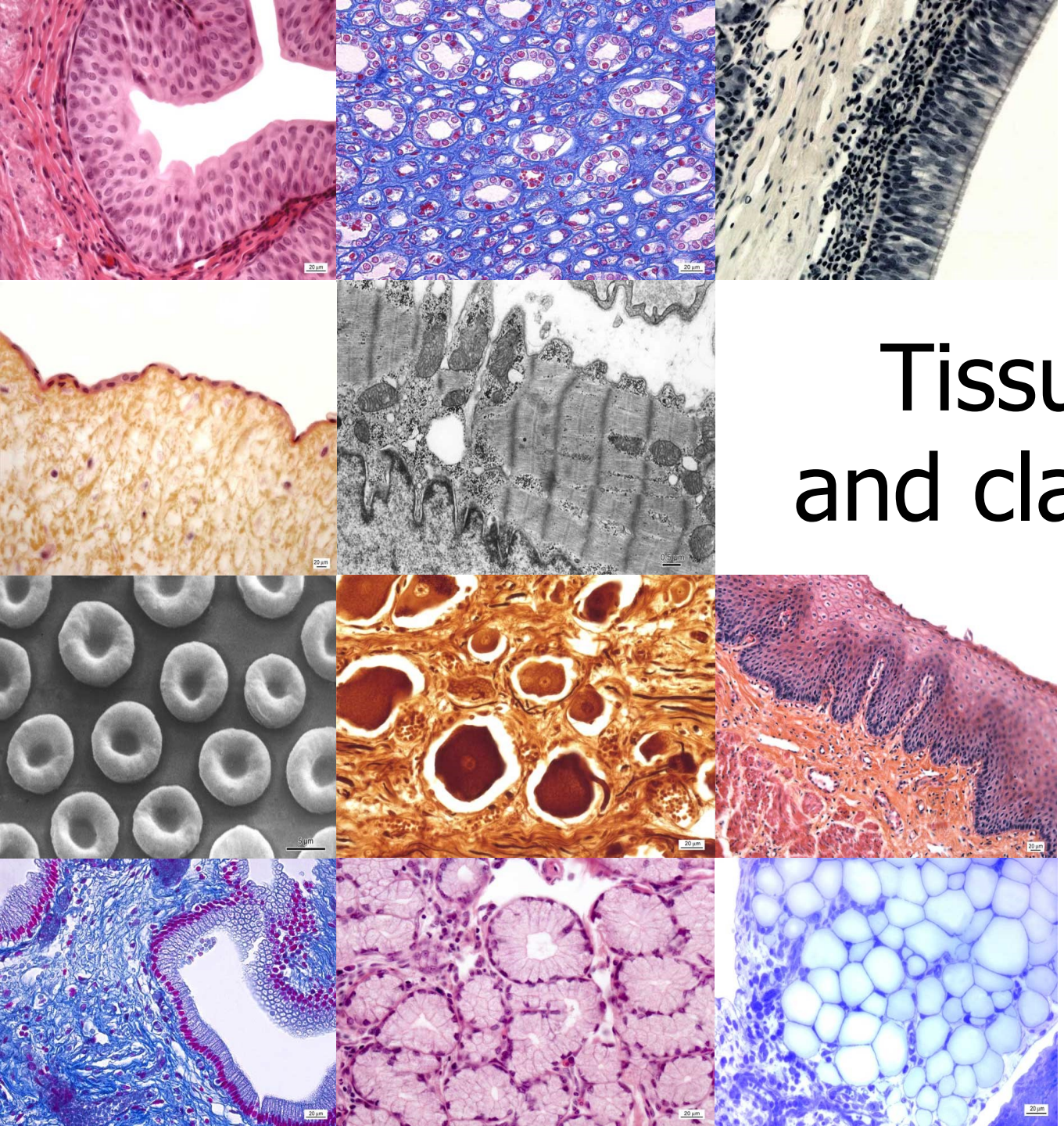
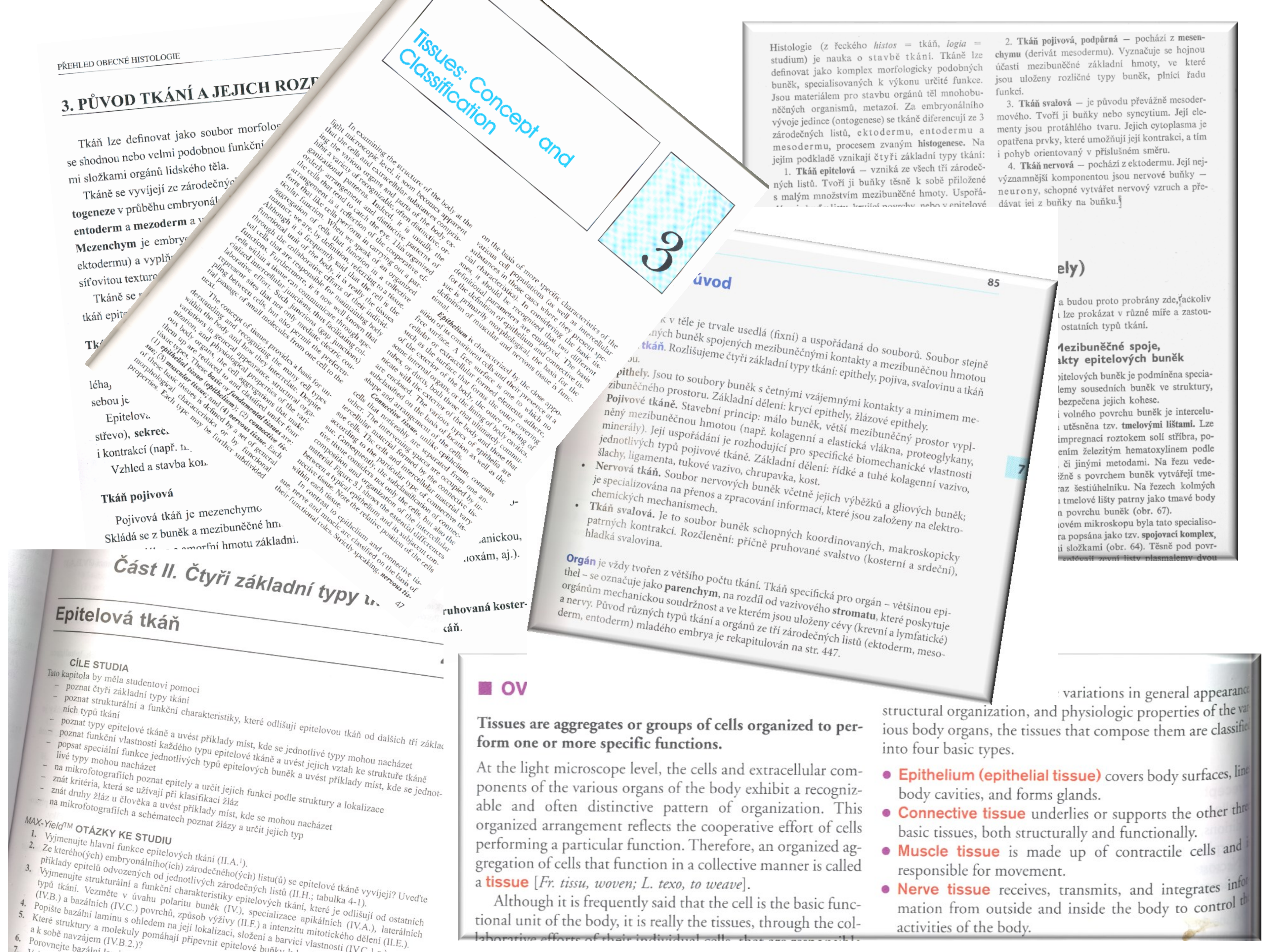


