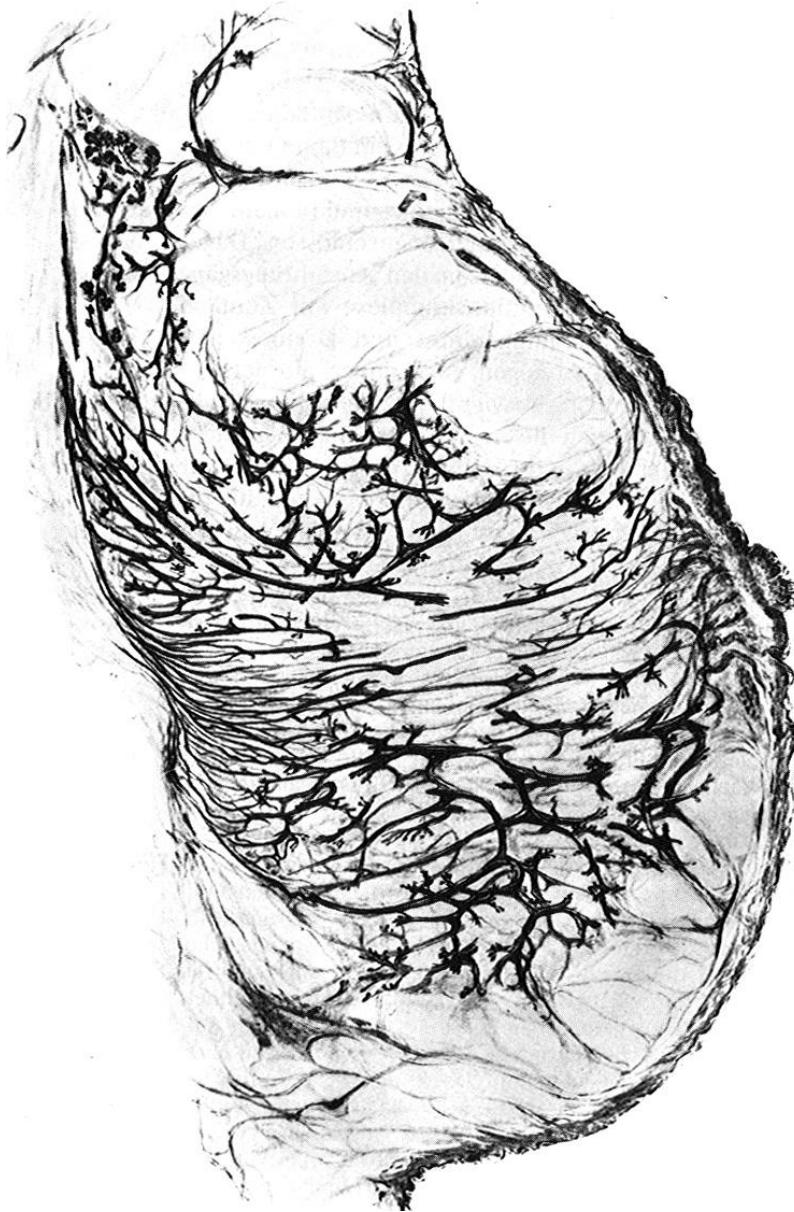


Fig. 7. Right breast. The skin and subcutaneous layer have been extracted in order to view the *lobi glandulae mammariae*, *ductus lactiferi* and *sinus lactiferi* (anterior view).

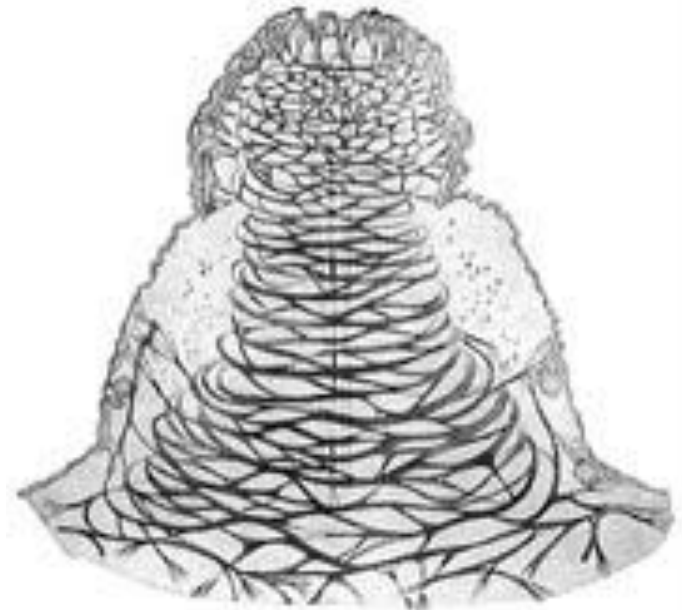
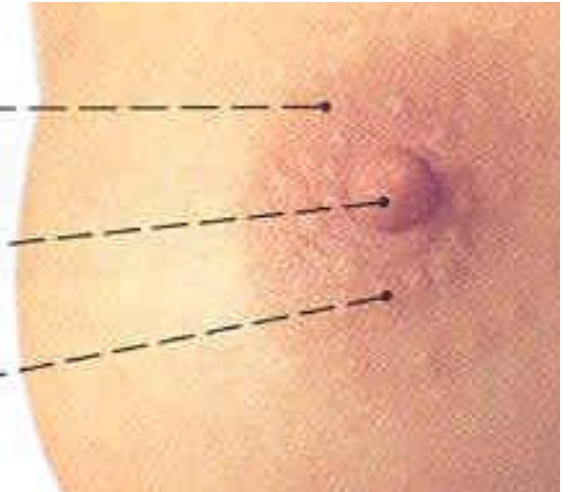
NIPPLE AND AREOLA MAMMAE



Areola
mammarum

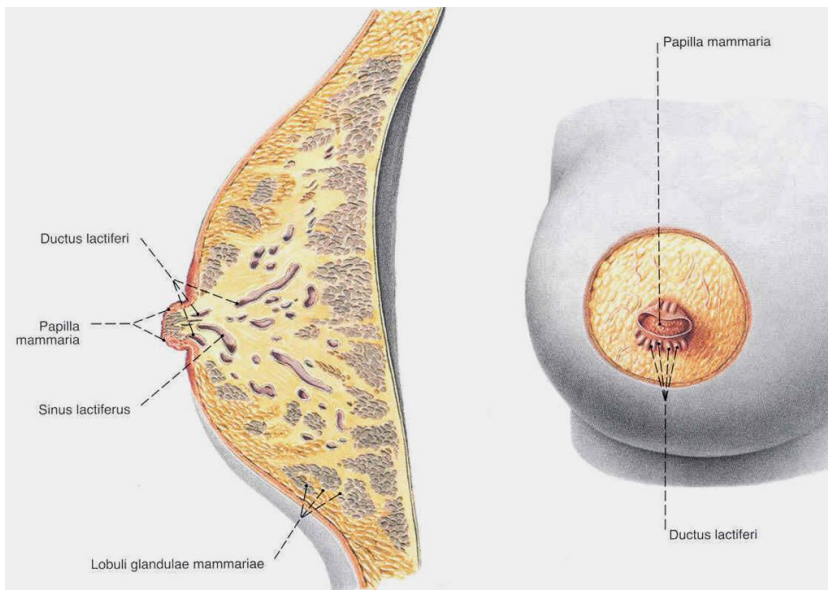
Papilla
mammaria

Glandulae
areolares

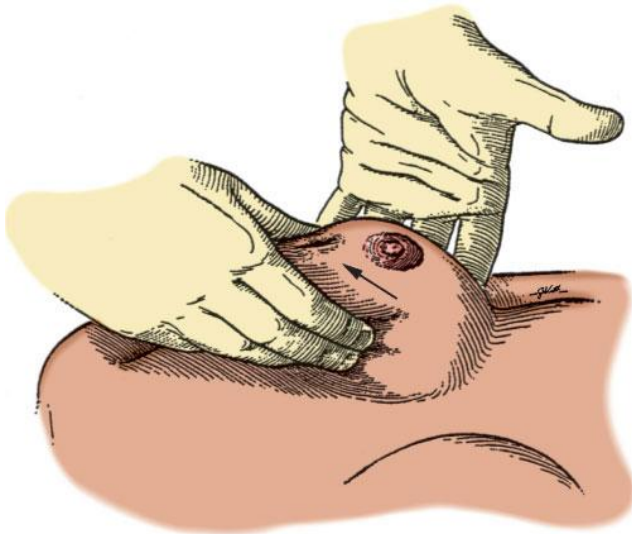


STRUCTURE OF THE MAMMA

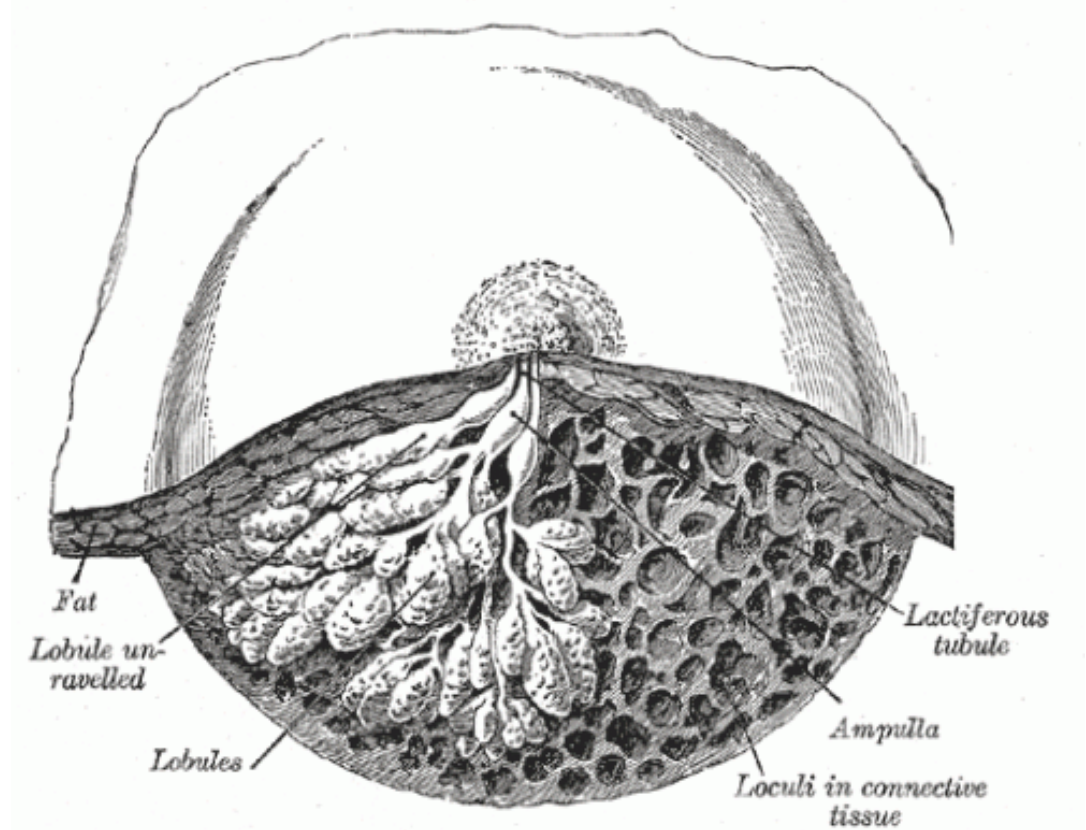
- 12-15-20 glandular lobes (largest: axillary lobe)
- corpus adiposum és suspensory lig.
- superficial pectoral fascia
- pectoralis major et minor muscles
- deep pectoral fascia and clavipectoral fascia
- thoracic wall



RETINACULA MAMMAE (Cooper ligaments)

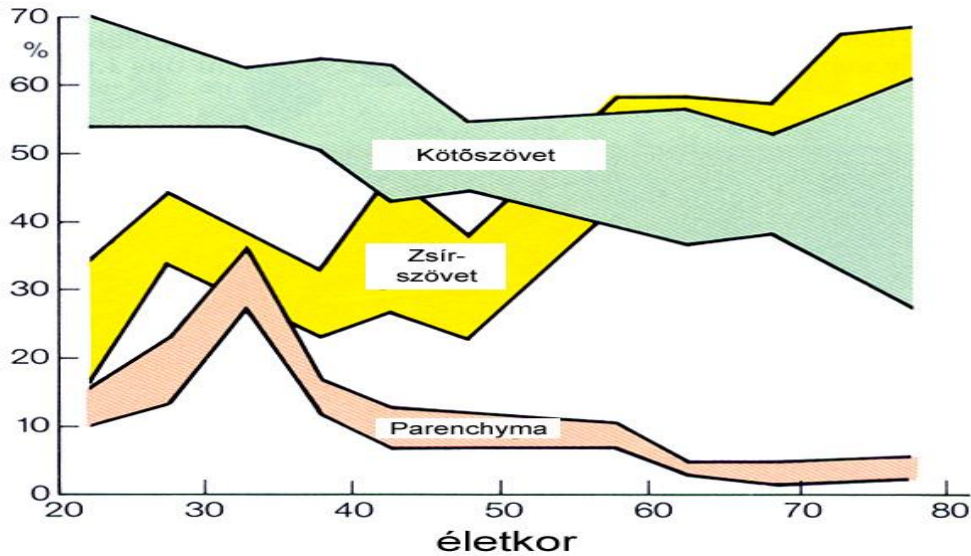
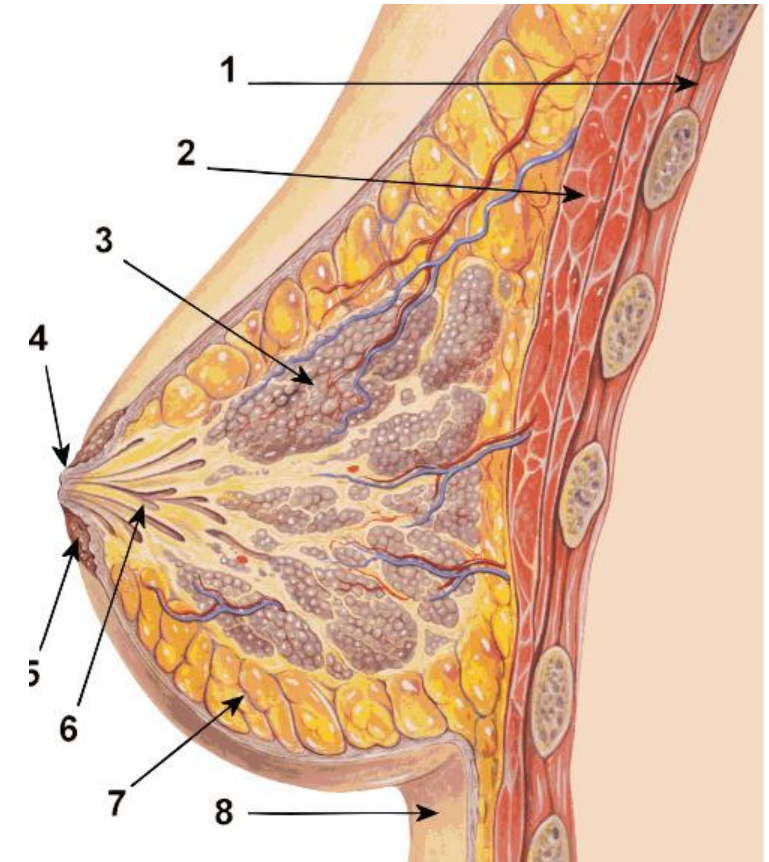
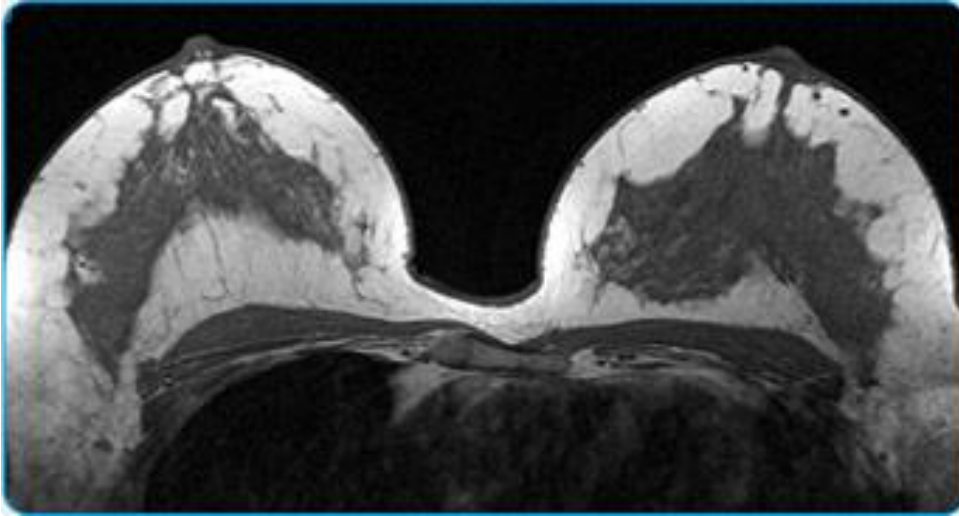


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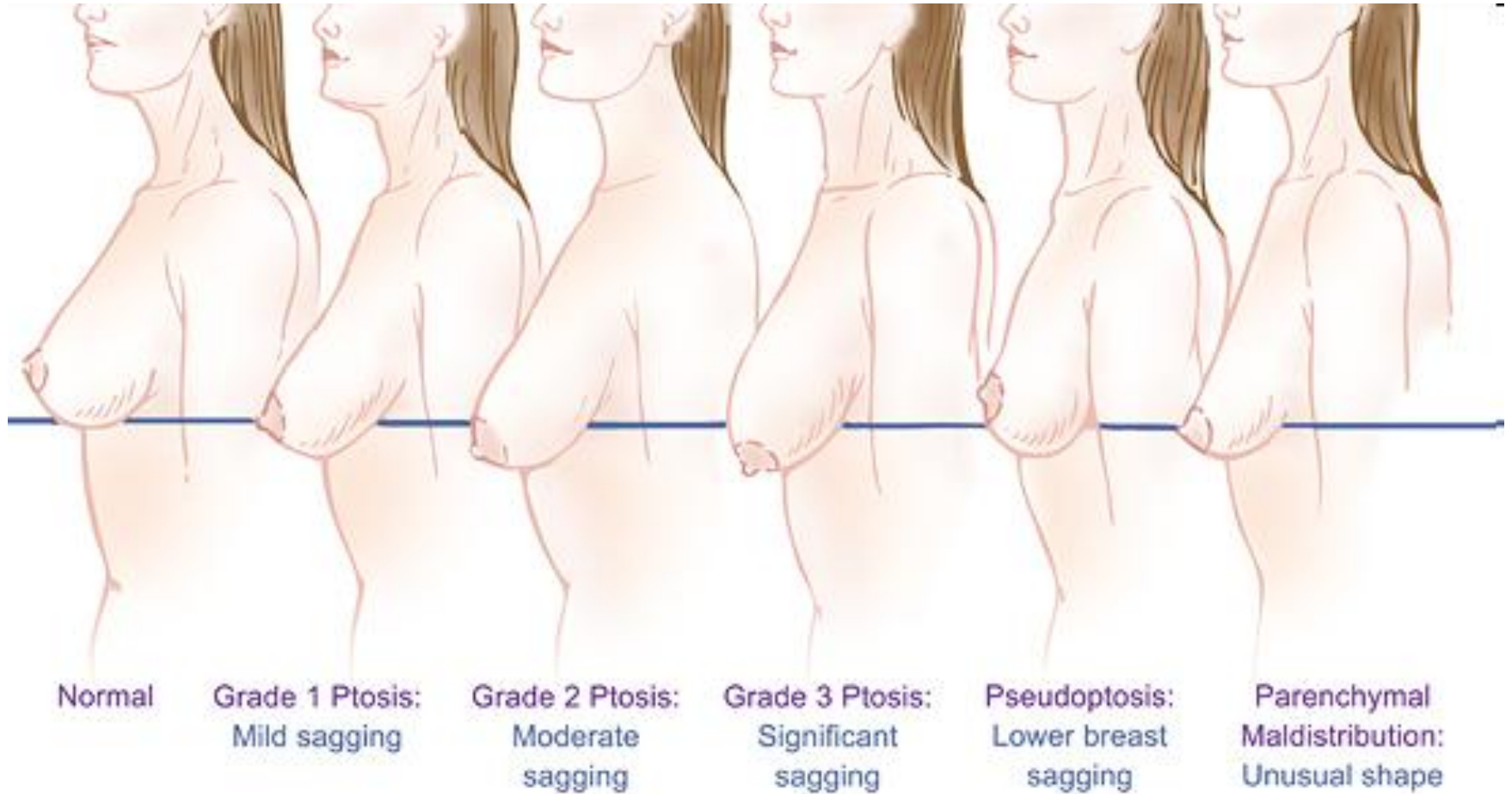


RETICULAR CONNECTIVE TISSUE

Corpus adiposum mammae



POSITIONAL CHANGES OF THE BREAST



Normal

Grade 1 Ptosis:
Mild sagging

Grade 2 Ptosis:
Moderate
sagging

Grade 3 Ptosis:
Significant
sagging

Pseudoptosis:
Lower breast
sagging

Parenchymal
Maldistribution:
Unusual shape

***Vessels and nerves
of the mamma,
clinical relevance***

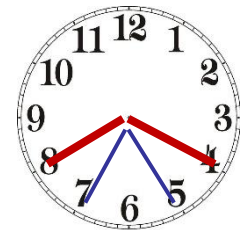
SENSORY INNERVATION OF THE BREAST

Skin innervation comes from the supraclavicular nerves then from the 4th, 5th and 6th (ant + post) intercostal nerves.