Tissue concept and classification

Petr Vaňhara, PhD

Department of Histology and Embryology,
Faculty of Medicine MU

pvanhara@med.muni.cz



PŘEHLED OBECNÉ HISTOLOGIE
3. PŮVOD TKÁNÍ A JEJICH ROZ
Tissues: Concept and Classification
3
úvod
85
Část II. Čtyři základní typy
Epitelová tkáň
CÍLE STUDIA
MAX-Yield™ OTÁZKY KE STUDIU
OV
Tissues are aggregates or groups of cells organized to perform one or more specific functions.
At the light microscope level, the cells and extracellular components of the various organs of the body exhibit a recognizable and often distinctive pattern of organization. This organized arrangement reflects the cooperative effort of cells performing a particular function. Therefore, an organized aggregation of cells that function in a collective manner is called a tissue [Fr. tissu, woven; L. texo, to weave].
Although it is frequently said that the cell is the basic functional unit of the body, it is really the tissues, through the col-
variations in general appearance, structural organization, and physiologic properties of the various body organs, the tissues that compose them are classified into four basic types.
Epithelium (epithelial tissue) covers body surfaces, lines body cavities, and forms glands.
Connective tissue underlies or supports the other three basic tissues, both structurally and functionally.
Muscle tissue is made up of contractile cells and is responsible for movement.
Nerve tissue receives, transmits, and integrates information from outside and inside the body to control the activities of the body.
Histologie (z řeckého histos = tkáň, logia = studium) je nauka o stavbě tkání. Tkáně lze definovat jako komplex morfologicky podobných buněk, specialisovaných k výkonu určité funkce. Jsou materiálem pro stavbu orgánů těl mnohobuněčných organismů, metazoí. Za embryonálního vývoje jedince (ontogenese) se tkáně diferencují ze 3 zárodečných listů, ektodermu, entodermu a mesodermu, procesem zvaným histogenese. Na jejím podkladě vznikají čtyři základní typy tkání:
1. Tkáň epitelová – vzniká ze všech tří zárodečných listů. Tvoří ji buňky těsně k sobě přiložené s malým množstvím mezibuněčné hmoty.
2. Tkáň pojivová, podpůrná – pochází z mesenchymu (derivát mesodermu). Vyznačuje se hojnou účastí mezibuněčné základní hmoty, ve které jsou uloženy rozličné typy buněk, plnící řadu funkcí.
3. Tkáň svalová – je původu převážně mesodermového. Tvoří ji buňky nebo syncytium. Její elementy jsou protáhlého tvaru. Jejich cytoplasma je opatřena prvky, které umožňují její kontrakci, a tím i pohyb orientovaný v příslušném směru.
4. Tkáň nervová – pochází z ektodermu. Její nejvýznamnější komponentou jsou nervové buňky – neurony, schopné vytvářet nervový vzruch a předávat jej z buňky na buňku.