Most important is the ***4th IC nerve***, because it supplies the nipple – areola complex with its *lateral cutaneous branch*.

It reaches the

- posterior part of the LEFT breast at 4 o'clock ,
- posterior part of the RIGHT breast at 8 o'clock.



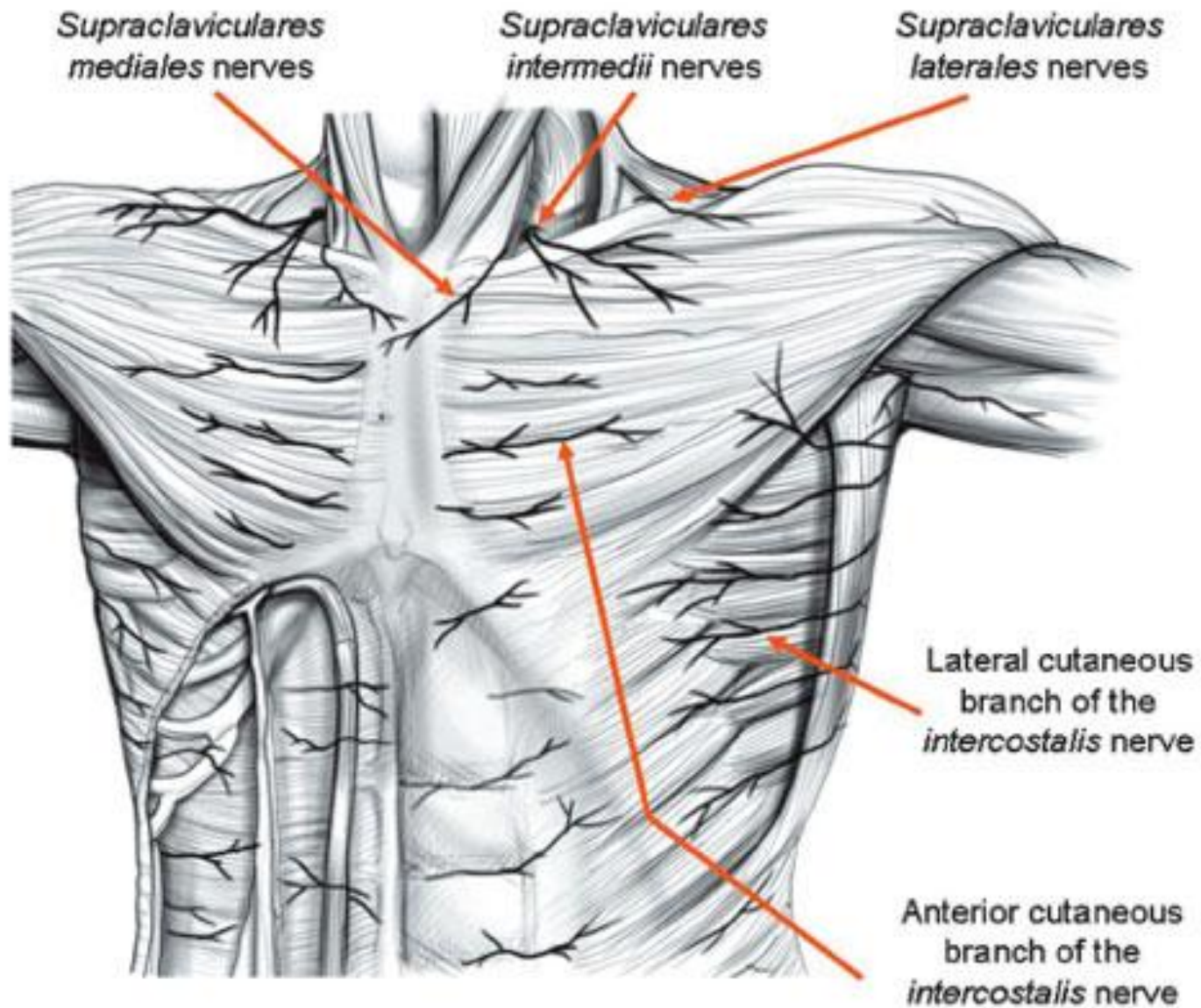
As it reaches the areola, becomes superficial and gives off 5 branches:

1 median, 2 superior and 2 inferior branches

The lowest branch enters the areola of the LEFT breast at 5 o'clock and the RIGHT breast at 7 o'clock

If this branch is hurt, the sensory innervation of the nipple/areola is lost. (e.g. the nerve may be cut during mastopexy, or reduction, *Riordan, 2005*).

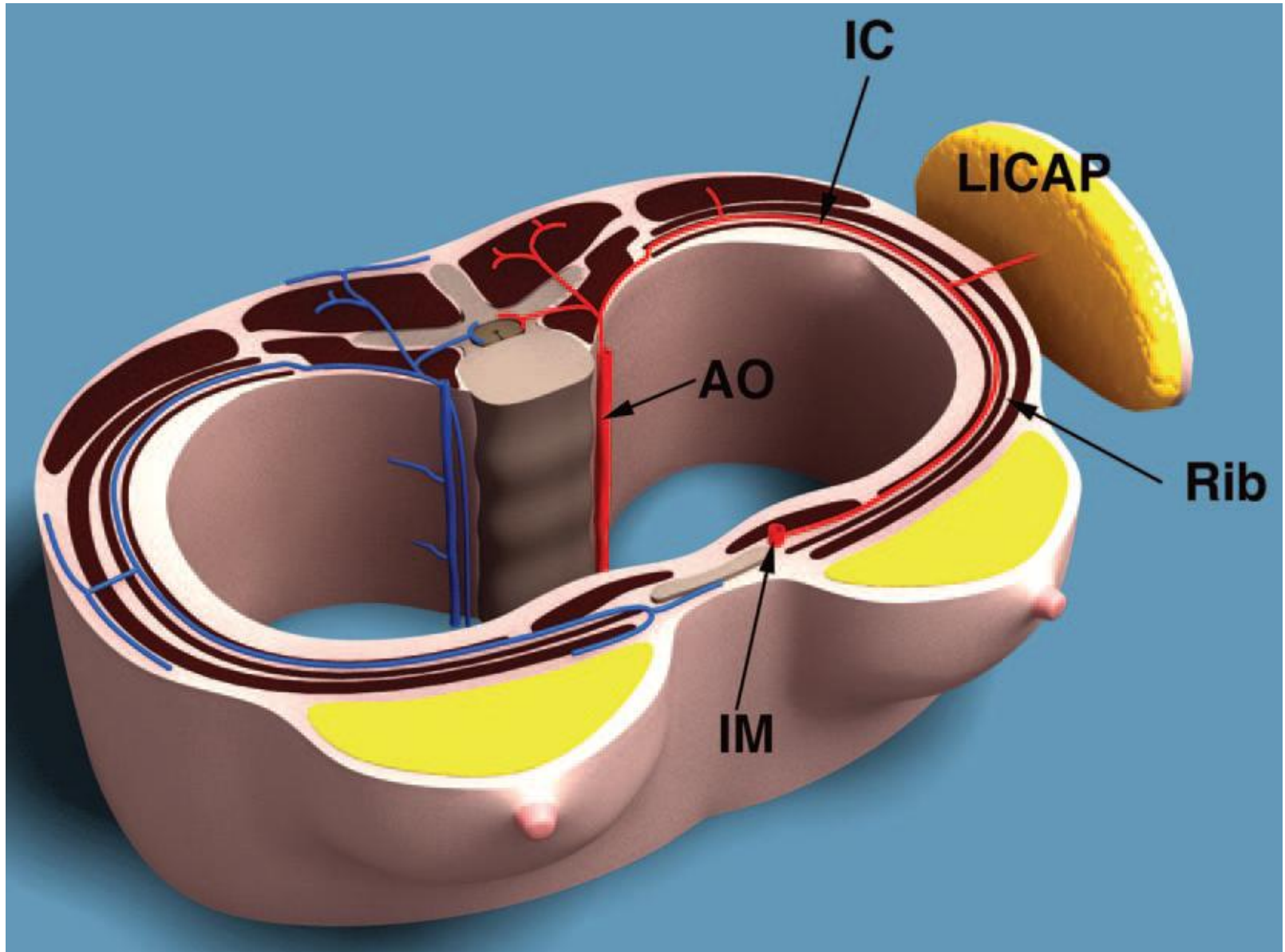
The nipple - areola complex contains many free nerve endings and Meissnerian corpuscles.



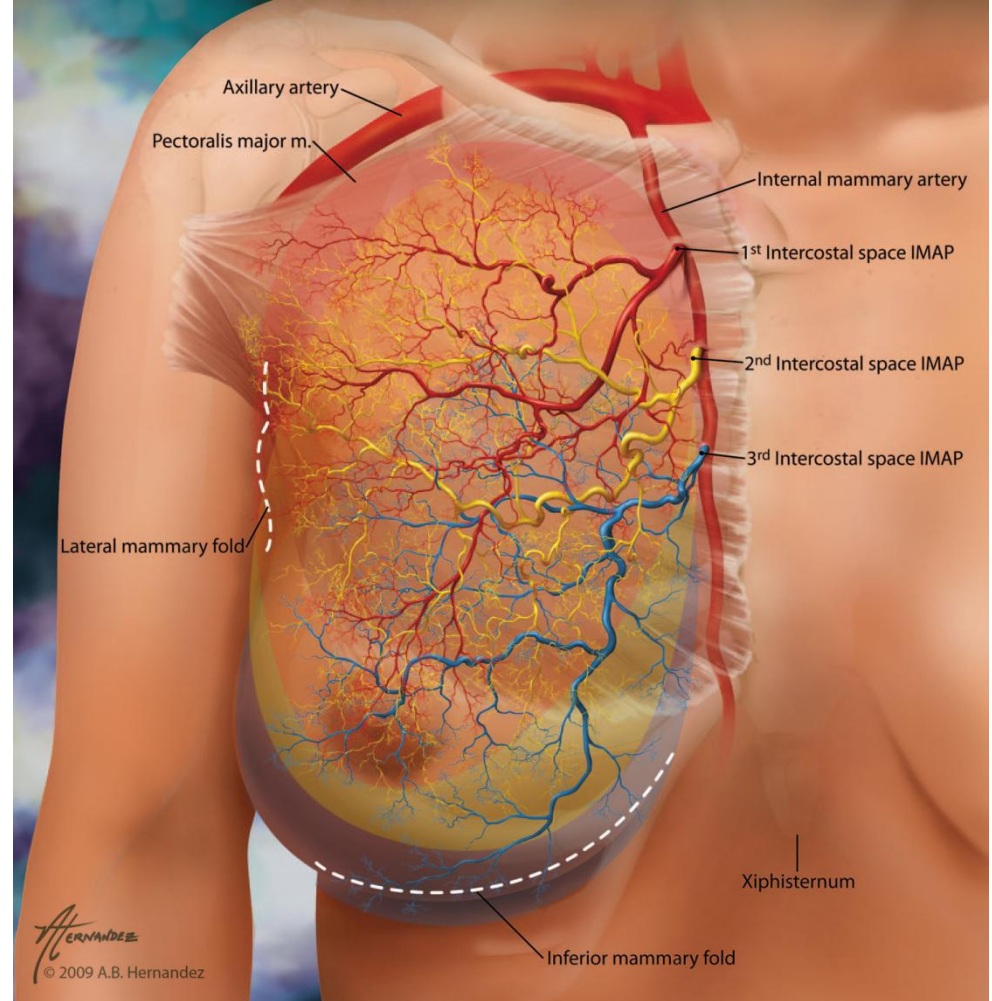
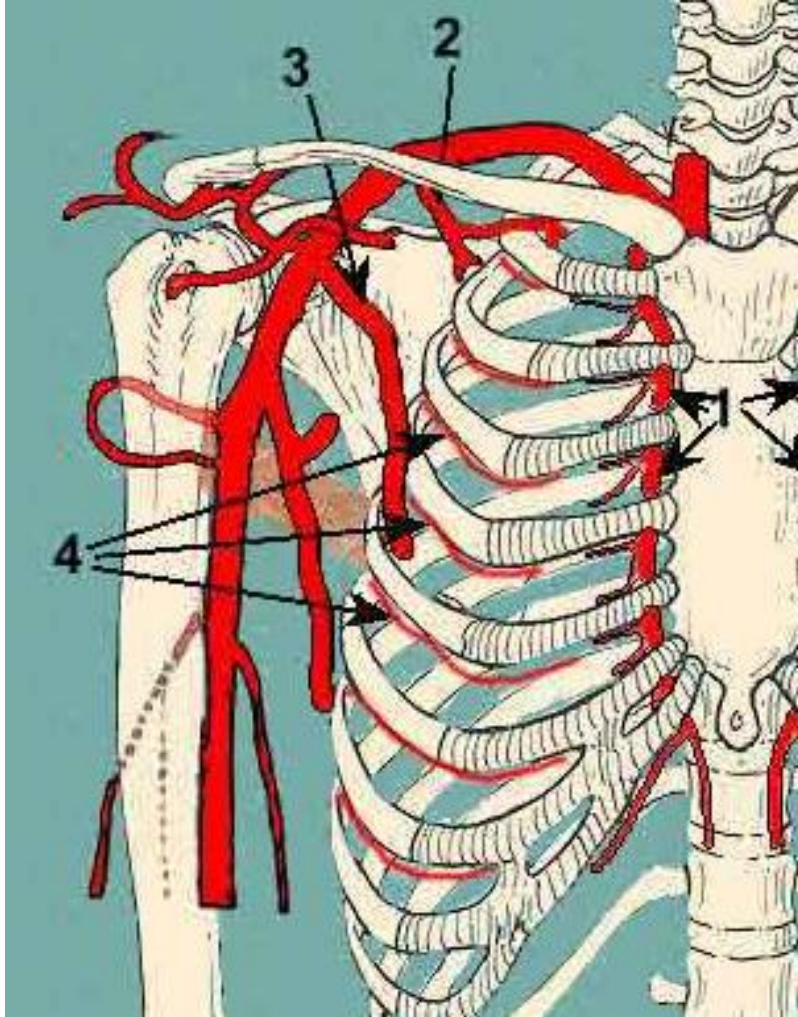
Patrick

Fig. 9. Innervation of the breast (anterior view of the trunk).

VESSELS OF THE REGION



VASCULAR SUPPLY



VASCULAR SUPPLY

1 ▶

2 ▶

3 ▶

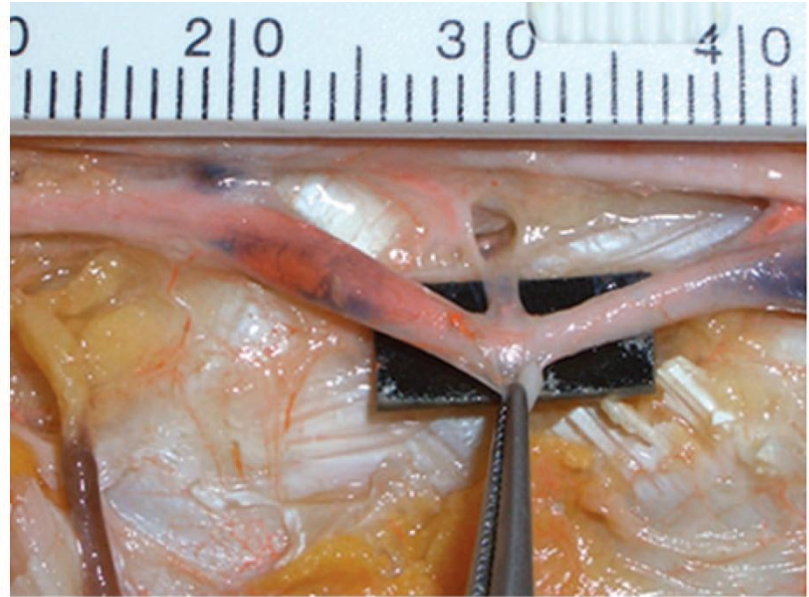
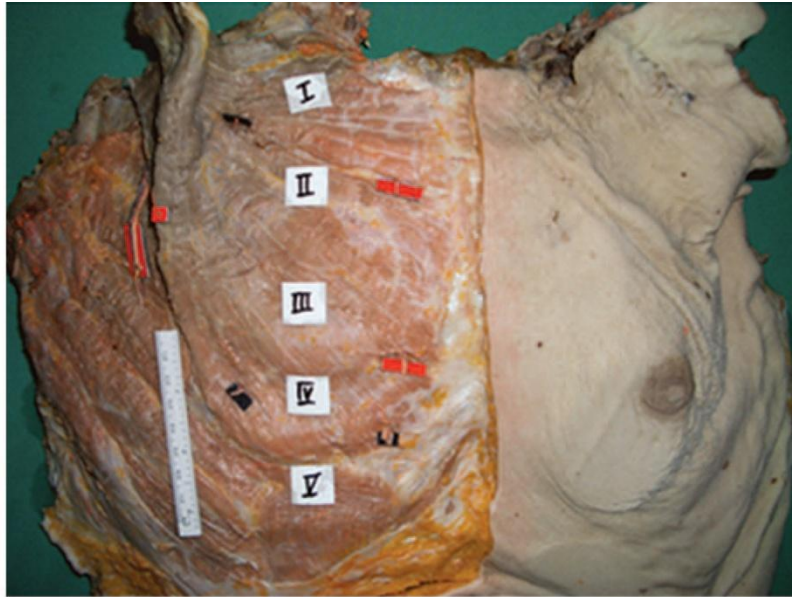
4 ▶

5 ▶

3 ▶

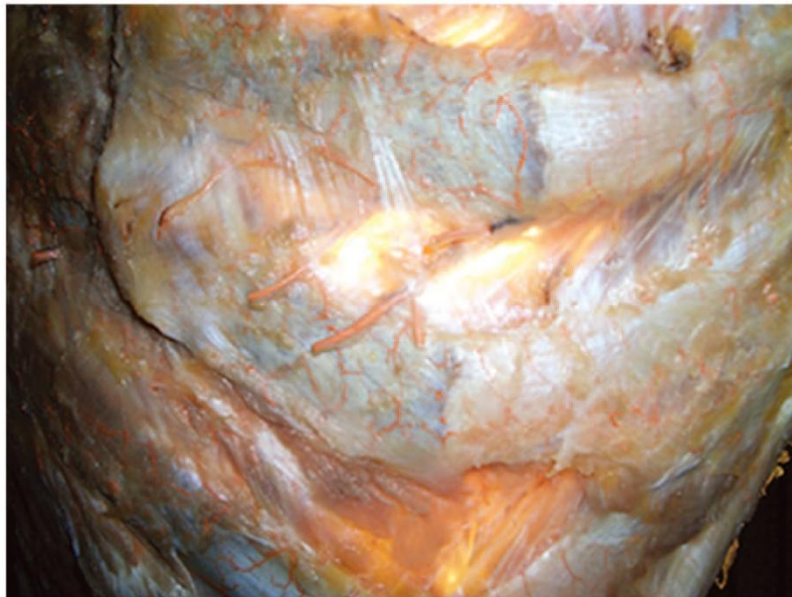
2 ▶

2 ▶



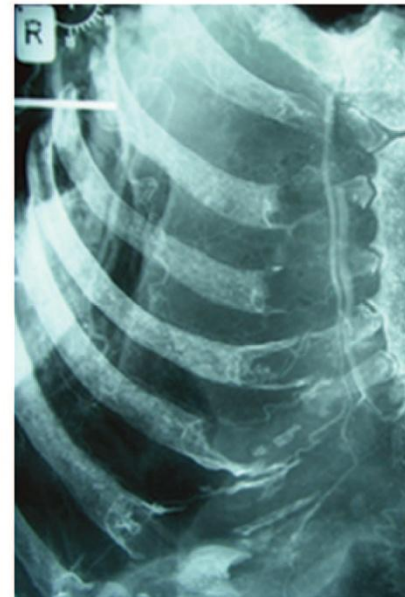
◀ 3
◀ 6

2 ▶



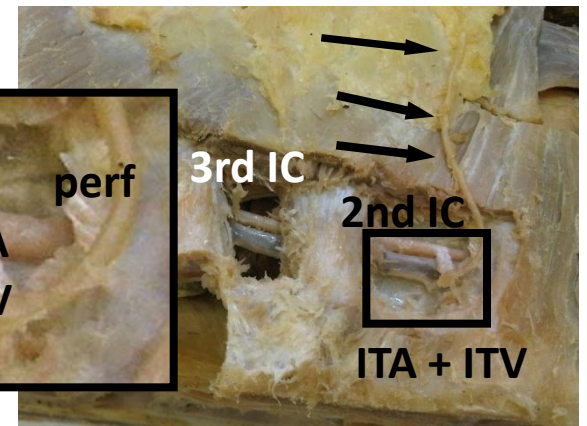
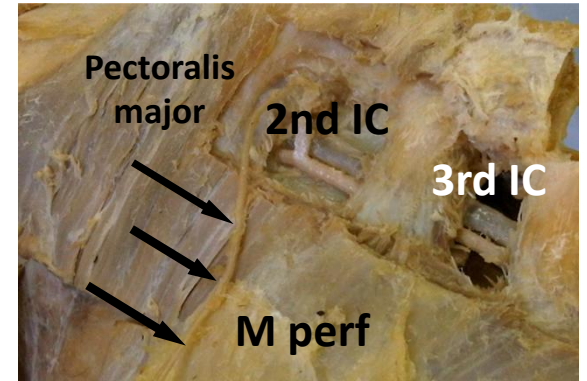
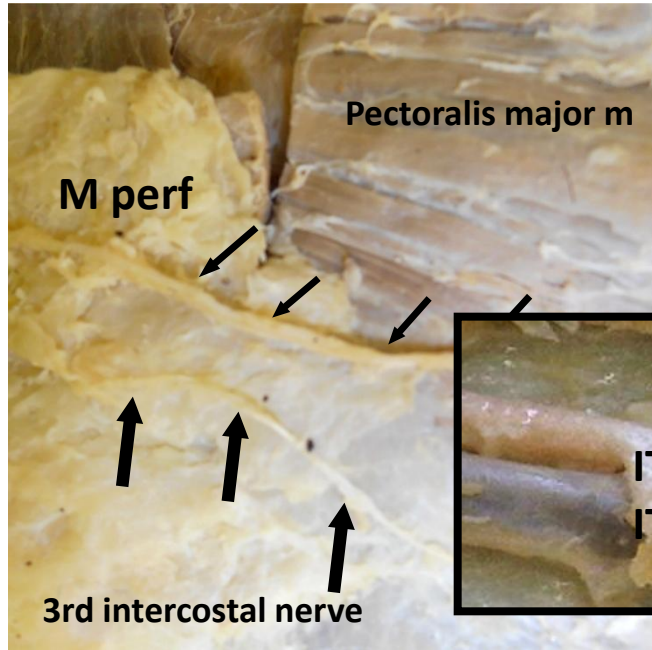
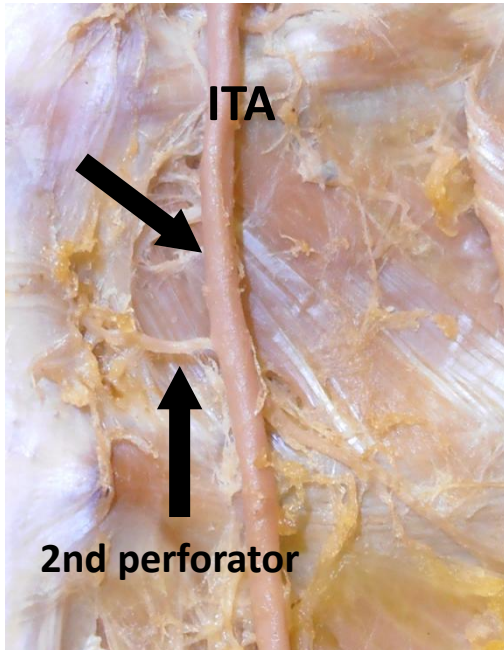
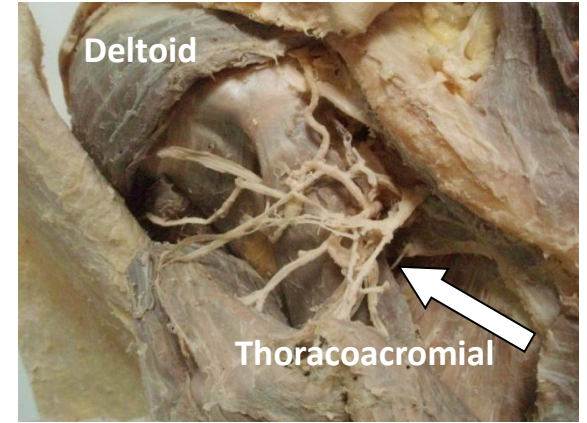
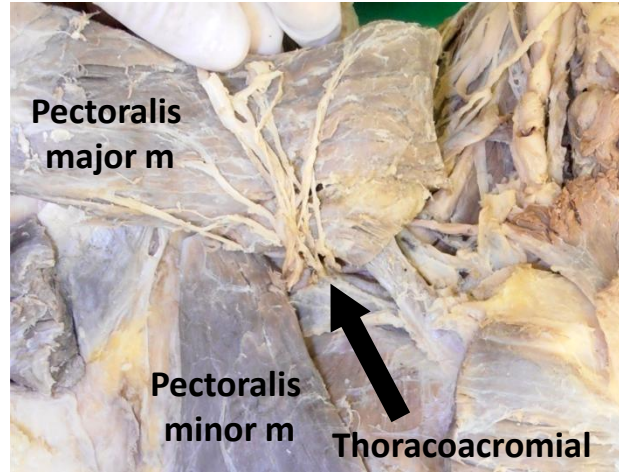
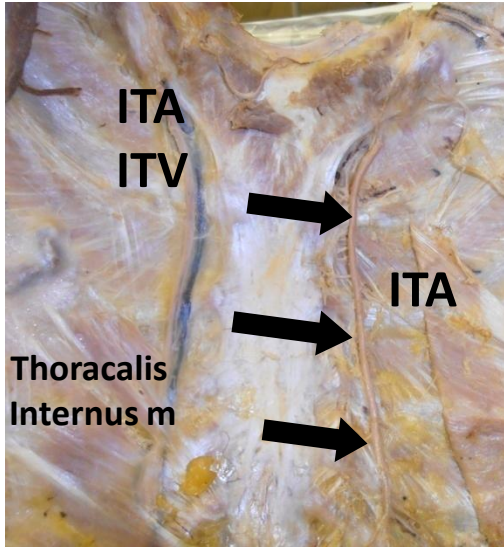
5 ▶

7 ▶

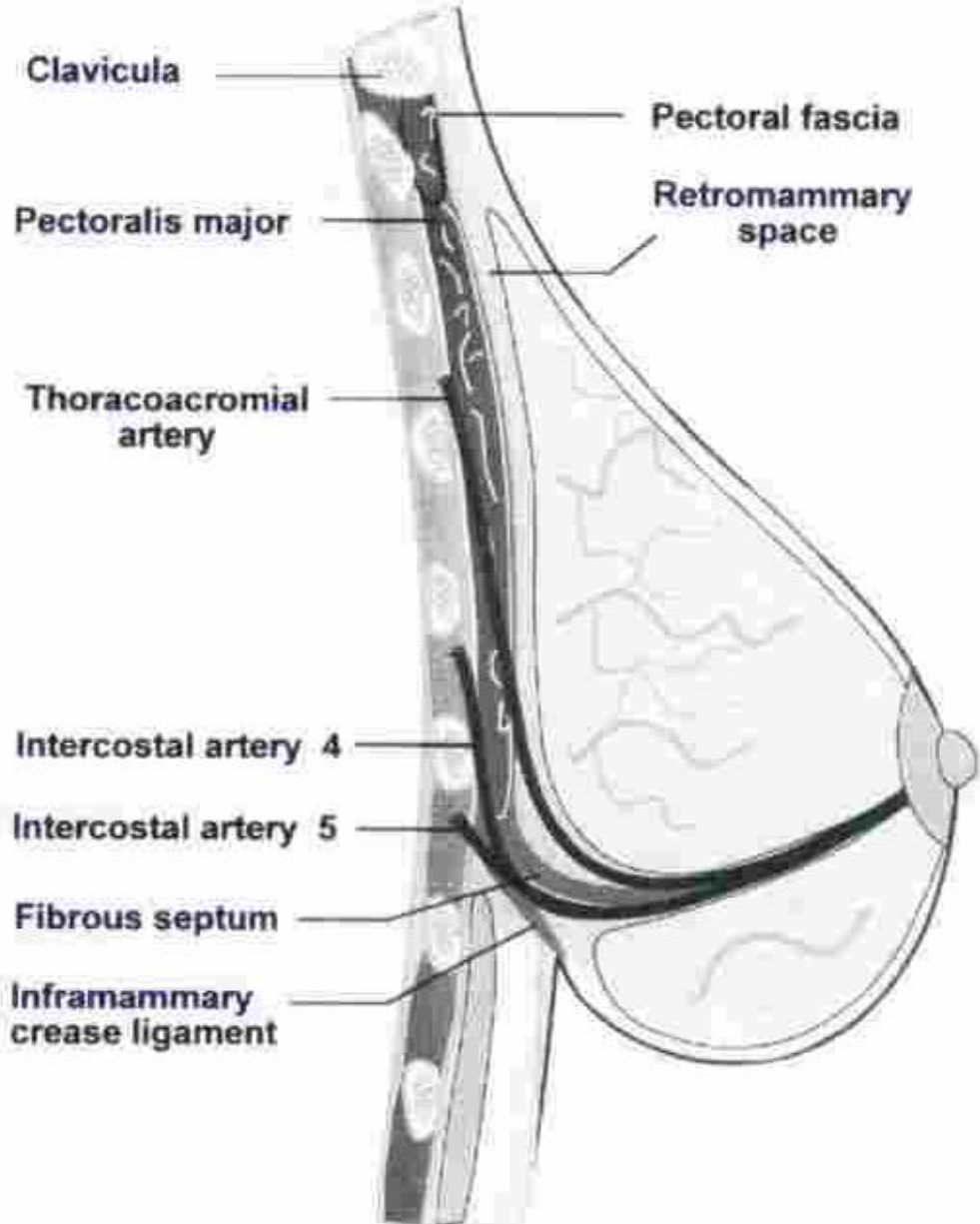
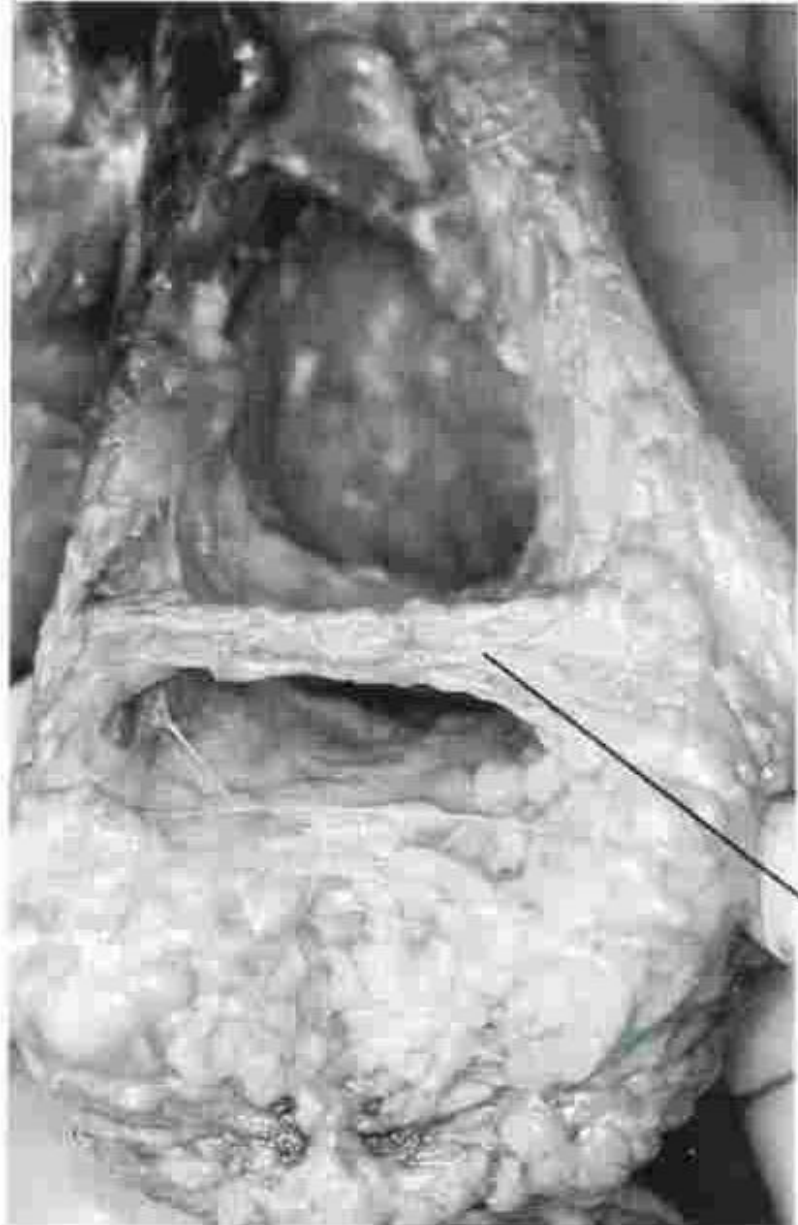


◀ 6
◀ 3
◀ 3

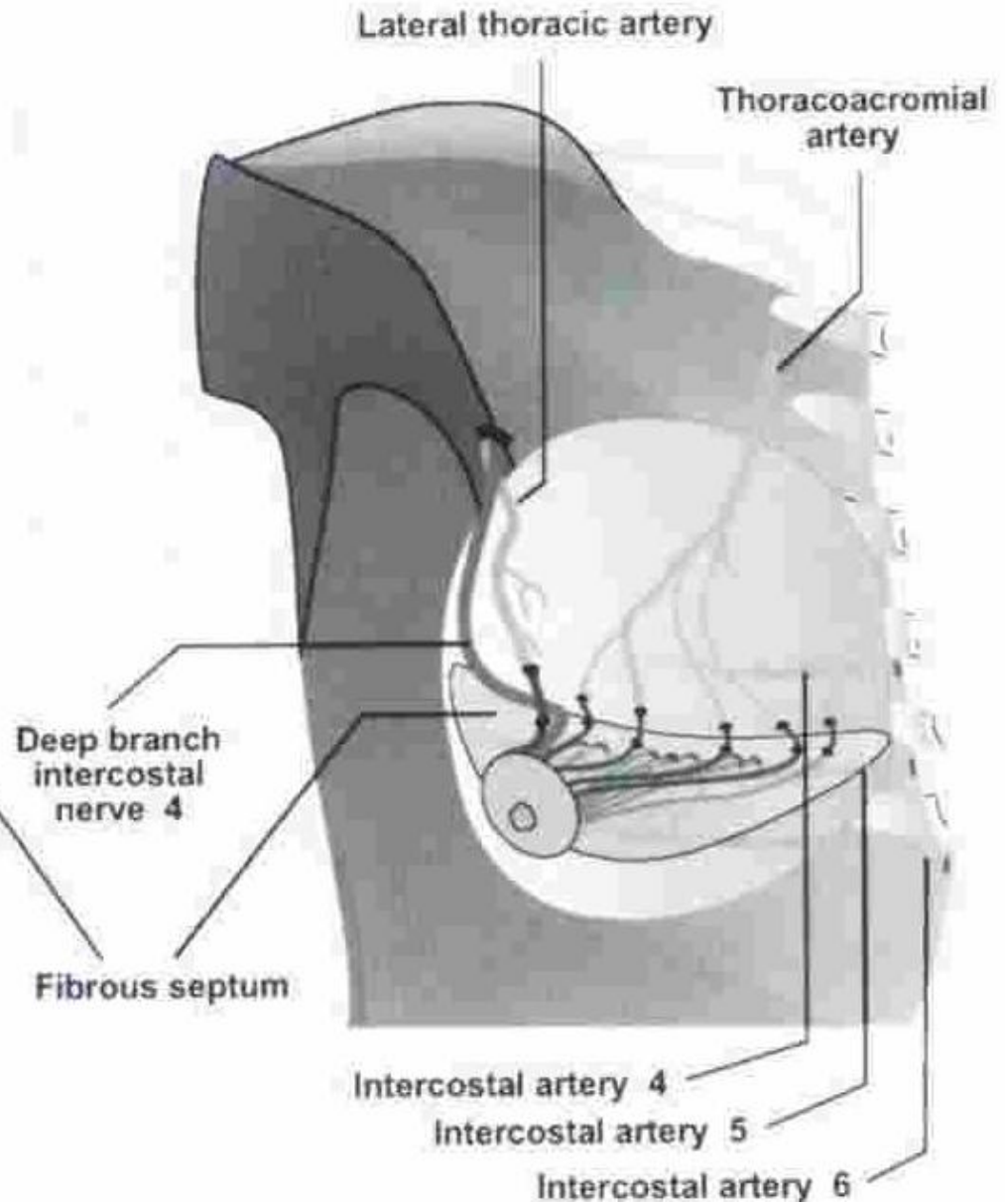
VASCULAR SUPPLY



BLOOD SUPPLY TO THE NIPPLE - AREOLA COMPLEX

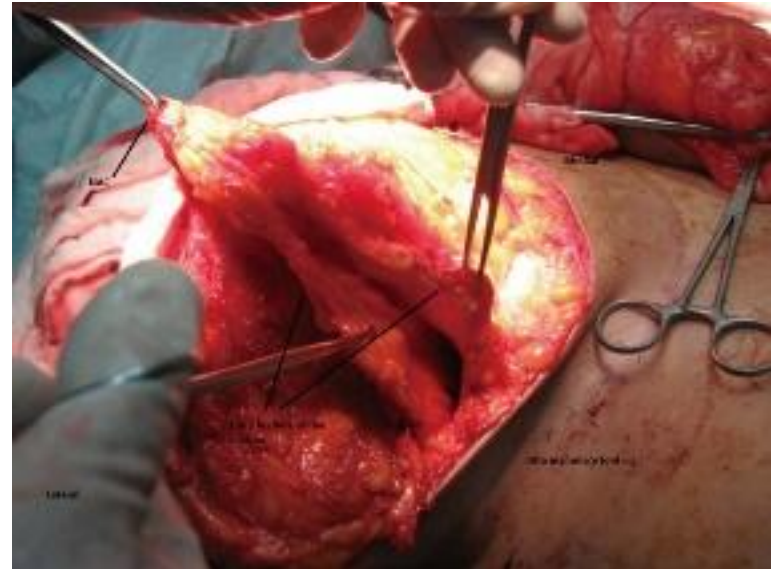
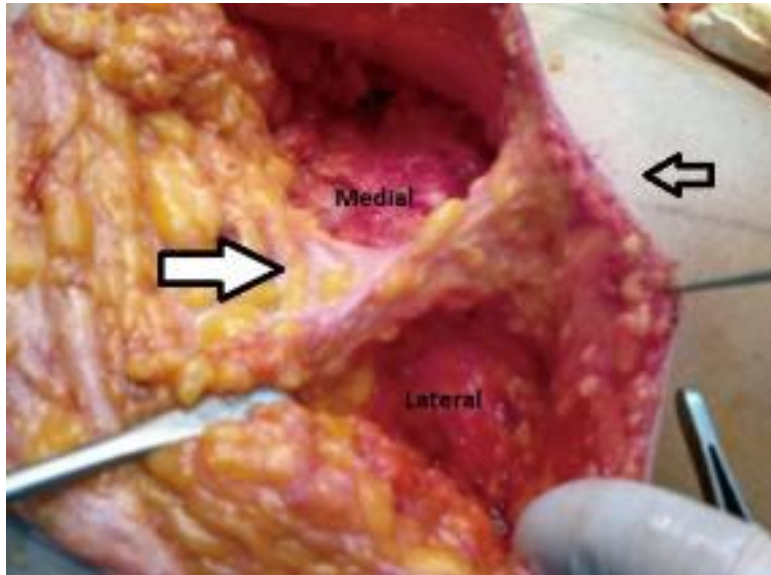


POSITION OF THE WUEHRINGER LIGAMENT



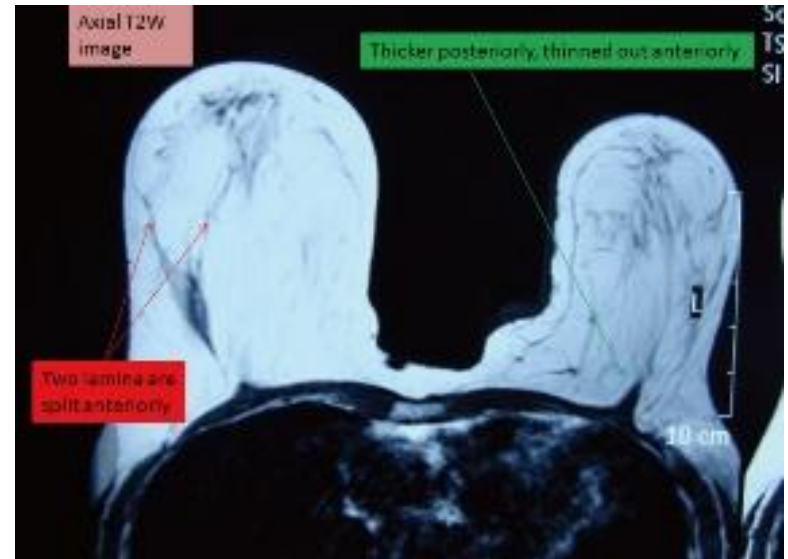
POSITION OF THE MEDIAN SEPTUM

Recently described



Anatomical location of septum

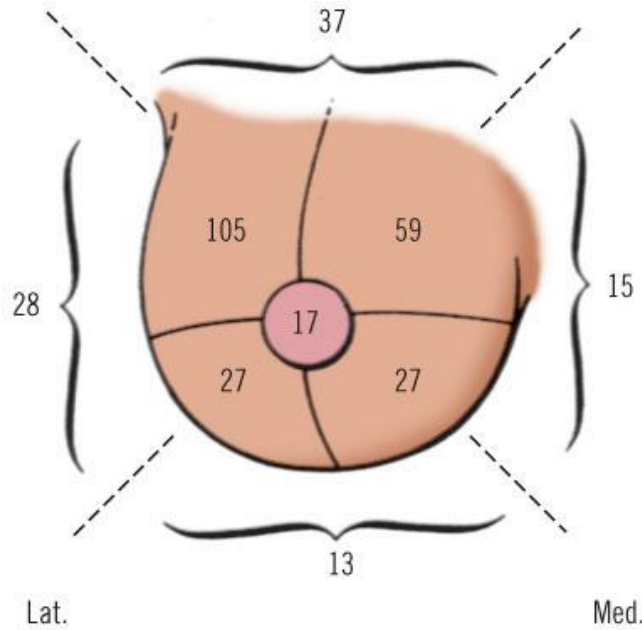
The bilaminar septum (thick white arrow) at mid infra-mammary sulcus (black arrow) dividing the lower part of breast into medial and lateral compartments. Contains type I collagen