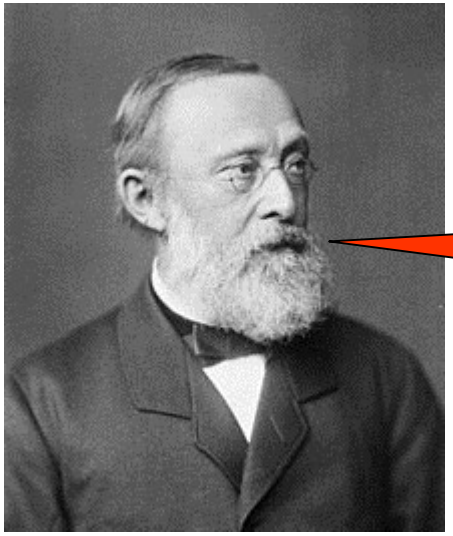
MODERN CELL TEHORY

Matthias Jacob Schleiden

- Cells are the **basic units** of any organism
- New cells **origin** only **from other** cells
-
- Cells **exchange energy** (open thermodynamic system)
-
- Genetic **information** is **inherited** in new generations
- Chemical and structural composition of cells is generally **identical**

Theodor Schwann

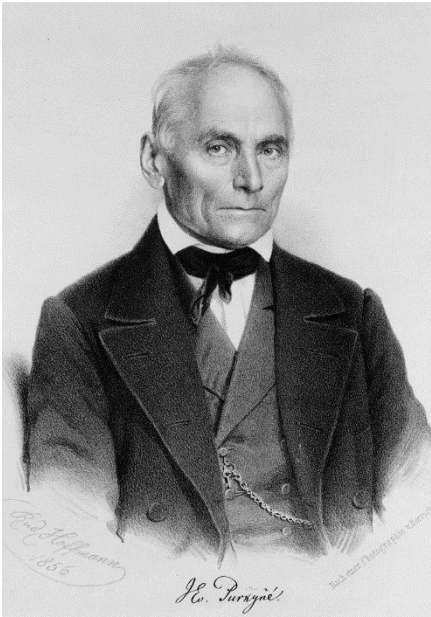
Rudolf Wirchow



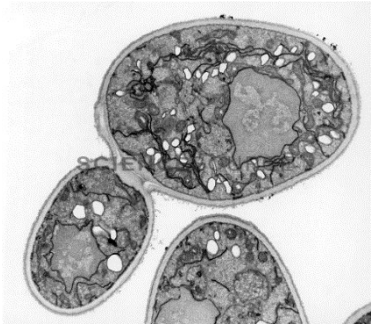
Omnis cellula e cellula!

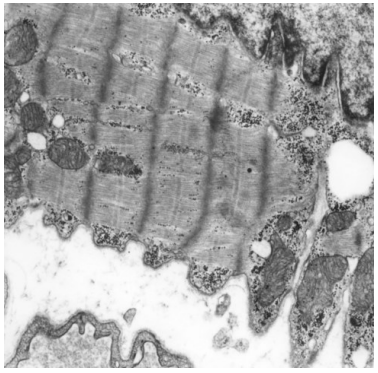
Robert Remak

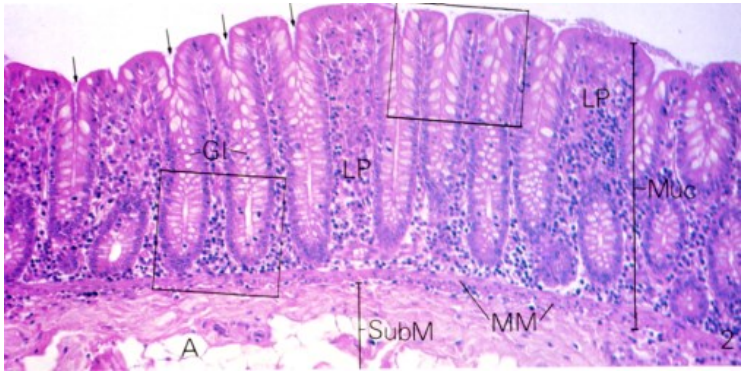
J.E.P.

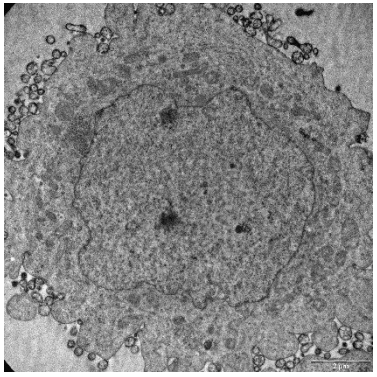


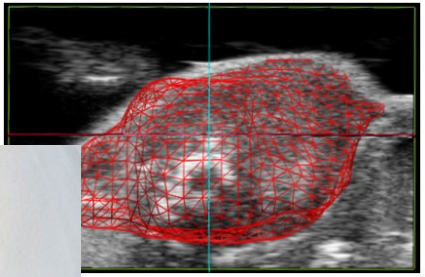
CELL AND TISSUE VARIABILITY IN A MULTICELLUALR BODY