MAMMARY CARCINOME MORBIDITY AND MORTALITY

A

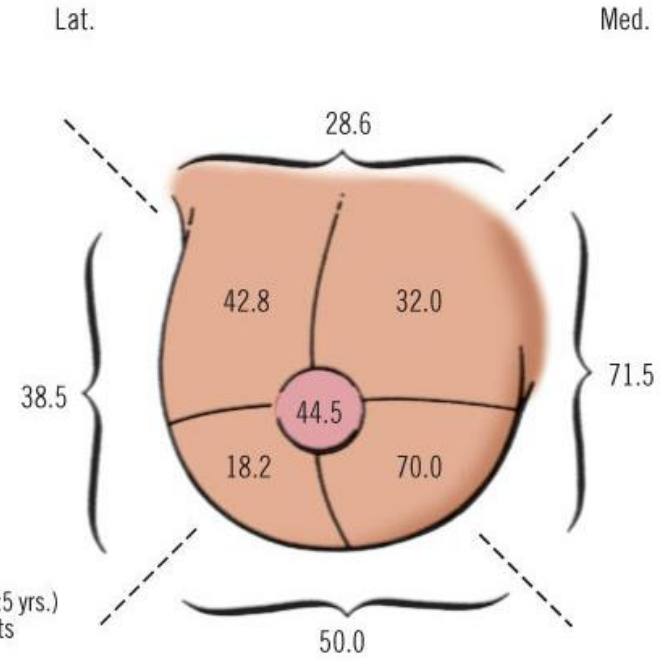
Incidence
328 cases



B

Mortality
(% dying <5 yrs.)
142 patients
all ages

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Dr. Molnár Béla Ákos
Egyetemi adjunktus
Semmelweis Egyetem I. Sebészeti Klinika c

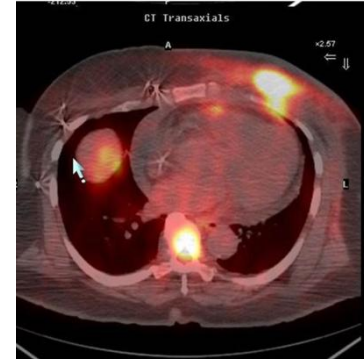


MAMMARY CARCINOME



Diagnosis

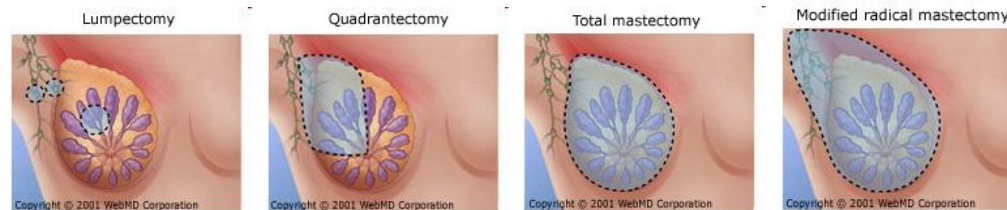
Histology, PETCT (Grading, Staging)



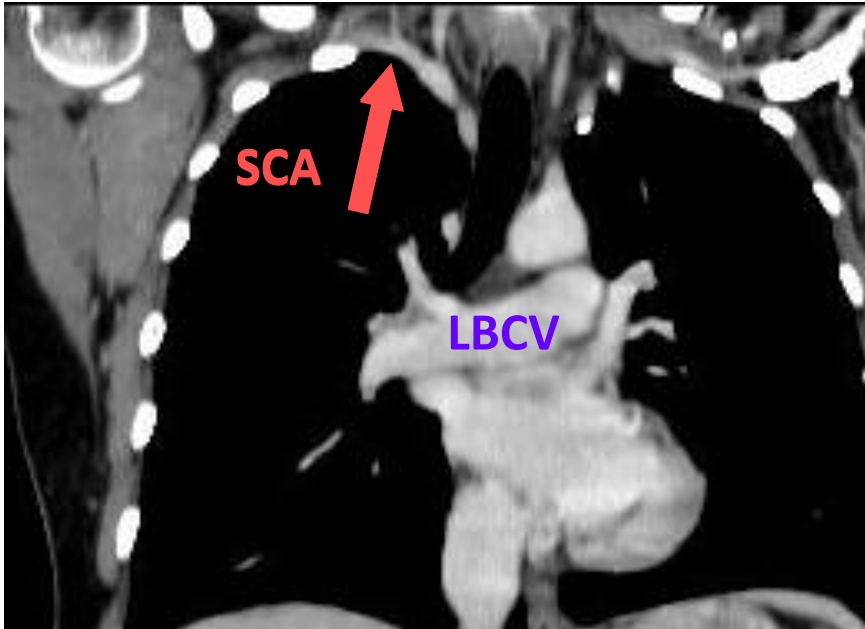
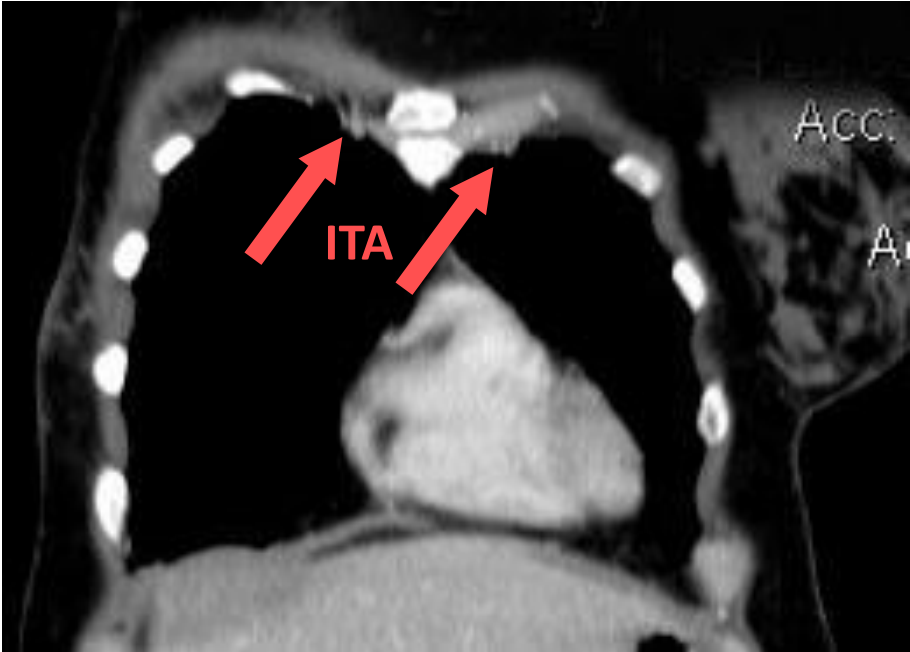
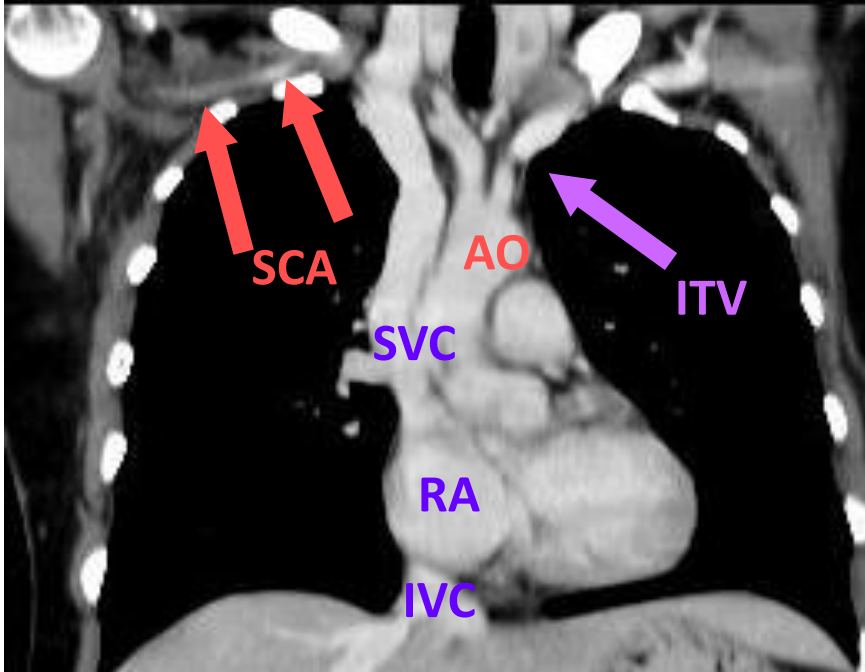
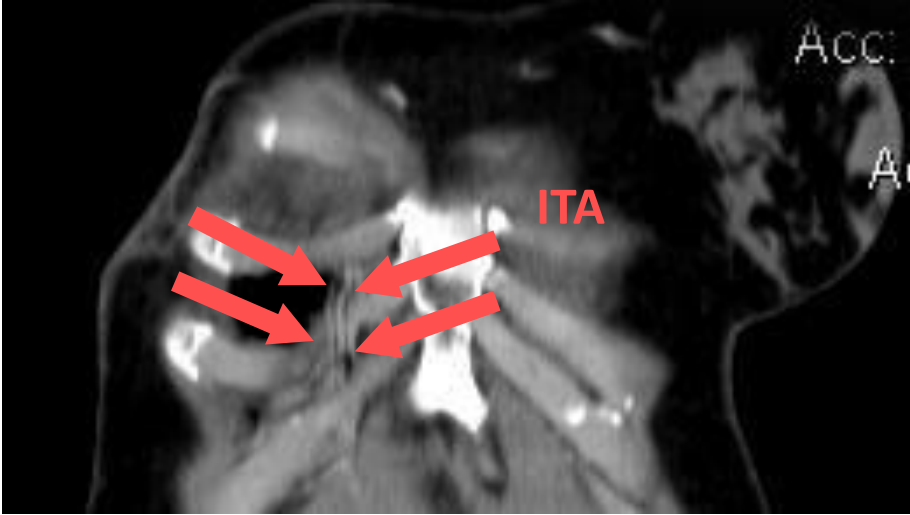
Treatment



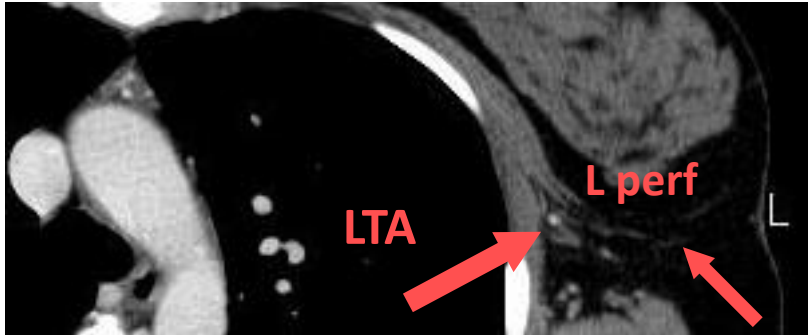
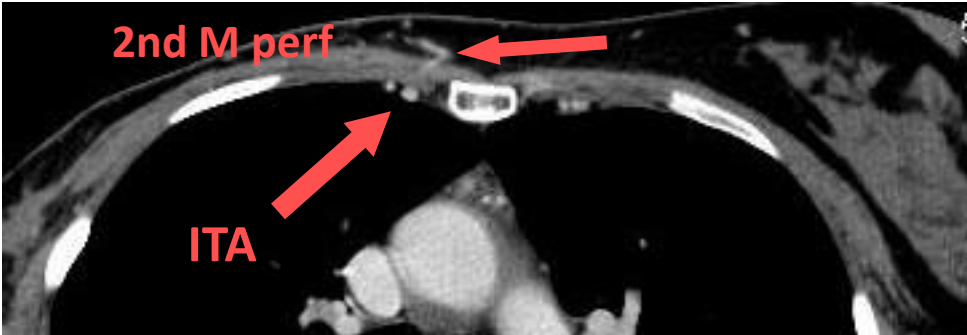
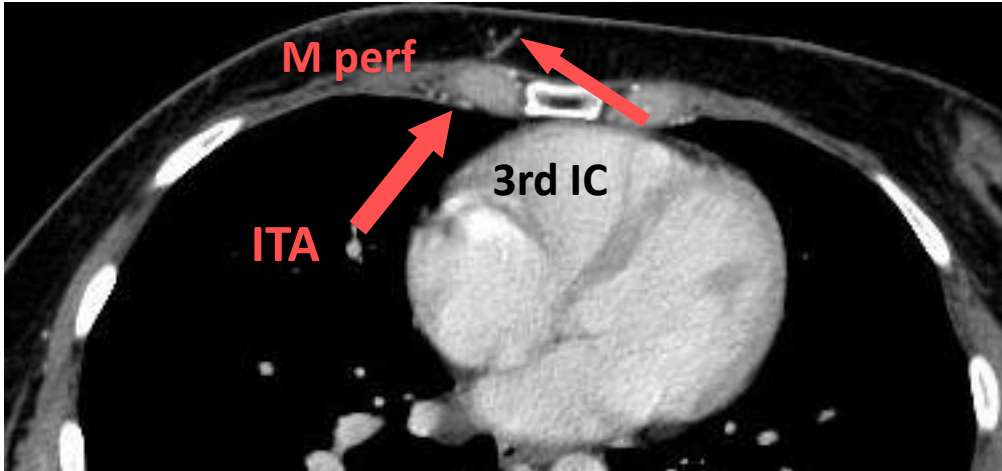
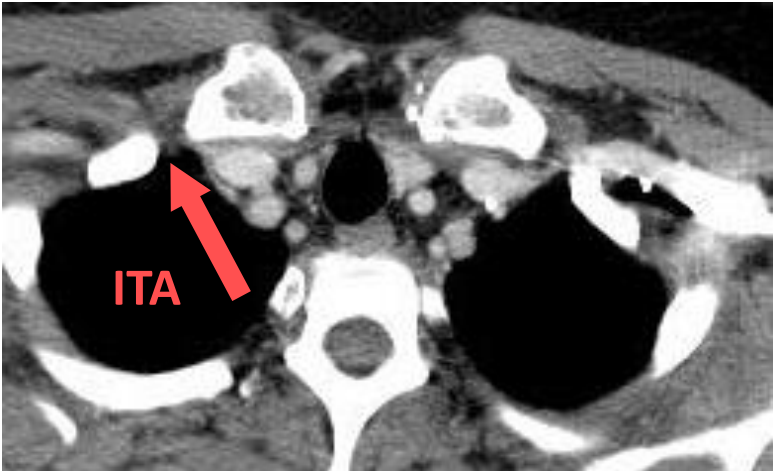
Immediate
or
deferred breast reconstruction



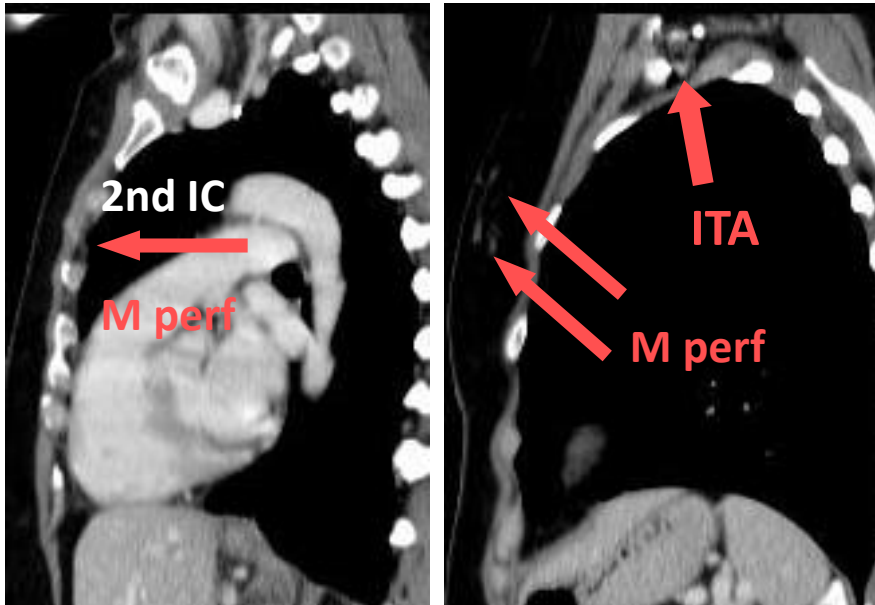
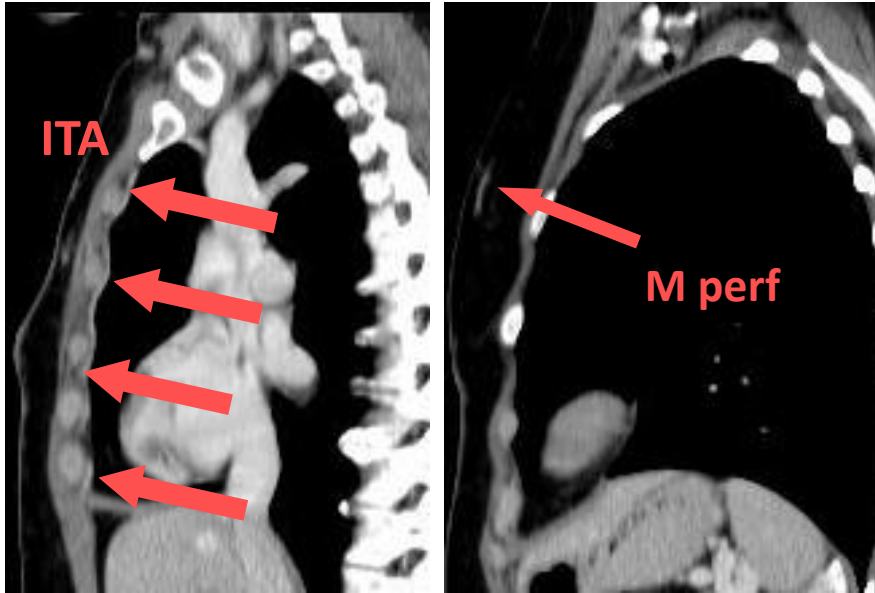
Coronal CT images



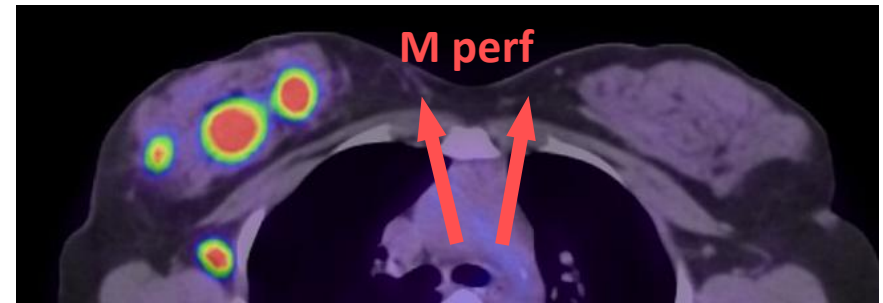
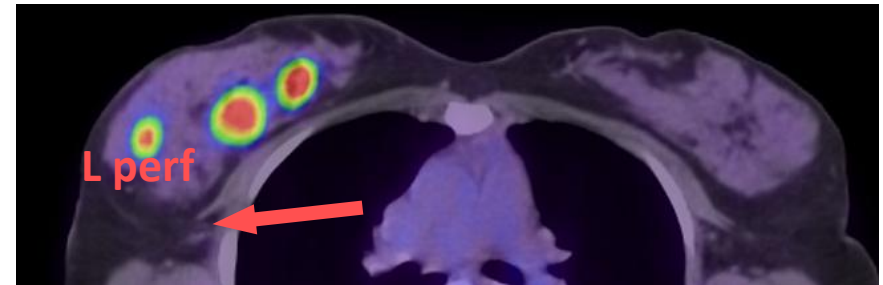
Tansverse CT images



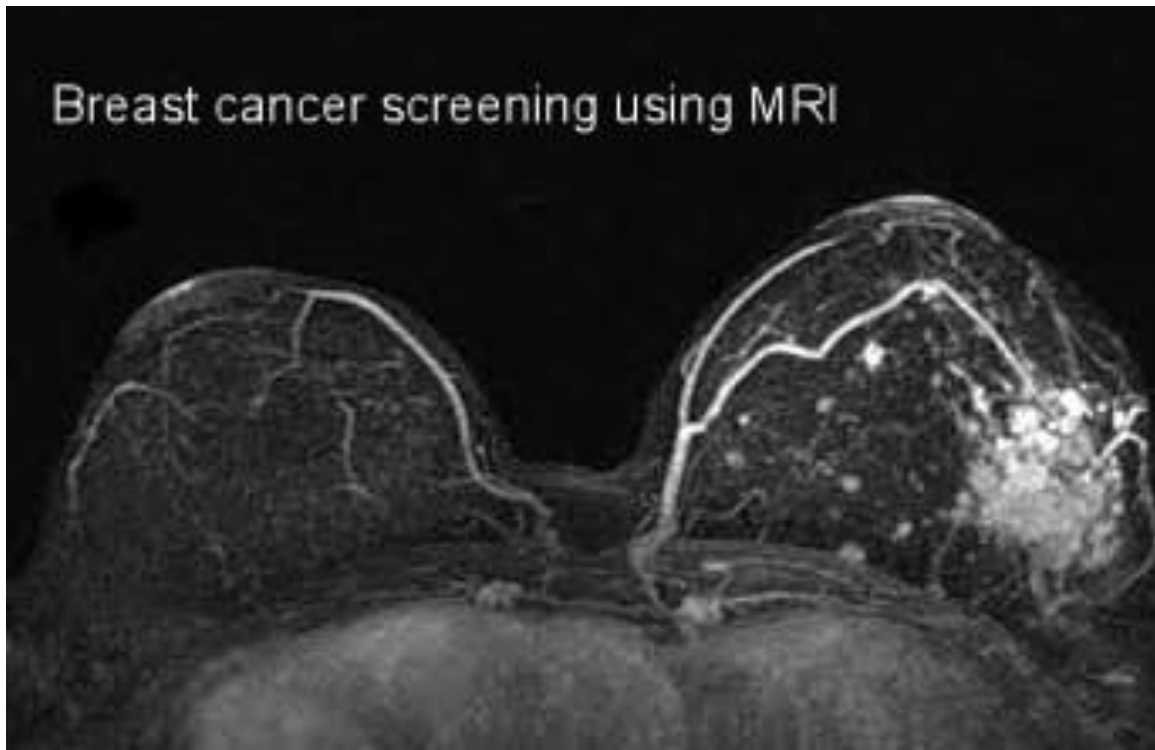
Sagittal CT images



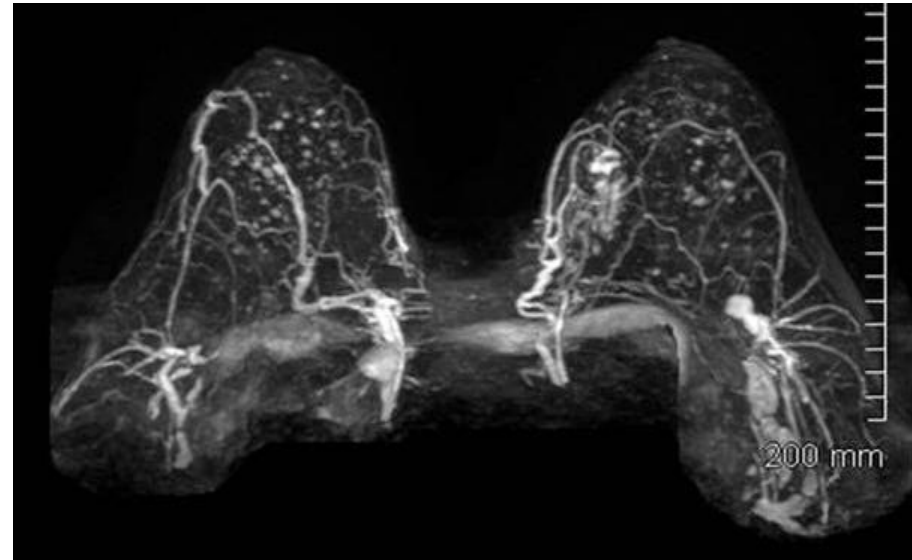
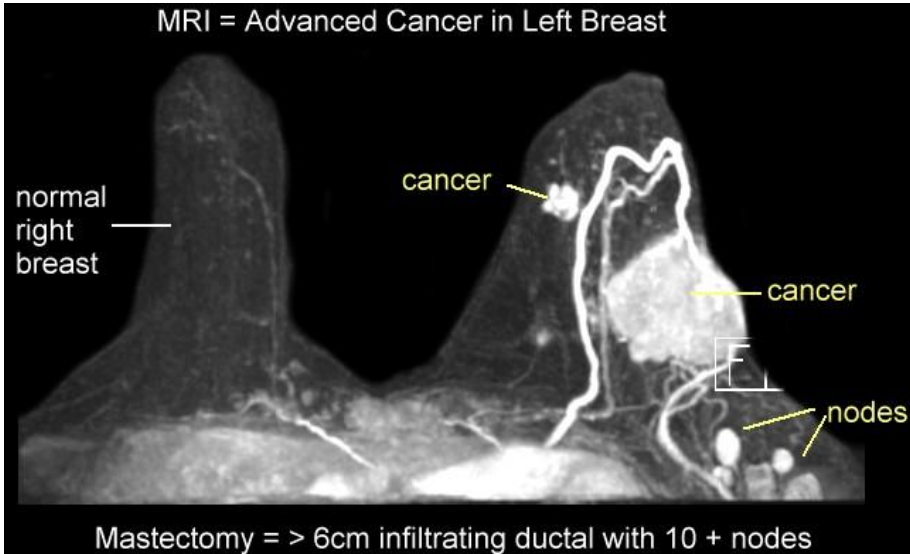
Transverse PETCT images



Breast cancer screening using MRI



MRI = Advanced Cancer in Left Breast



IMAP FLAP DESIGN & ARC OF ROTATION

IMAP PERFUSION (PERFORASOME)

360° Arc of Rotation

IMAP in ICS 2

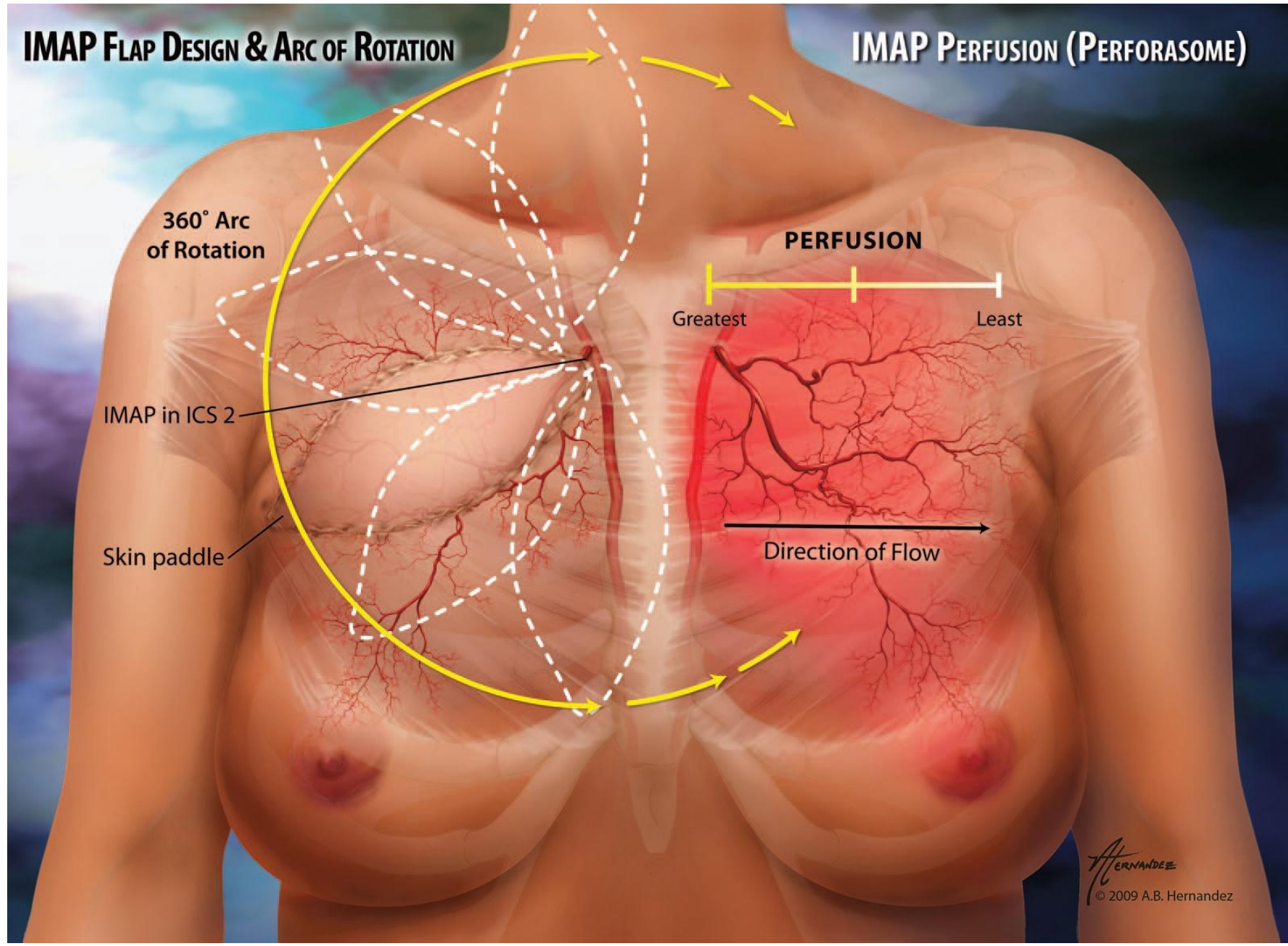
Skin paddle

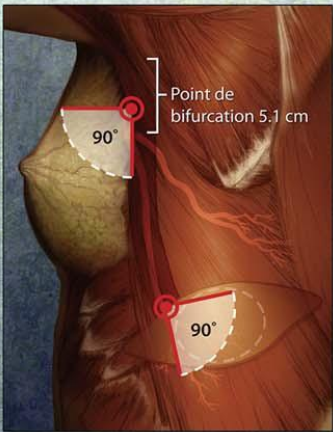
PERFUSION

Greatest

Least

Direction of Flow





TRANSPOSITION DORSALE DU LAMBEAU GDCM

- Artère thoracodorsale
- Branche transverse de l'artère thoracodorsale ①
- Branche descendante de l'artère thoracodorsale ②
- Bandelette musculaire prelevé le long du pédicule ③
- La palette cutanée du lambeau
- Muscle grand dentelé
- Muscle oblique externe
- Muscle grand dorsal

Distance à partir du creux axillaire /
Distance à partir du bord antérieur du muscle GD

- ① = 5.1cm / 2.2cm
- ② = 10cm / 2.4cm
- ③ = 15cm / 2.9cm



TRANSPOSITION ANTÉRIEURE DU LAMBEAU GDCM



a. axillaris

a., v., n. thoracodorsalis

m. Latissimus dorsi



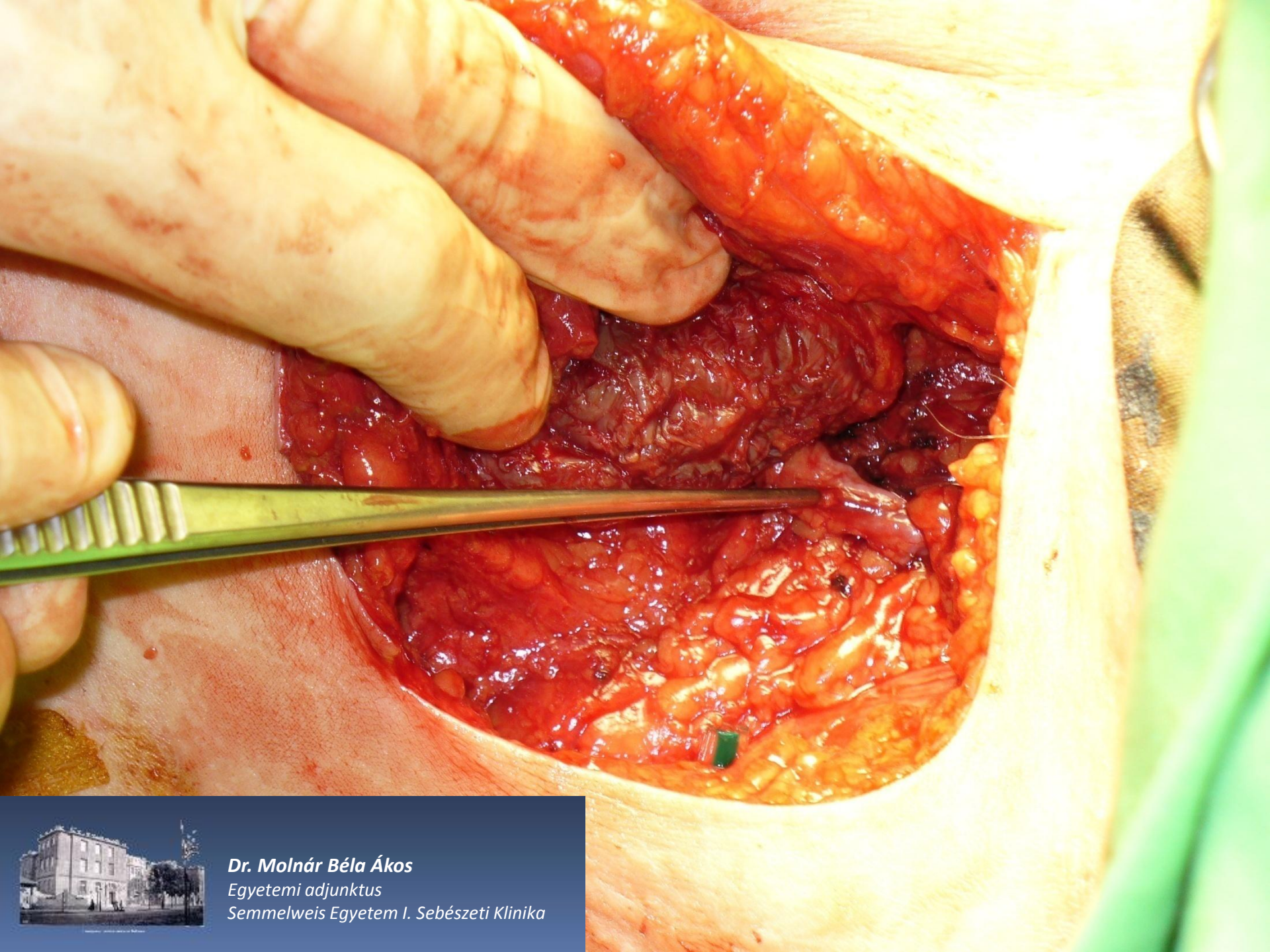
Dr. Molnár Béla Ákos
Egyetemi adjunktus
Semmelweis Egyetem I. Sebészeti Klinika



a., v., n. thoracodorsalis



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Dr. Béla Ákos Molnár
Adjunct Professor
Semmelweis University 1st Surgery Clinic



Dr. Béla Ákos Molnár
Adjunct Professor
Semmelweis University 1st Surgery Clinic

ONCOPLASTIC RECONSTRUCTION FOLLOWING MAMMA ABLATION

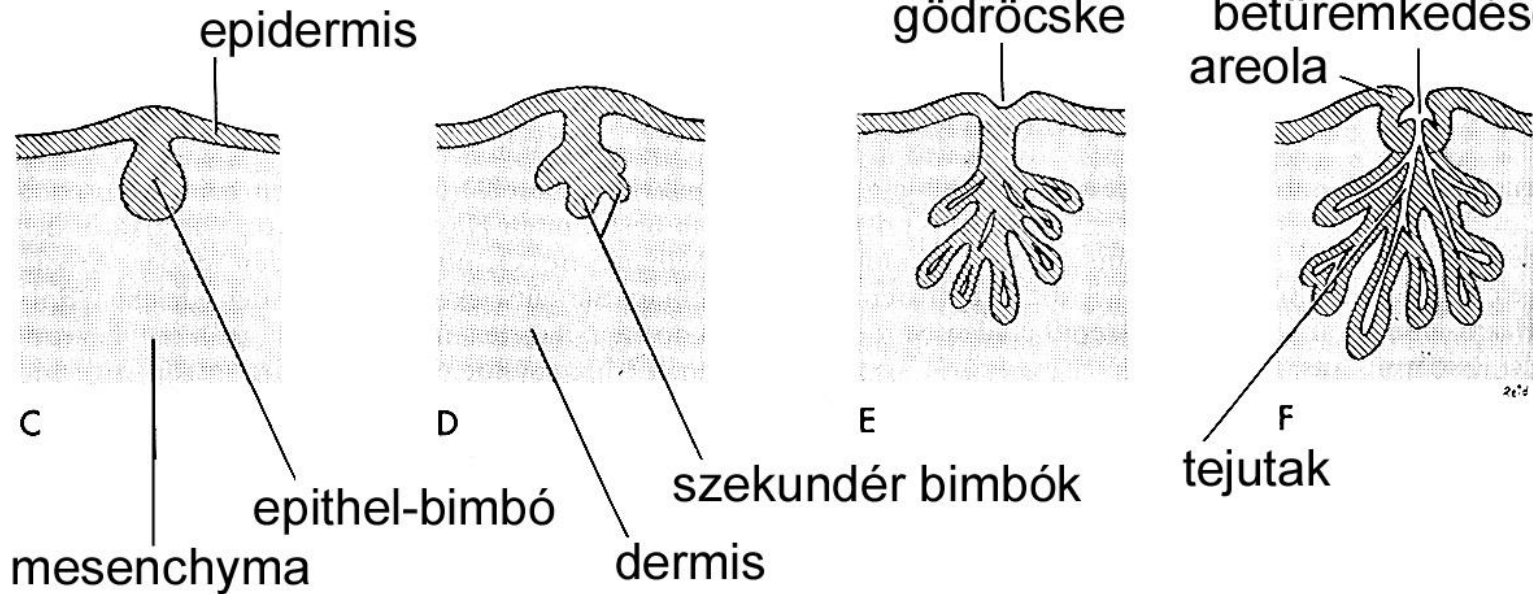
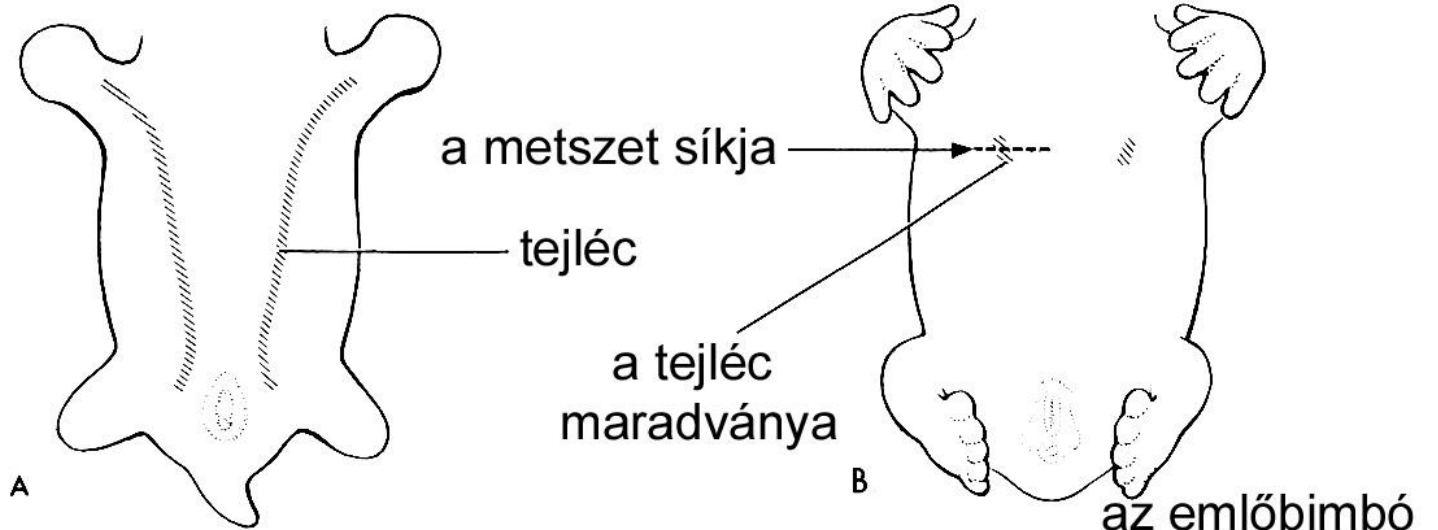