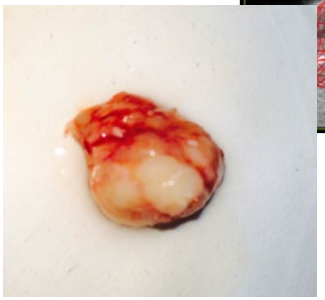


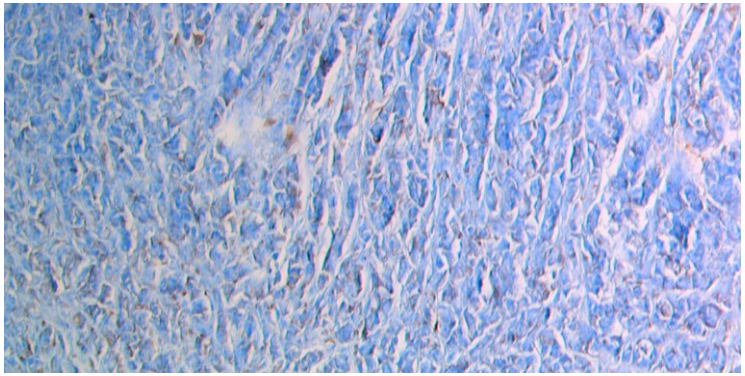








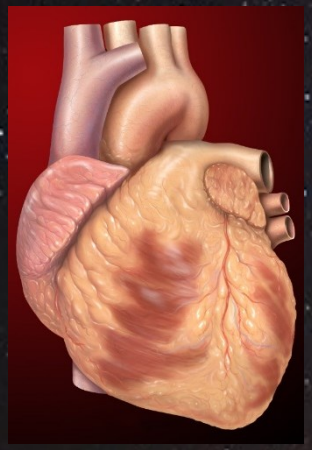


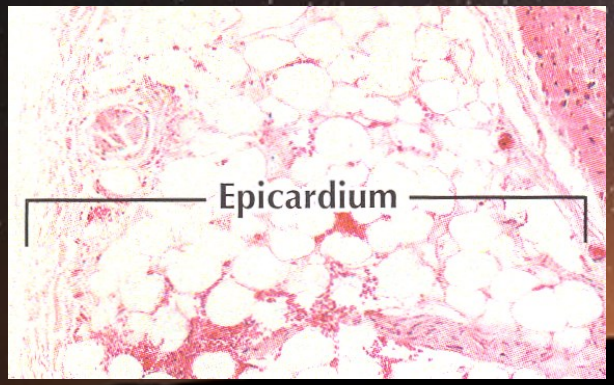


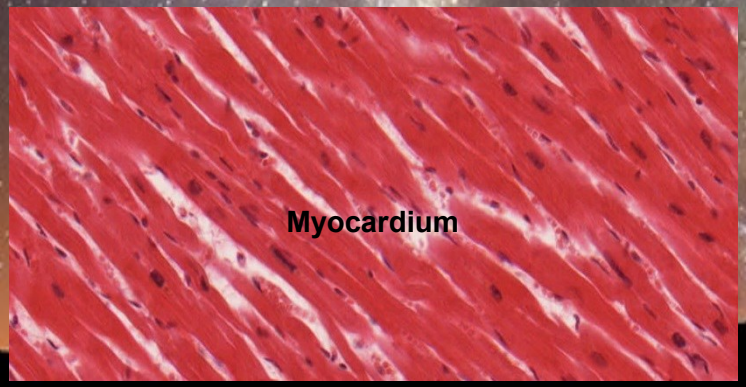
TISSUES AND ORGANS

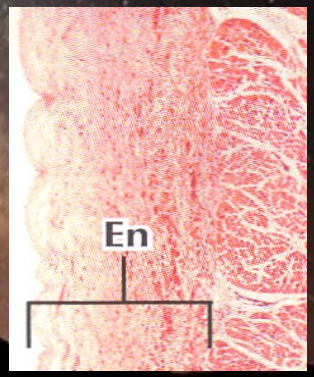
- **6 × 10^{13} CELLS** of **200** different types
- **cells form functional, three-dimensional, organized aggregations of morphologically similar cells and their products or derivatives - TISSUES**
-- **tissues constitutes ORGANS and organ systems**

25-40×10^9



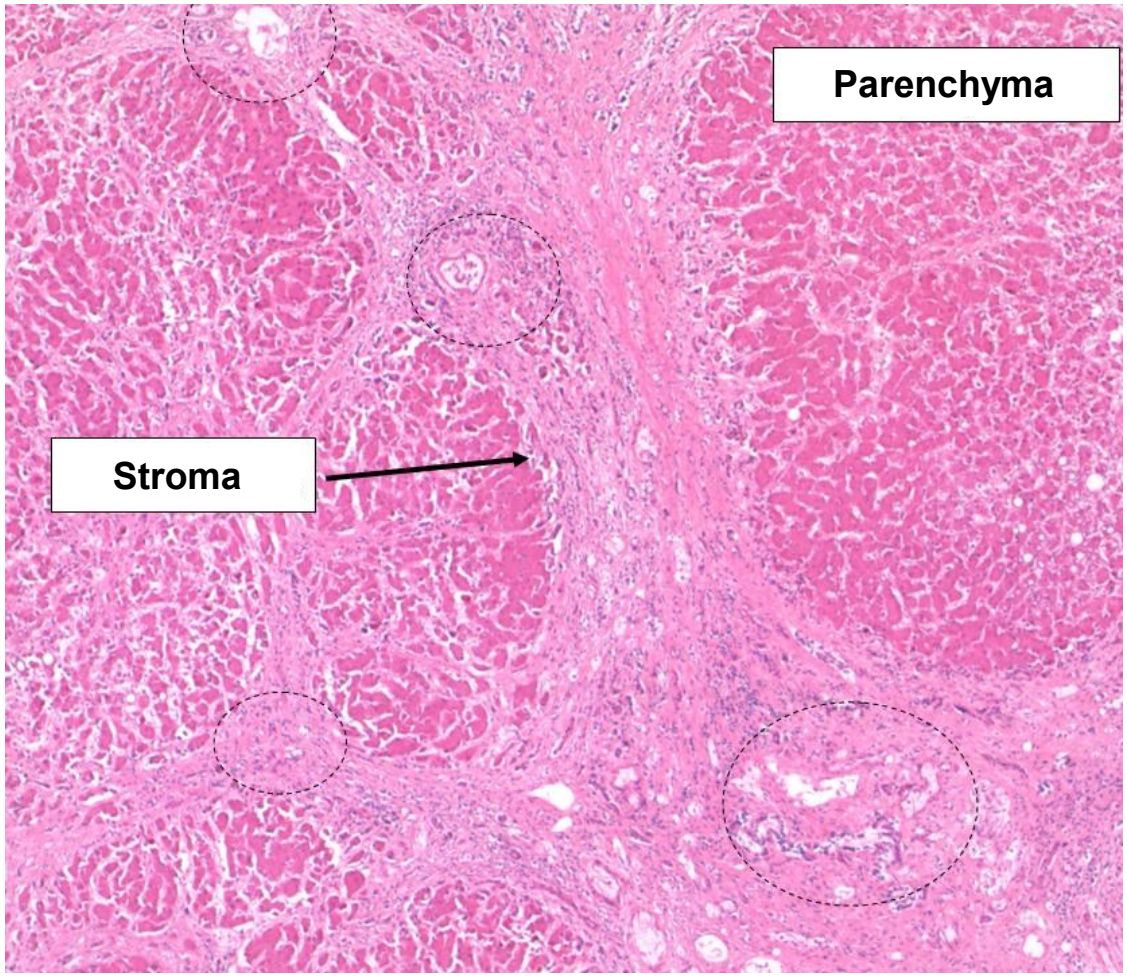






Parenchyma: functional component of a tissue (liver, lung, pancreatic, kidney parenchyma)

Stroma: surrounding, supportive tissue



LIVER

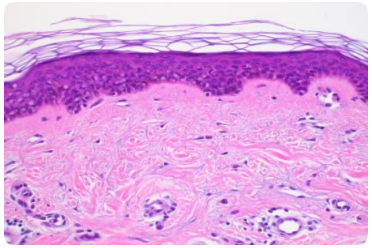
Parenchyma:
- Hepatocytes
- Sinusoids and adjacent structures

Stroma:
- Connective tissue and adjacent structures
- Vessels
- Nerves
- Bile ducts

CONTEMPORARY TISSUE CLASSIFICATION

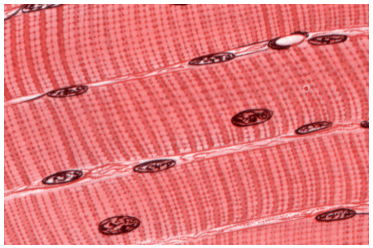
Based on **morphology** and **function**:

Epithelium



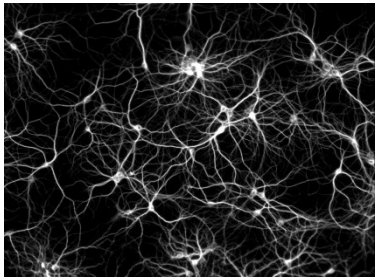
Continual, avascular layers of cells with different function, oriented to open space, with specific junctions and minimum of ECM and intercellular space.
Derivates of all three germ layers

Muscle



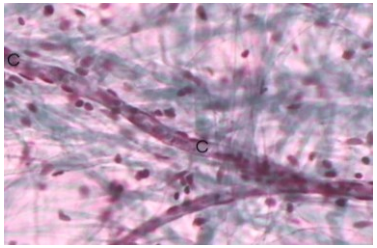
Myofibrils → contraction
Mesoderm – skeletal muscle, myocard, mesenchyme – smooth muscles
Rarely ectoderm (eg. m. sphincter a m. dilatator pupillae)

Nerve



Neurons and neuroglia
Reception and transmission of electric signals
Ectoderm, rarely mesoderm (microglia)