Dr. Béla Ákos Molnár
Adjunct Professor
Semmelweis University 1st Surgery Clinic

***Development of the
mammary gland***

Lactation

„PLACODES” OF THE GLAND



MILK LINE & MALFORMATIONS ***politelia***

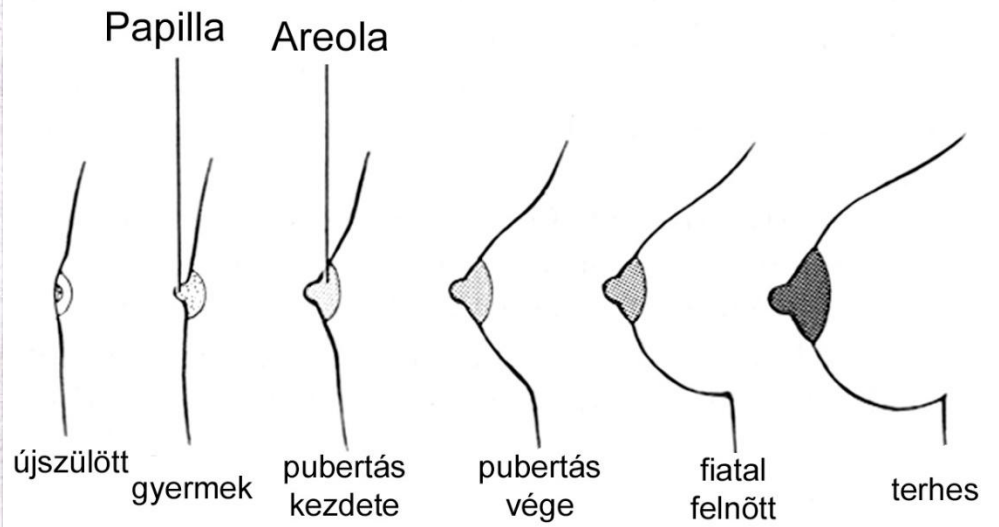
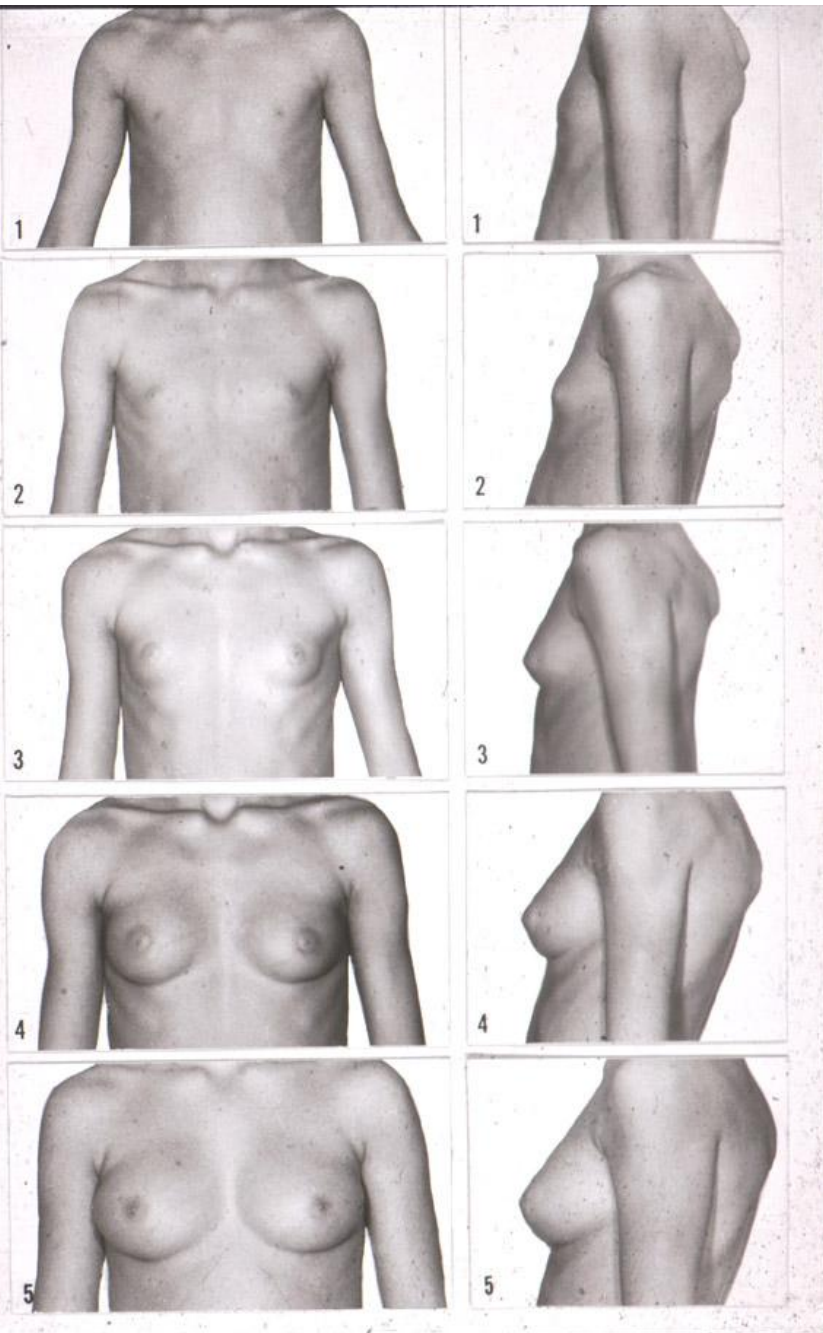


DEVELOPMENTAL MALFORMATIONS

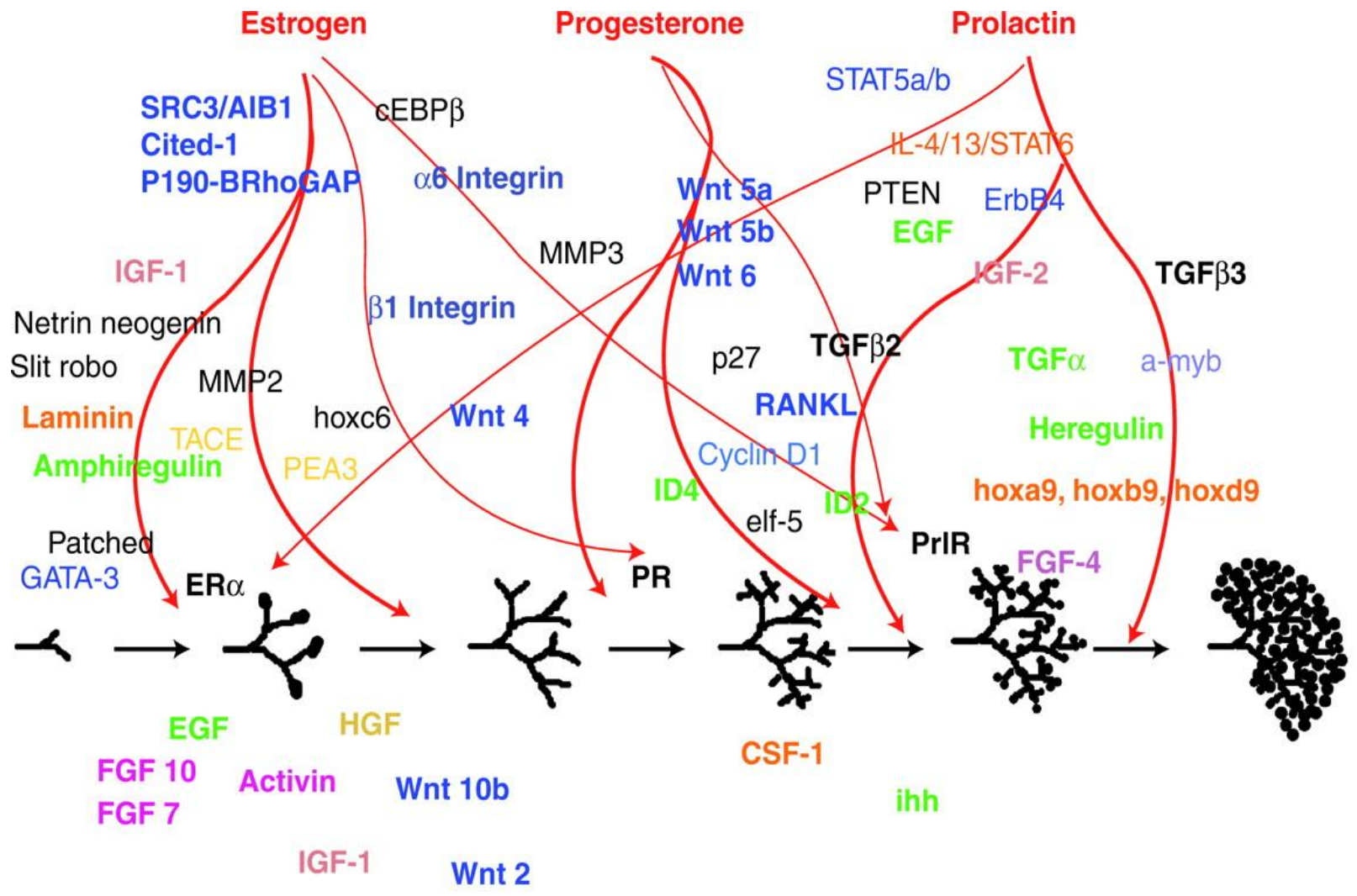
Accessory mammary gland



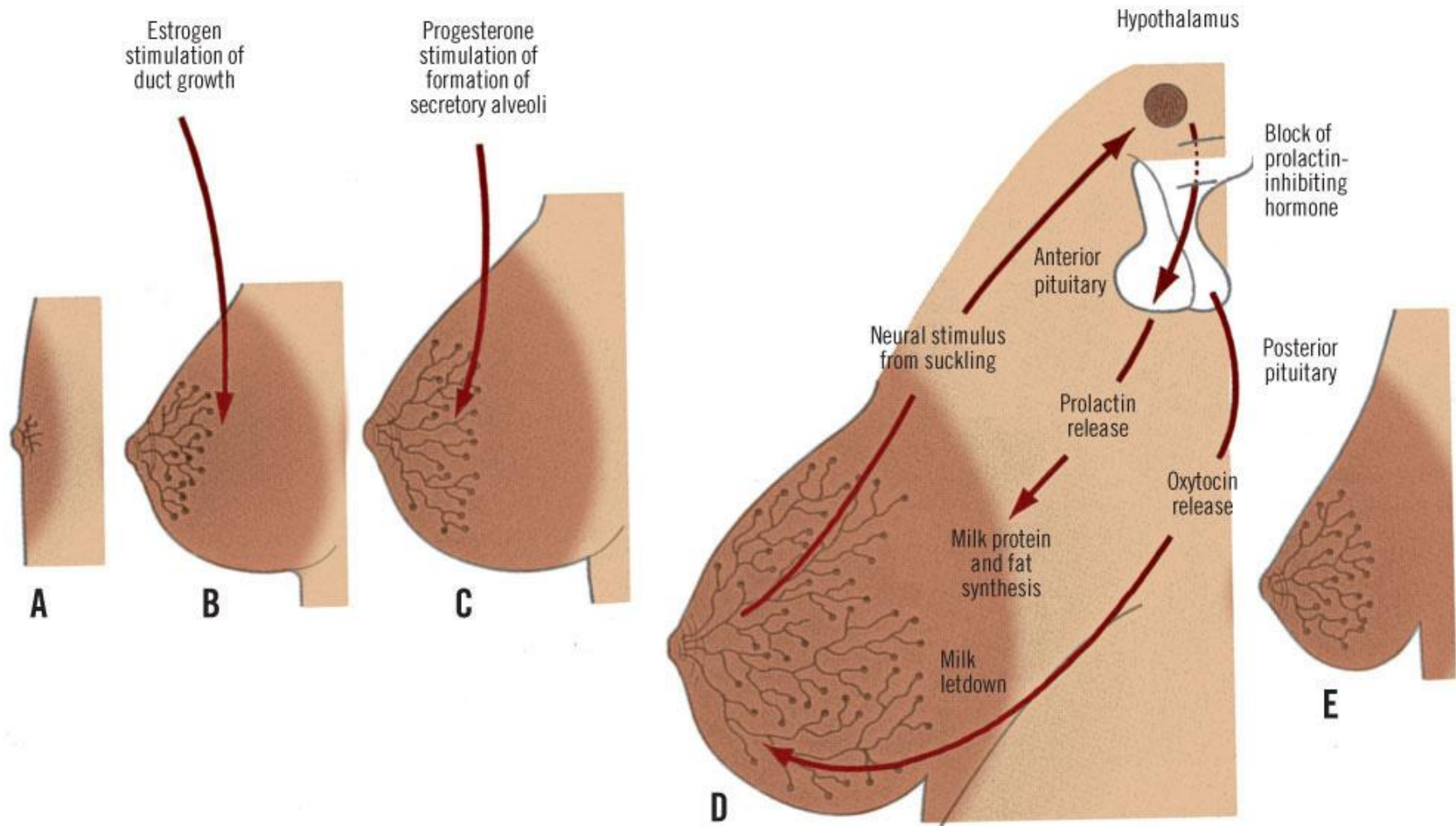
MORPHOLOGICAL CHANGES OF THE BREAST



MOLECULAR REGULATION OF THE DEVELOPMENT



HORMONES ACTING ON THE MAMMARY GLAND AND DUCTS



HORMONES

From the 18th week of pregnancy hormones that stimulate the growth of the milk duct system

Progesterone - growth in size of **alveoli** and **lobes**; high levels of progesterone inhibit lactation
Progesterone levels drop after birth; this triggers the onset of milk production

Estrogen - growth + diff of **milk duct system**. High levels of estrogen inhibit lactation. Estrogen levels drop at delivery and remain low for the first several months of breastfeeding. Breastfeeding mothers should avoid estrogen-based birth control methods, as a spike in estrogen levels may reduce a mother's milk supply.

Prolactin - growth and diff of **alveoli**, + diff of **ducts**. *High levels of prolactin during pregnancy and breastfeeding also increase insulin resistance, increase growth factor levels (IGF-1) and modify lipid metabolism in preparation for breastfeeding. During lactation, prolactin is the main factor maintaining tight junctions of the ductal epithelium and regulating milk production through osmotic balance.*

Human placental lactogen (HPL) – released from the 2 month of pregnancy, Similar to prolactin.

Follicle stimulating hormone (FSH), luteinizing hormone (LH), and human chorionic gonadotropin (hCG), control estrogen and progesterone, prolactin and growth hormone production.

Growth hormone (GH) is similar to prolactin and contributes to galactopoiesis.

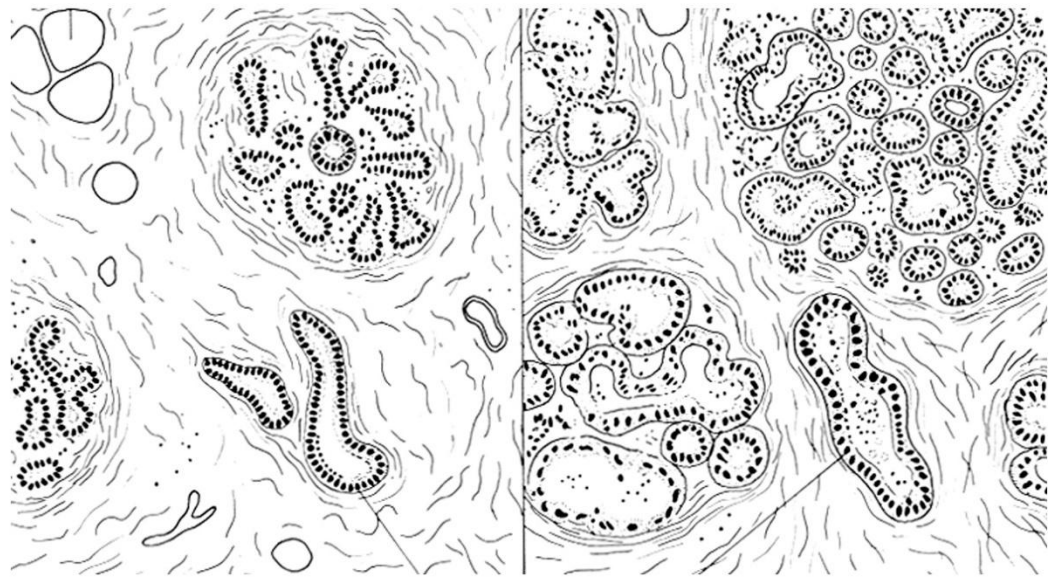
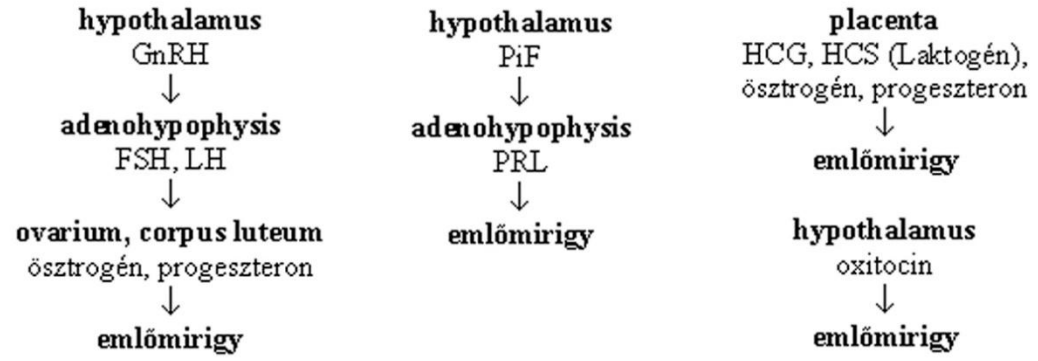
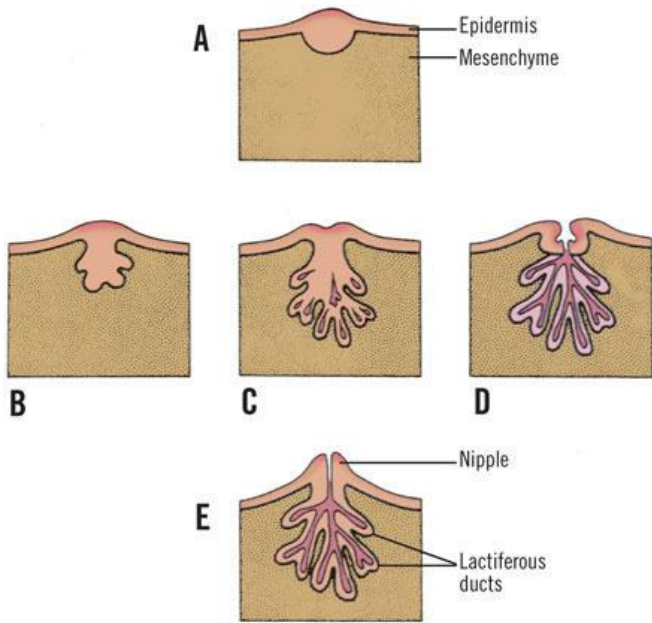
Adrenocorticotrophic hormone (ACTH) and **glucocorticoids** have an important role in inducing lactation. Glucocorticoids play a complex regulating role in the maintenance of tight junctions.

Thyroid-stimulating hormone (TSH) and **thyrotropin-releasing hormone (TRH)** are important galactopoietic hormones whose levels are naturally increased during pregnancy.

Oxytocin contracts the smooth muscle layer of alveoli and is necessary for the **milk ejection reflex**, or *let-down*, in response to suckling.

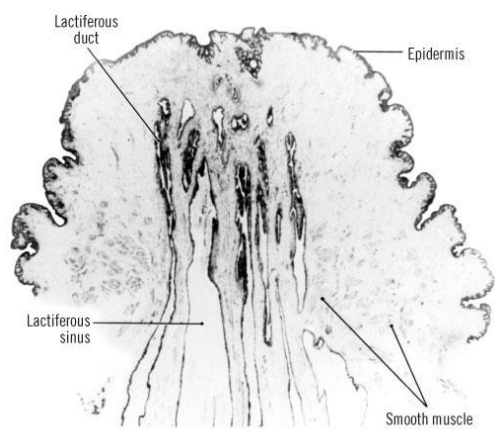
It is also possible to induce lactation without pregnancy. Protocols for inducing lactation are called the Goldfarb protocols. Using birth control pills to mimic the hormone levels of pregnancy, then discontinuing the birth control, followed by use of a double electric breast pump for 15 minute sessions at regular 2-3 hour intervals (100+ minutes total per day)_ helps induce milk production.

SECRETORY ACTIVITY / LACTATION



nyugalmi állapot

mamma lactans



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SECRETORY ACTIVITY / LACTATION

At birth, **prolactin** levels remain high, while the **delivery of the placenta** results in a sudden drop in **progesterone**, **estrogen**, and **HPL** levels. This abrupt **withdrawal of progesterone** in the presence of high prolactin levels stimulates milk production

When the **breast is stimulated**, **prolactin levels rise & peak in about 45 min**, and return to the pre-breastfeeding state about 3 hours later.