Connective

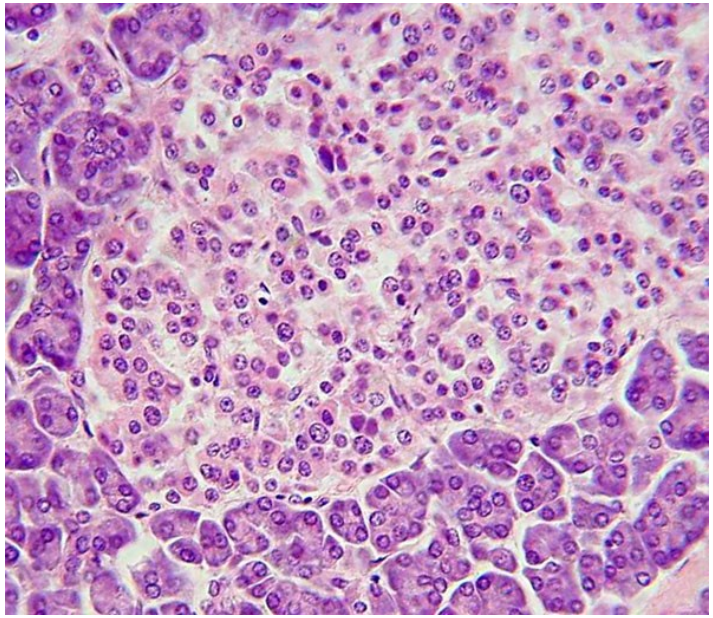


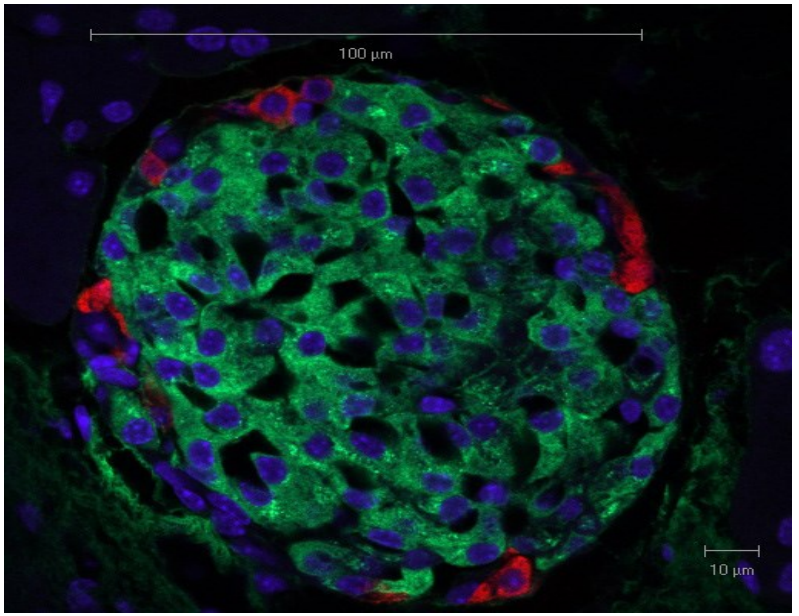
Dominant extracellular matrix
Connective tissue, cartilage, bone…
Mesenchyme

TISSUE DEFINITION

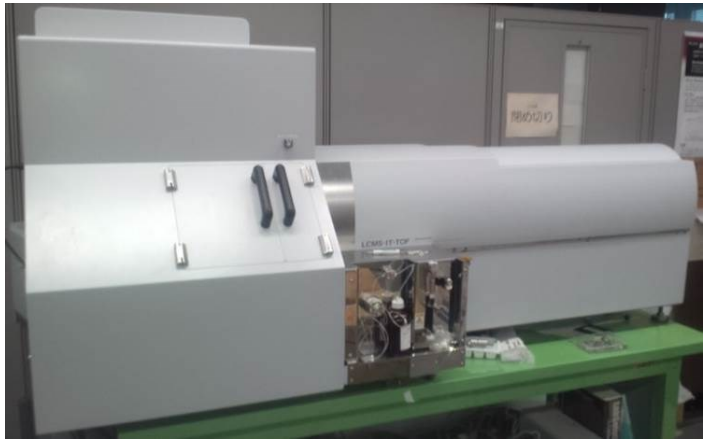
Functional, three-dimensional, organized aggregation of morphologically similar cells, their products and derivatives

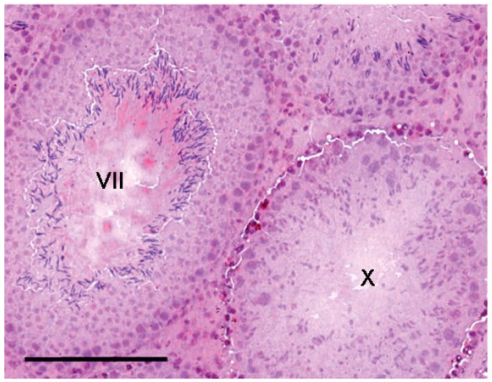
- classical histological definition is based on microscopic visualization

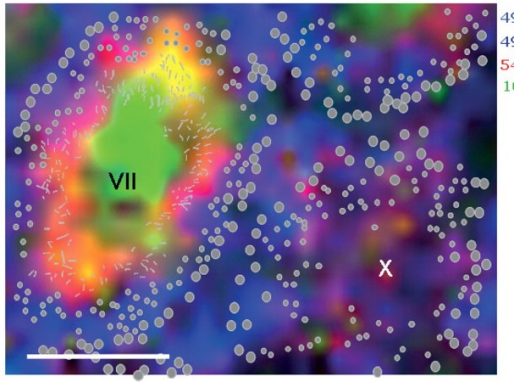


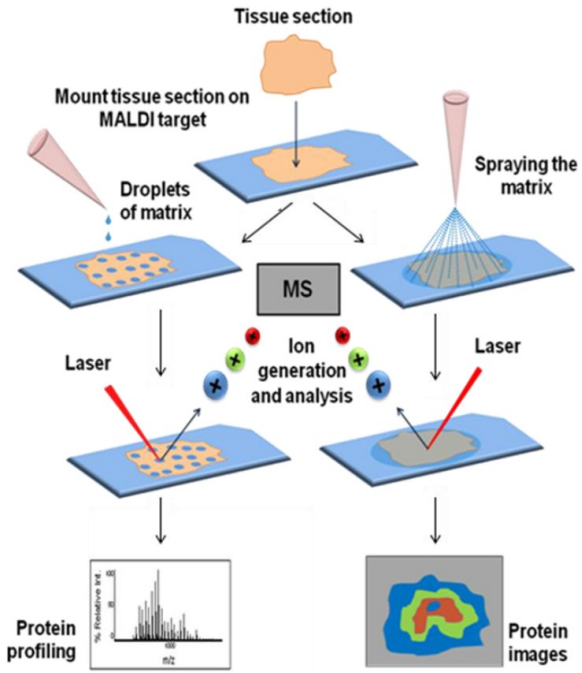


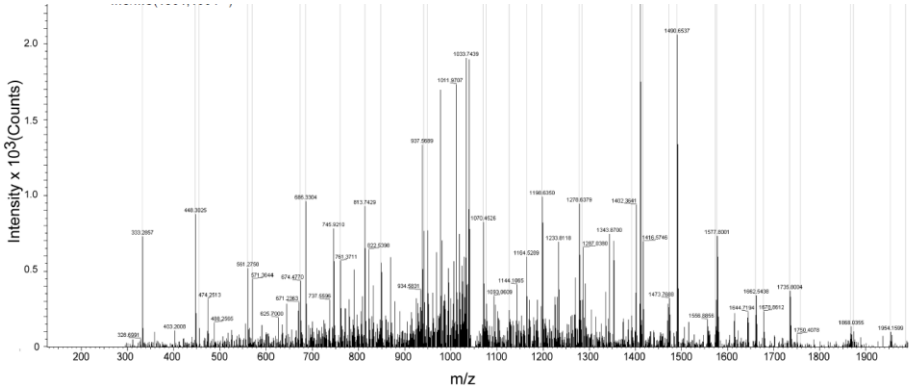
HISTOLOGY IS NOT ONLY ABOUT MICROSCOPY





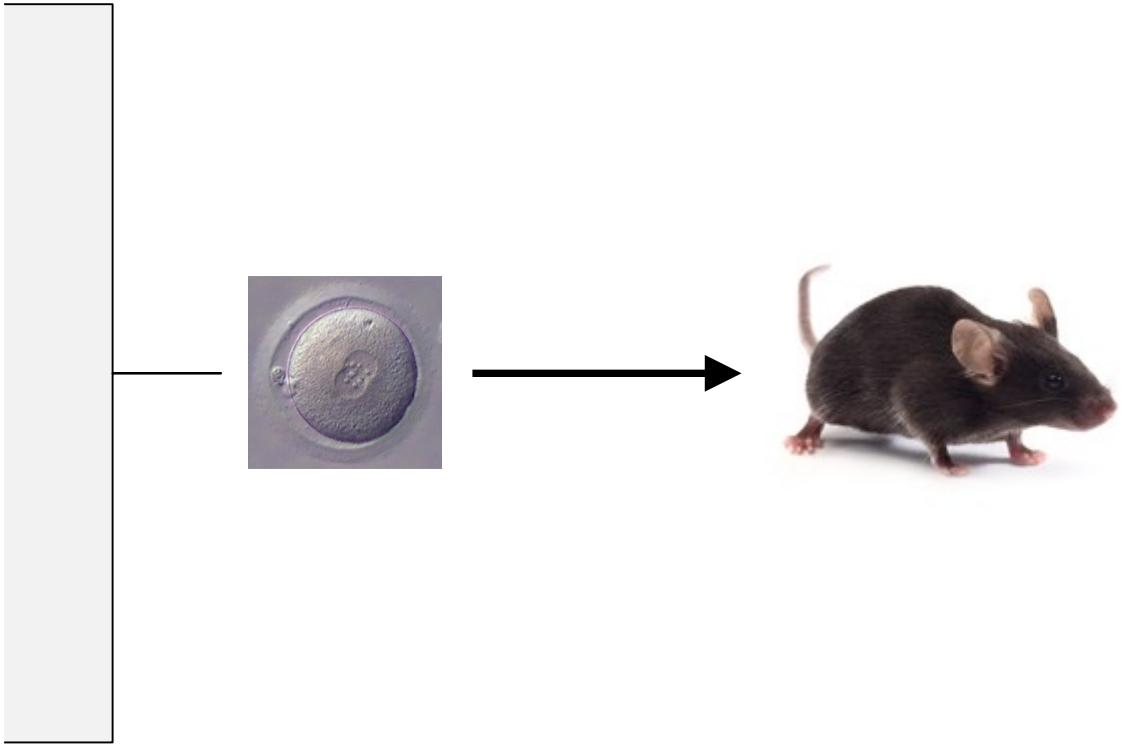






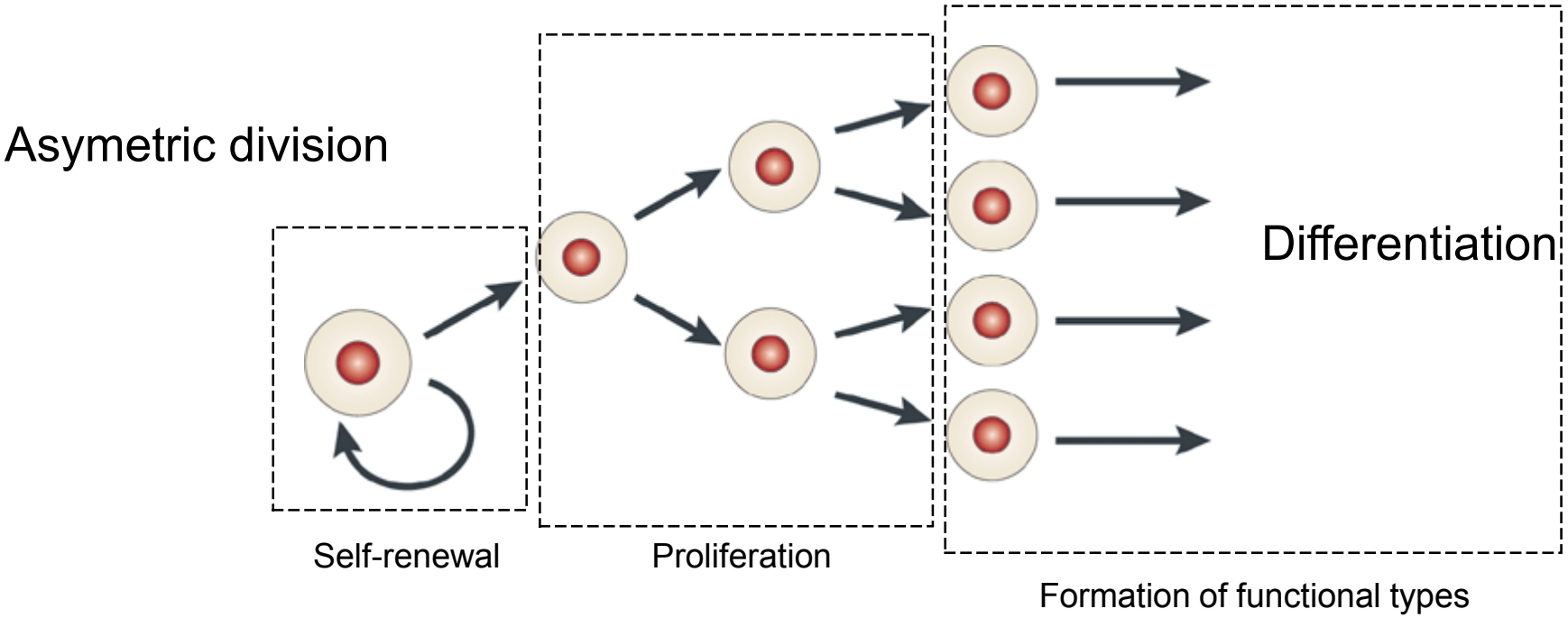
BASIC PRINCIPLES OF HISTOGENESIS

- Proliferation
- Diferentation
- Migration
- Apoptosis
- Tissue patterns



FUNCTIONAL CELL TYPES DIFFERENTIATE FROM STEM CELLS

Stem cells are capable of differentiation and self-renewal