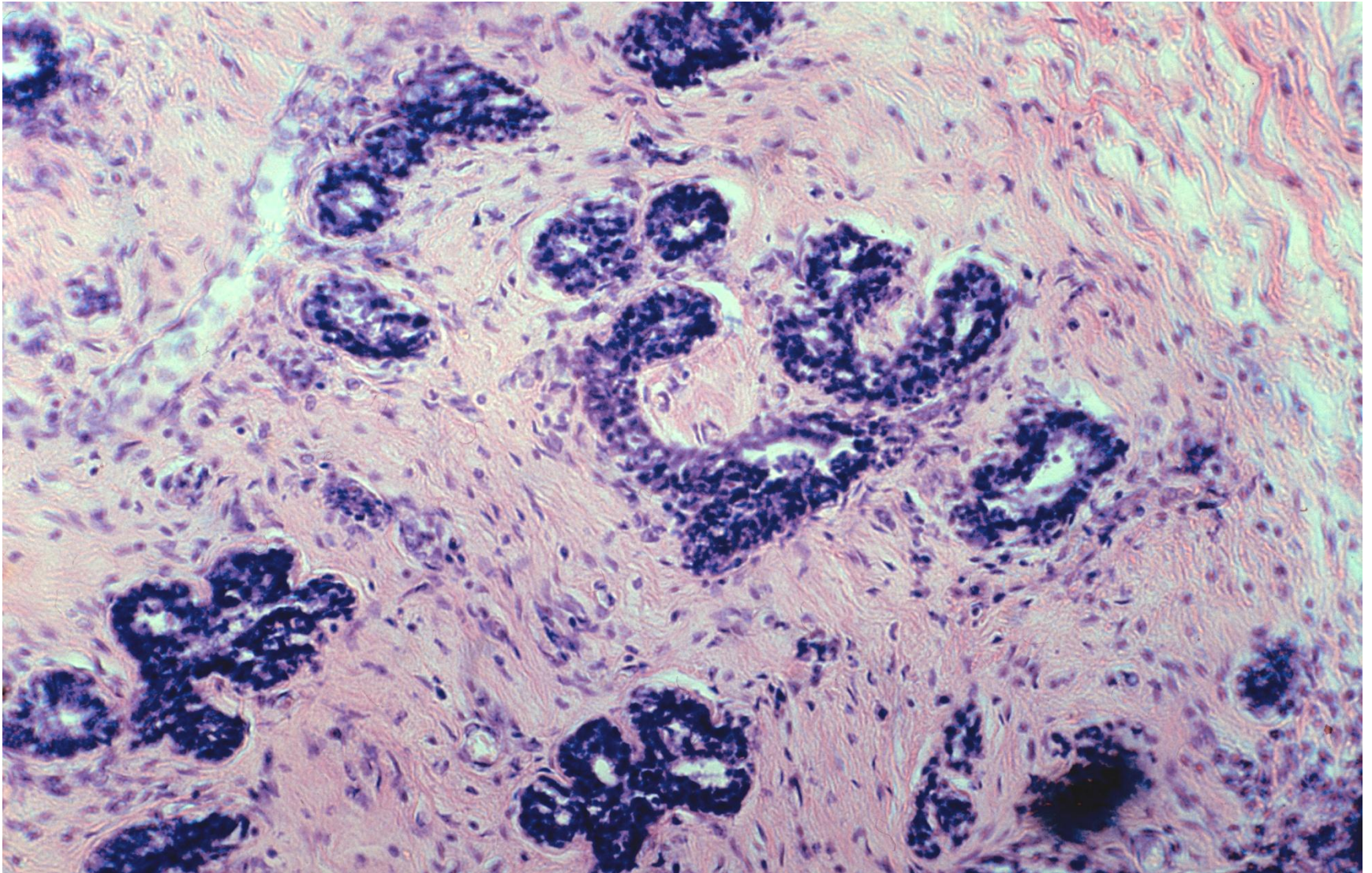
The release of prolactin triggers the cells in the alveoli to make milk.

Prolactin also transfers to the breast milk. Some research indicates that prolactin in milk is greater at times of higher milk production, and lower when breasts are fuller, and that the highest levels tend to occur between 2 a.m. and 6 a.m

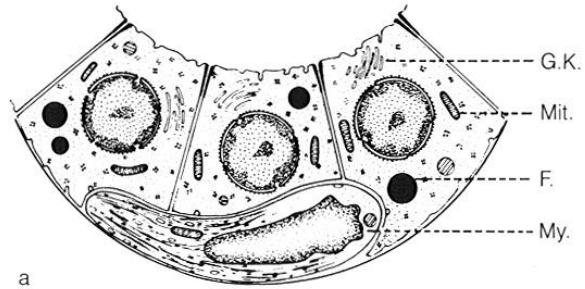
Colostrum is the first milk a breastfed baby receives. It contains higher amounts of **white blood cells** and **antibodies** than mature milk, and is especially high in **immunoglobulin A (IgA)**, which coats the lining of the baby's immature intestines, and **helps to prevent pathogens from invading** the baby's system. Secretory IgA also helps prevent food allergies.

Over the first two weeks, colostrum production slowly gives way to mature breast milk.

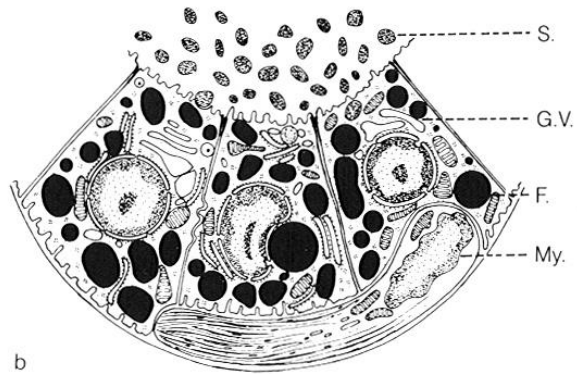
MAMMA NON-LACTANS



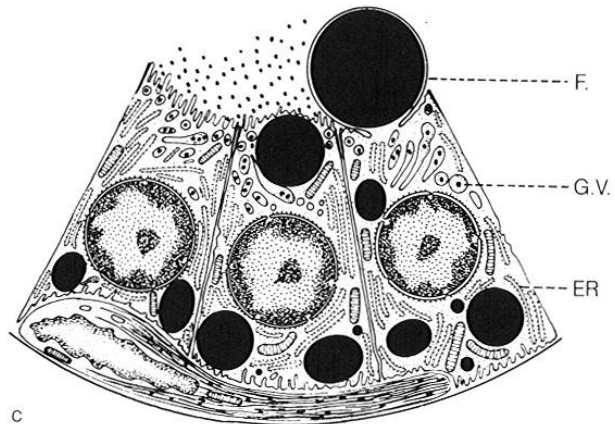
MAMMA LACTANS



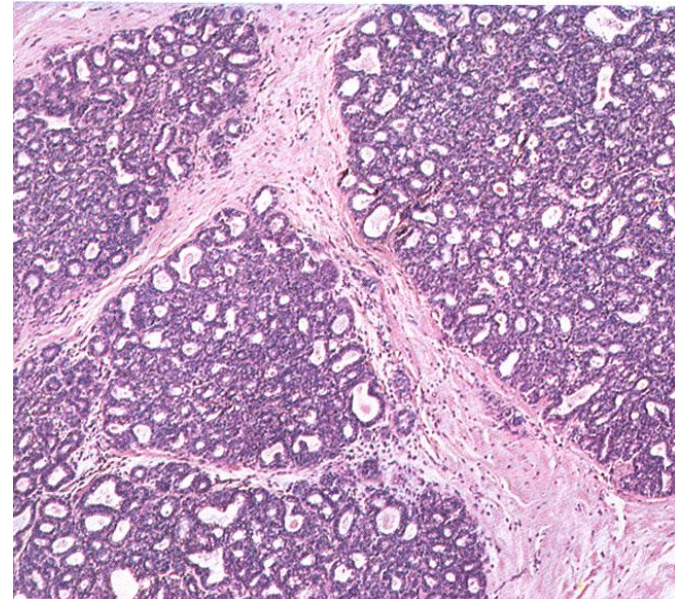
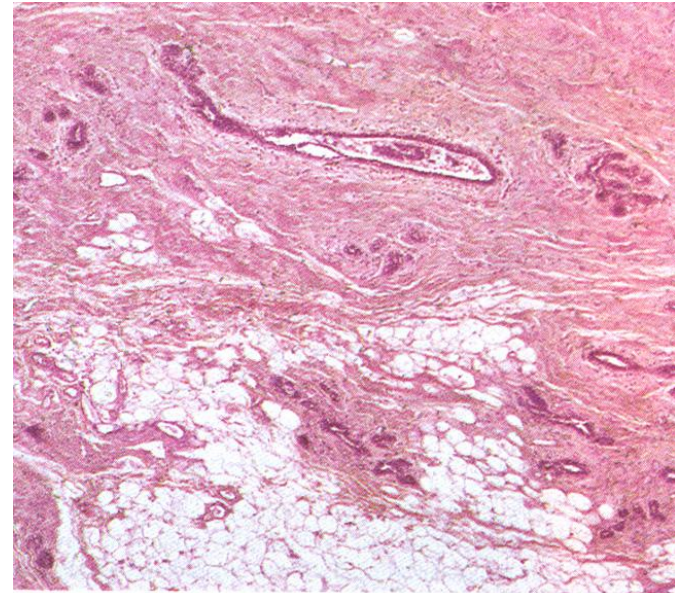
a



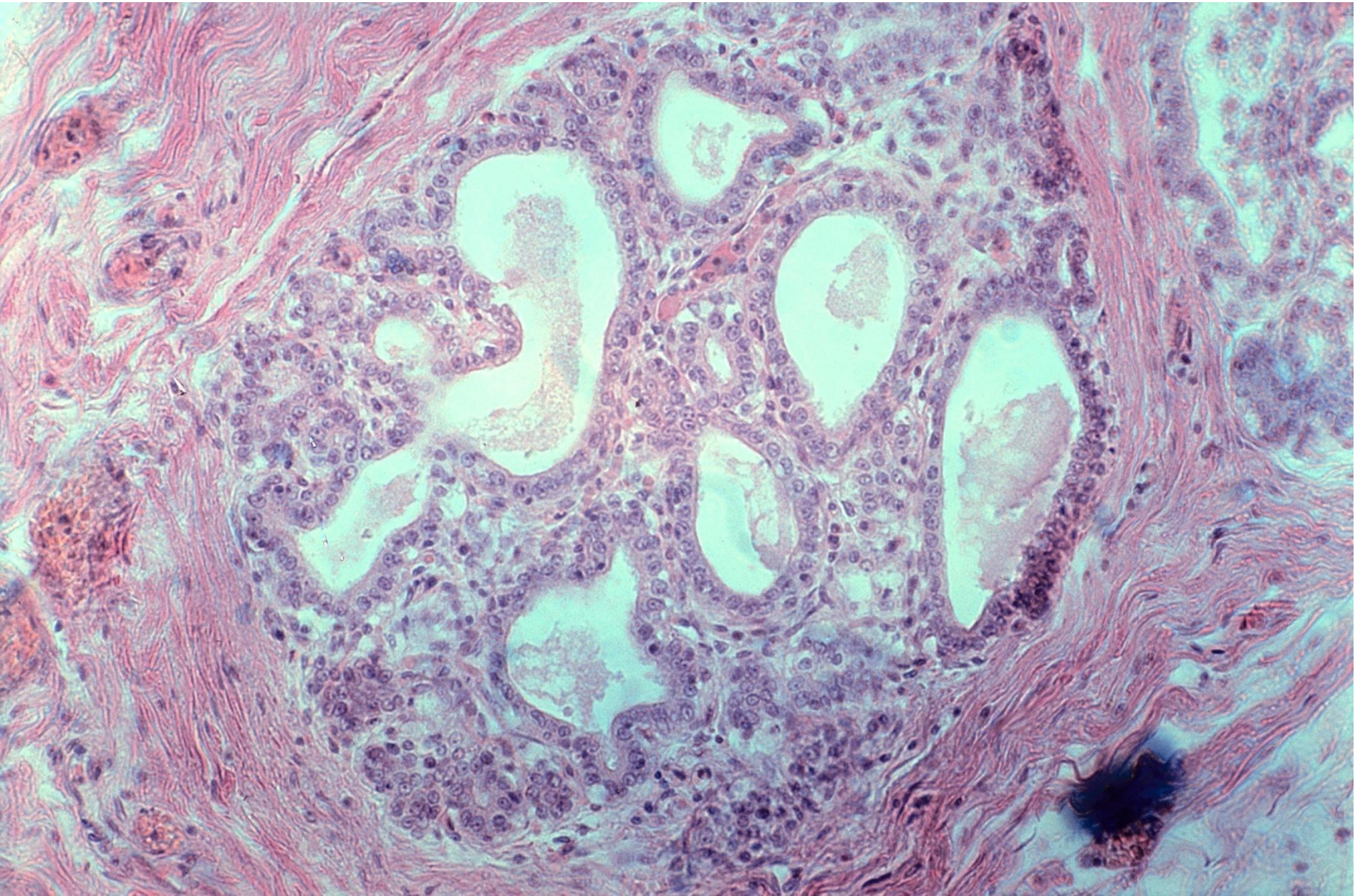
b



c



MAMMA LACTANS

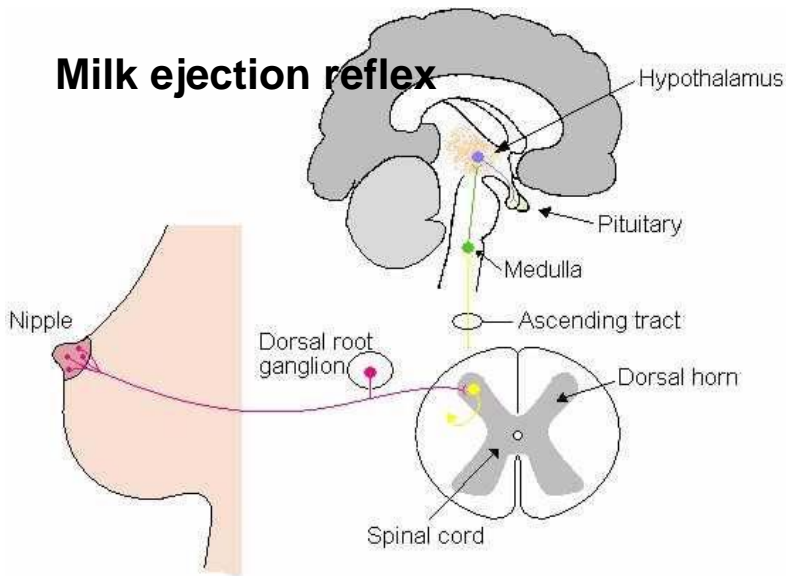


AUTOCRINE CONTROL OF LACTATION

The **hormonal system regulates** growth and differentiation of the gland during pregnancy and the first few days after the birth.

Autocrine (local) control begins when the milk supply is firmly established.

The more that milk is removed from the breasts, the more will be produced (milk supply is influenced by how often the baby feeds and how well it is able to transfer milk from the breast).



Suckling by the baby triggers **slowly-adapting and rapidly-adapting mechanoreceptors** in the areola.

The signal is transferred via the anterolateral tract, starting from the 4th IC nerve ascending 1 or 2 segments then it synapses with 2-order neurons in the dorsal horn.

The pathway terminates in the **paraventricular** and **supraoptic** nuclei in the hypothalamus, which signal to the **posterior pituitary** gland to produce **oxytocin**.

Oxytocin stimulates contraction of the **myoepithelial** cells surrounding the alveoli, which already hold milk. The increased pressure causes milk to flow through the duct system and be released through the nipple. This response can be **conditioned e.g. to the cry of the baby**.

MAMMA LACTANS

MORPHOLOGICAL CHANGES

- breast volume increases (hormonal influence)
- glandular tissue increases
- adipose tissue partially transdifferentiates (increases and decreases)
- pigmentation of areola increases (darkens)
- nipple protrudes

- **Montgomery glands (modified apocrine sweat glands) protrude**

(protects the nipple from mechanical and/or chemical irritation during suckling, the secretional product *moistens and fattens the nipple*

+ one of the **components is secreted in the amniotic fluid** – *the newborn recognizes this smell.*)



MORPHOLOGICAL CHANGES OF THE DUCTAL SYSTEM DURING LACTATION AND REGRESSION

LACTATION

- Breast volume increases, a **glandular cells differentiate**, adipose tissue decreases.
- The blind **terminal buds** grow into **alveoli**.
- The **ducts start to elongate**, branching is **increased**
- The stroma is **infiltrated** by **immune cells+ granulocytes**.
- **Montgomery glands protrude**

INVOLUTION

- Glandular stroma is reduced, adipose and connective tissue increases again.
- The **lamina basalis is enzymatically broken down** - resting breast.
- The alveolo-epithelial cells
 - die by **apoptosis**, macrophages eat up the debris (phagocytosis),
 - OR they **transdifferentiate** into ADIPOSE CELLS (pink adipocyte)
- **Regression** continues into the menopause. The alveolar system fully while the duct system only partially atrophies.

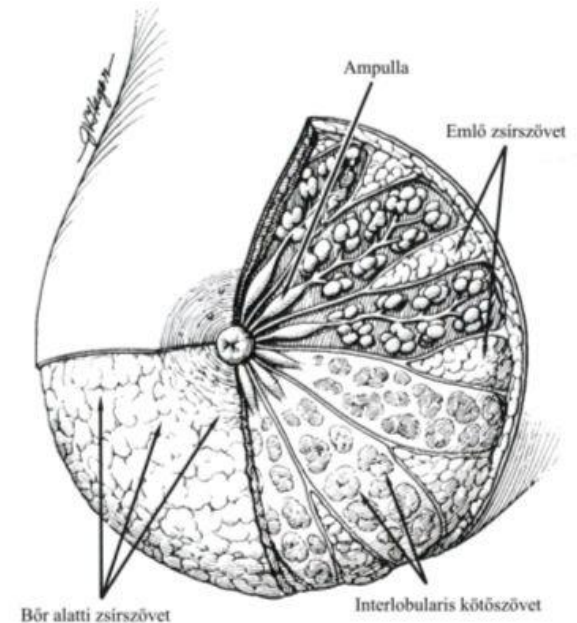
TRANSDIFFERENTIATION

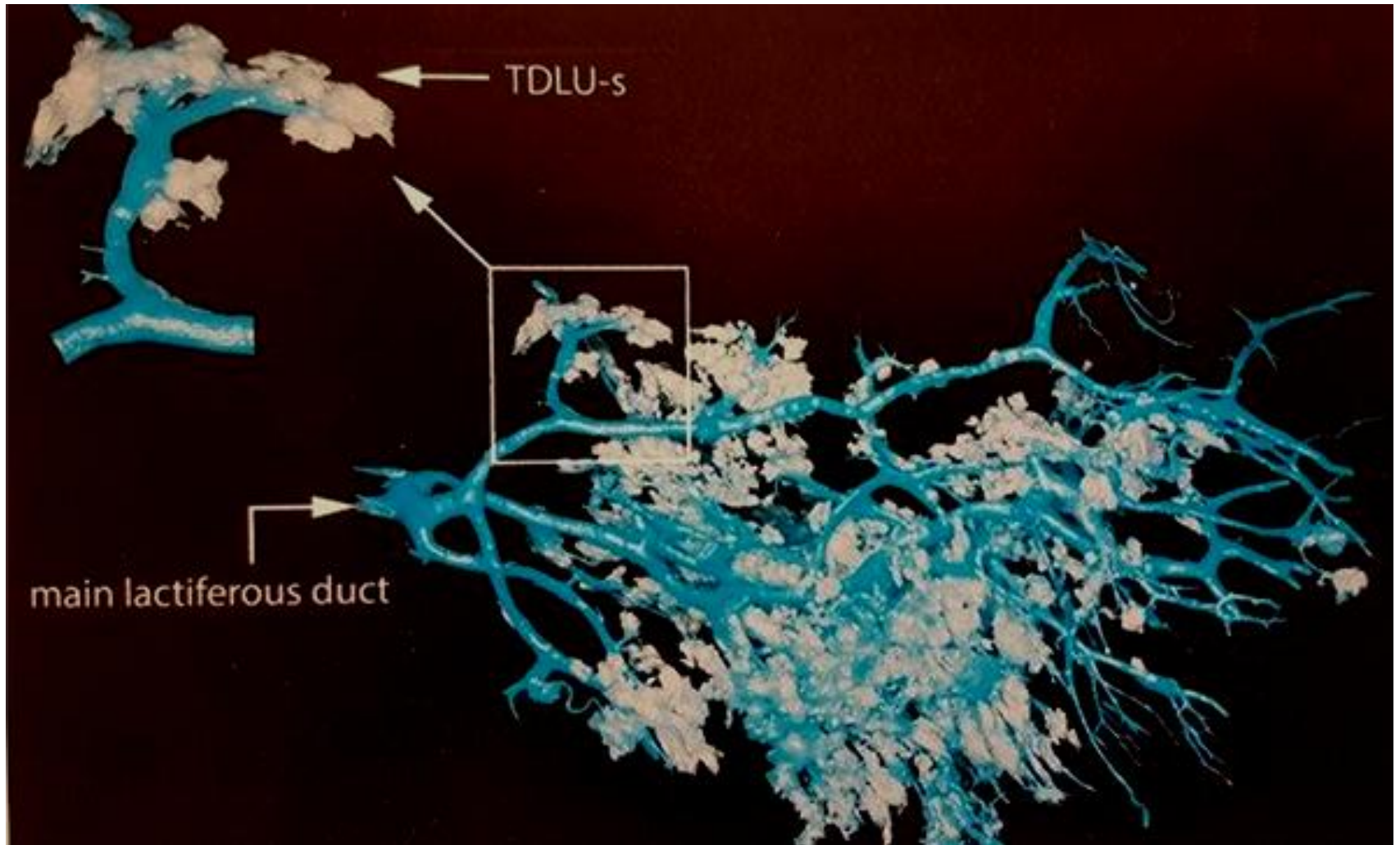
One mature somatic cells transforms into another type of mature somatic cell without taking up an intermediary progenitor or pluripotent stage/phase.

- LACTATION – involution : cyclic activity, the adipocytes and alveolar epithelial cells mutually transdifferentiate
- PINK ADIPOSE TISSUE – turn into alveolar epithelial cells in the lactating breast
- Role: to increase the secretional activity
- INVOLUTION – **pink** adipocytes will turn into **white** adipocytes

THE DUCT SYSTEM AS WE KNEW IT UNTIL NOW

- **15-20 lobes** (embedded in the Cooper ligaments)
- ***Intralobar*** ducts
- ***Extralobar*** system
- (one large excretory duct in a lobe = main lactiferous duct)
- ***TDLU***: terminal duct – lobule unit (the smallest structural and functional unit, to be studied by ultrasound)
- ***Lactiferous sinus*** (alternatively: ampulla, milk sinus)
Subareolar, radially oriented duct portions (before opening on the papilla)



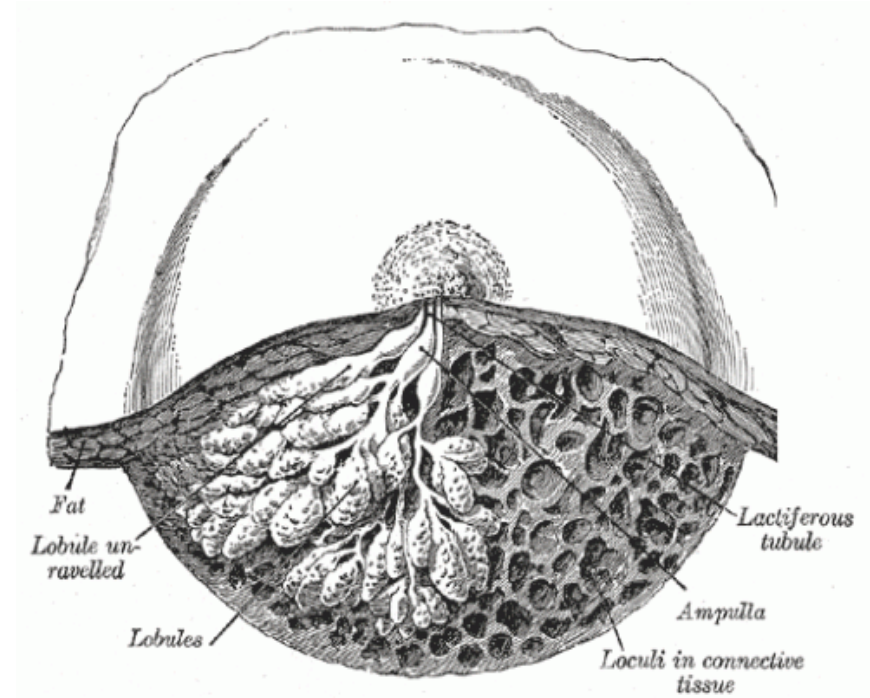


TERMINAL DUCT LOBULE UNIT (TDLU)

Dr. Péter Pálházi

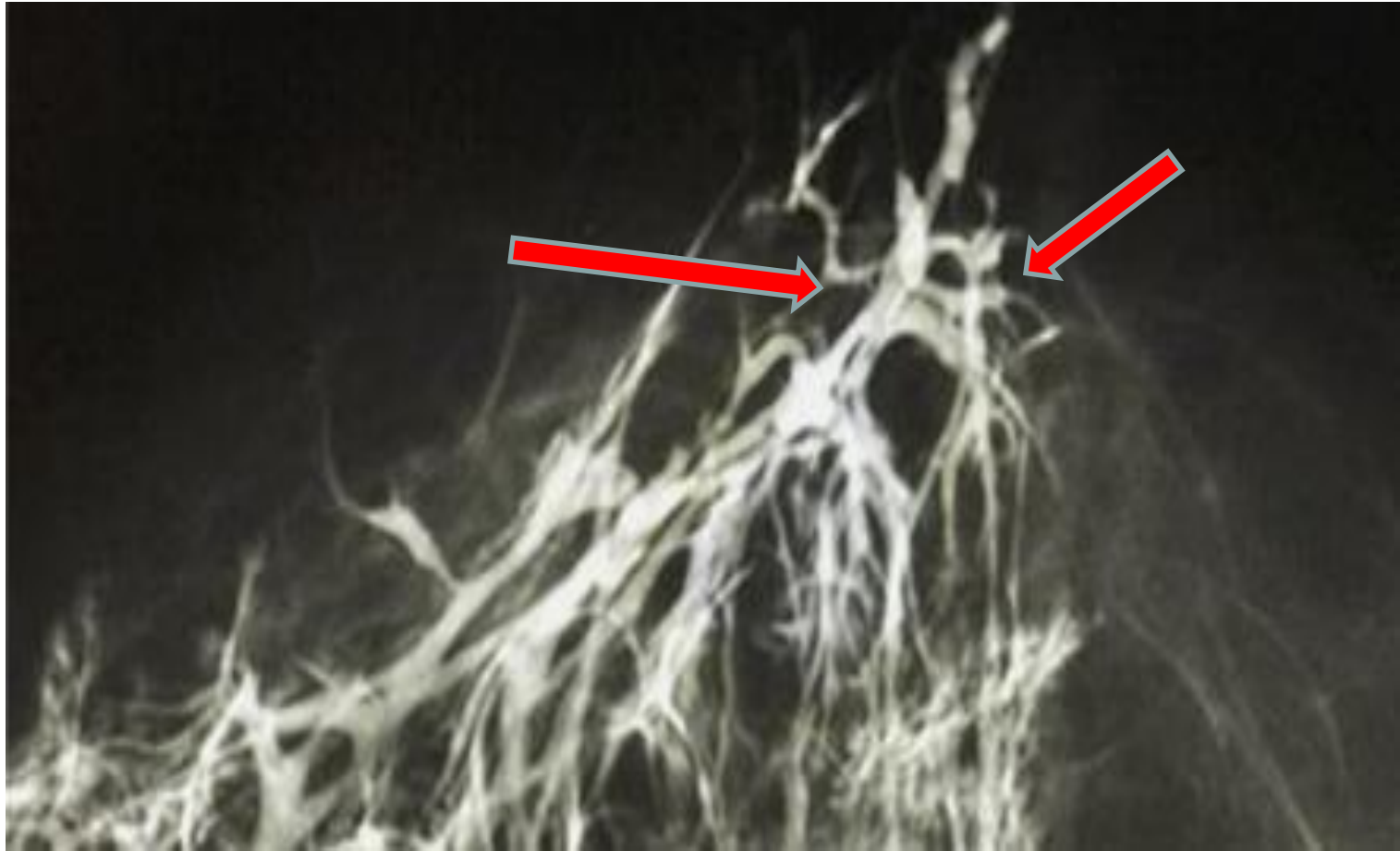
THE DUCT SYSTEM AS WE KNEW IT UNTIL NOW

- ***Functionally*** the milk sinuses are spindle shaped reservoirs with an elastic wall. They fill up with milk before the ejection



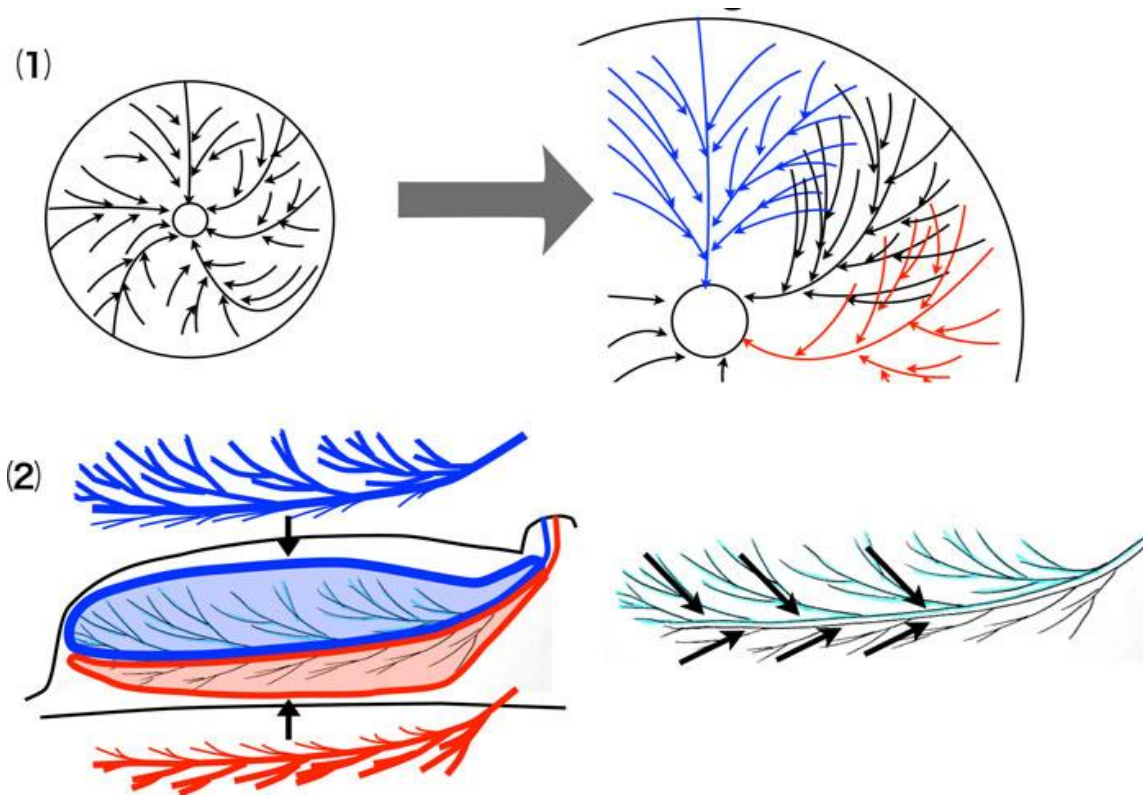
(ACCORDING TO COOPER)

THE DUCT SYSTEM REVISED



Galactographia, Dr. Dömötöri Zsuzsa felvétele, SE Radiológiai és Onkoterápiás Klinika

THE DUCT SYSTEM REVISED

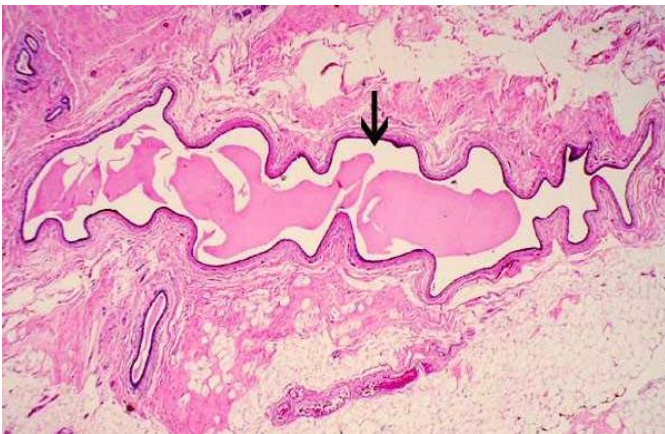
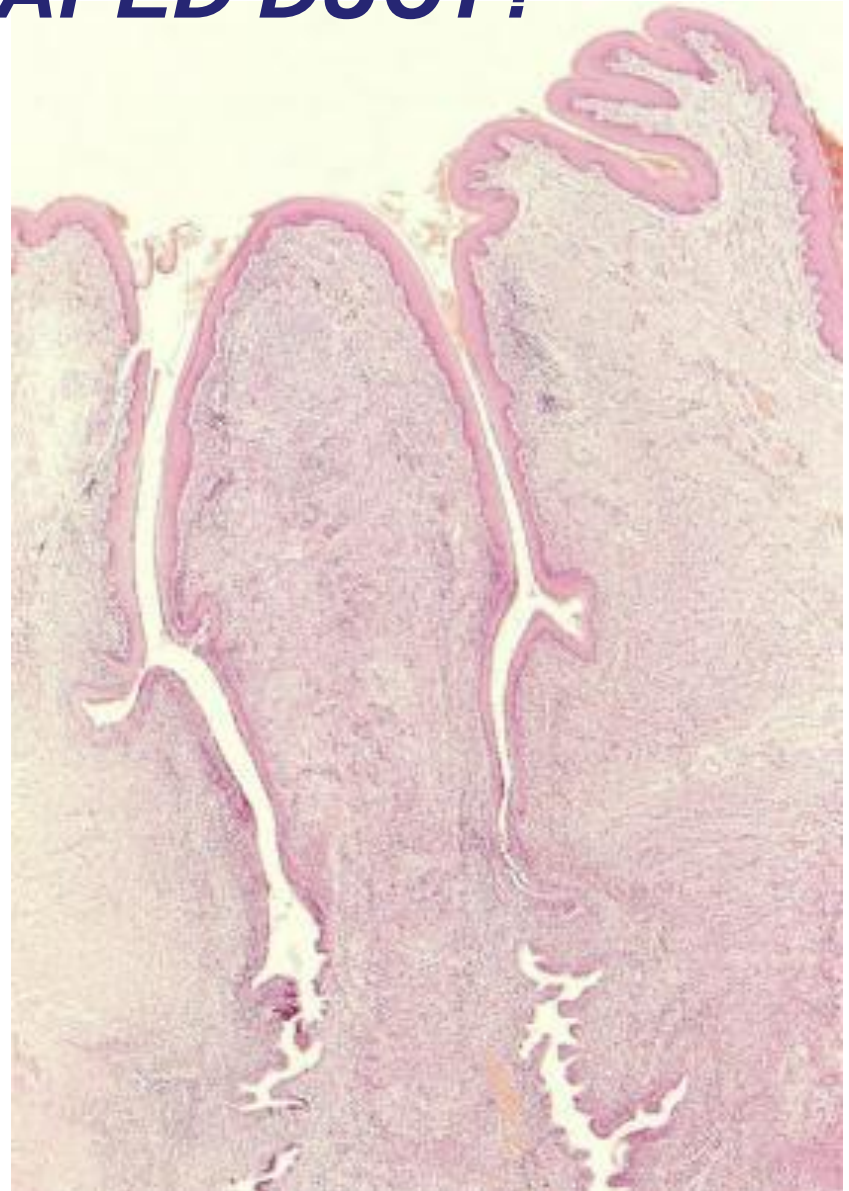
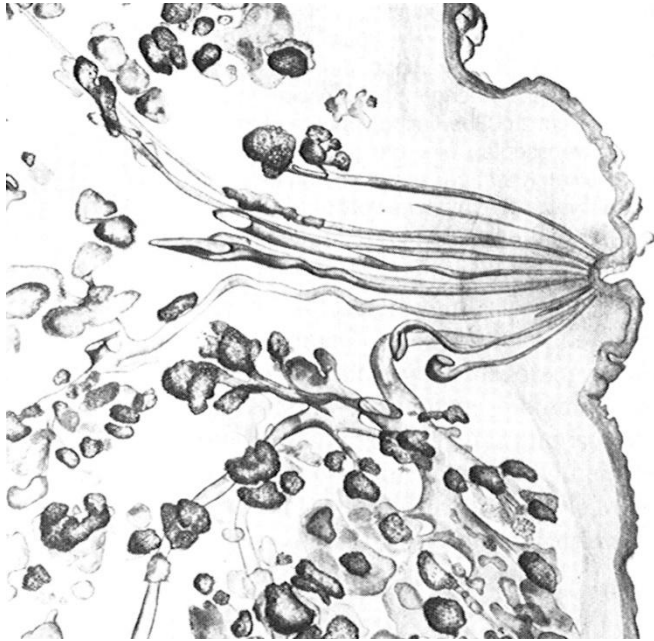


- **Lactiferous pores - excretory ducts - openings on the nipple** –the number of openings is much lower than it would be assumed from the number of ducts/ lobes (5-9)

- **Bidirectional flow in the ducts**

- The **duct wall** is thin and elastic when studied by ultrasound

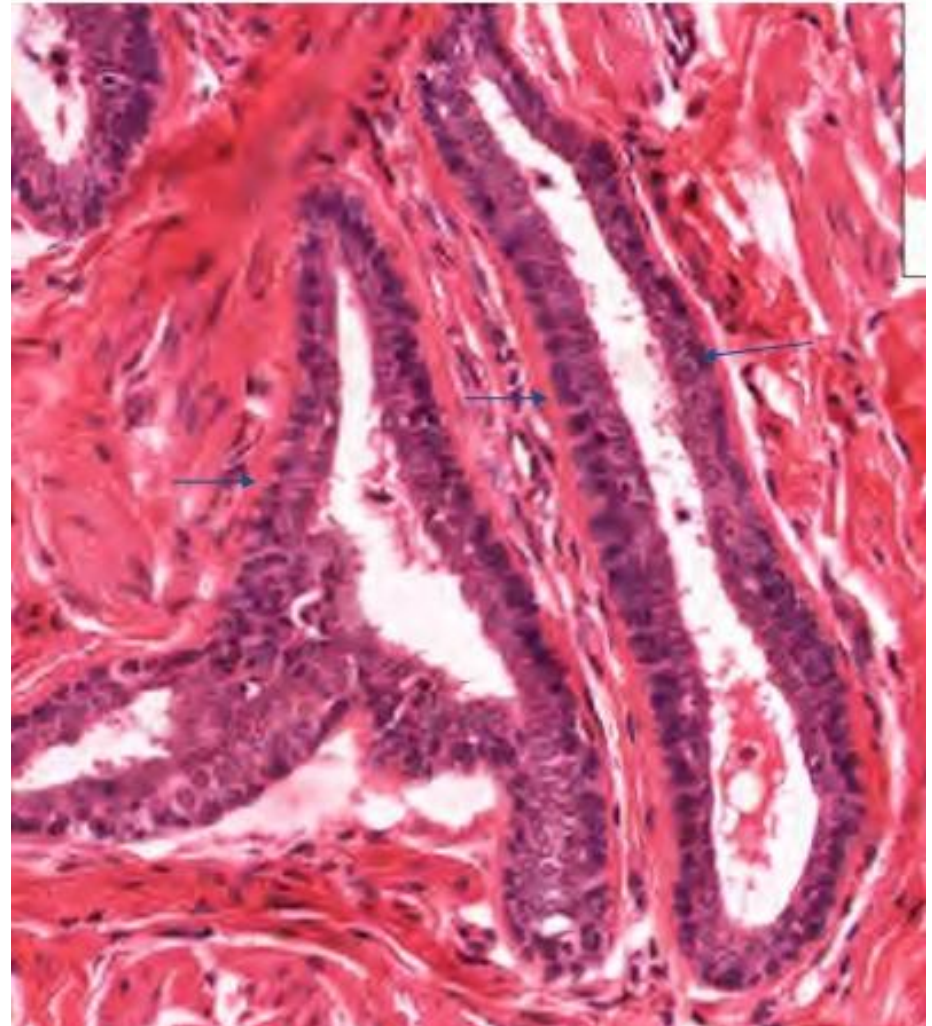
DOES THE SINUS EXIST AS A SPINDLE SHAPED DUCT?



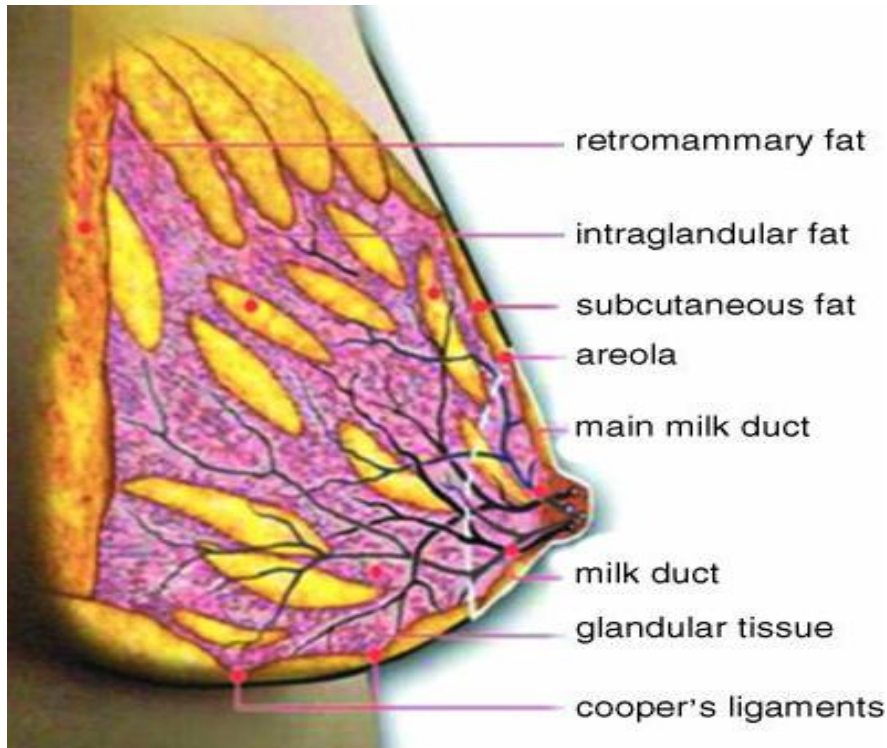
THE SINUS SEEMS TO BE A TRANSITIONAL STRUCTURE

It has no special histological structure

- the wall structure of the sinus DOES NOT DIFFER from the rest of the ductal system
- **Myoepithelial cells** surround the wall of the ducts (actin content increases during lactation)



NEW FINDINGS IN THE CLINICAL ANATOMY OF THE LACTATING BREAST



- There is no morphologically distinct sinus'
- The number of (viable) ducts does not equal the number of lobes
- The ducts form profuse anastomoses
- The main excretory ducts do not follow an ordinary, i.e. radially oriented course
- Bidirectional flow in the ducts
- Special cells of the intraglandular adipose tissue *transdifferentiate* into alveolar epithelial cells and vice versa

***Thank you very much for
your attention!***