Knoblich JA. Asymmetric cell division during animal development. 2001. Nat Rev Mol Cell Biol

STEM CELLS

Totipotent

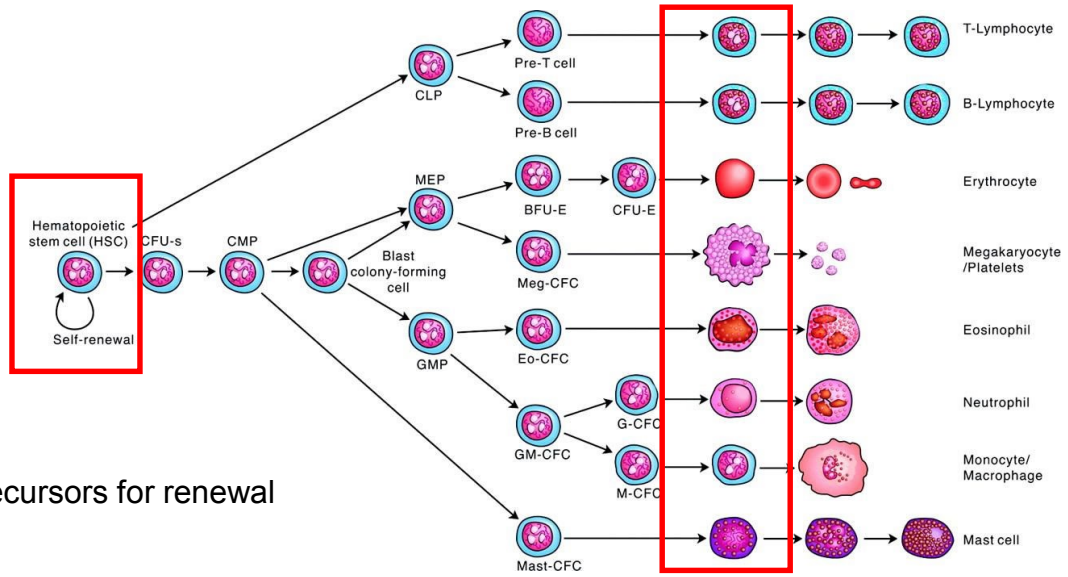
- Constitute all cells of the body incl. extraembryonic tissues
- Zygote and early stages

Pluripotent

- All cells in the body except for trophoblast
- Blastocyst – Inner cell mass - ICM (embryoblast)
- Embryonic stem cells

Multipotent

- Give rise to various cell types of a particular tissue
- Mesenchymal SC, hematopoietic SC

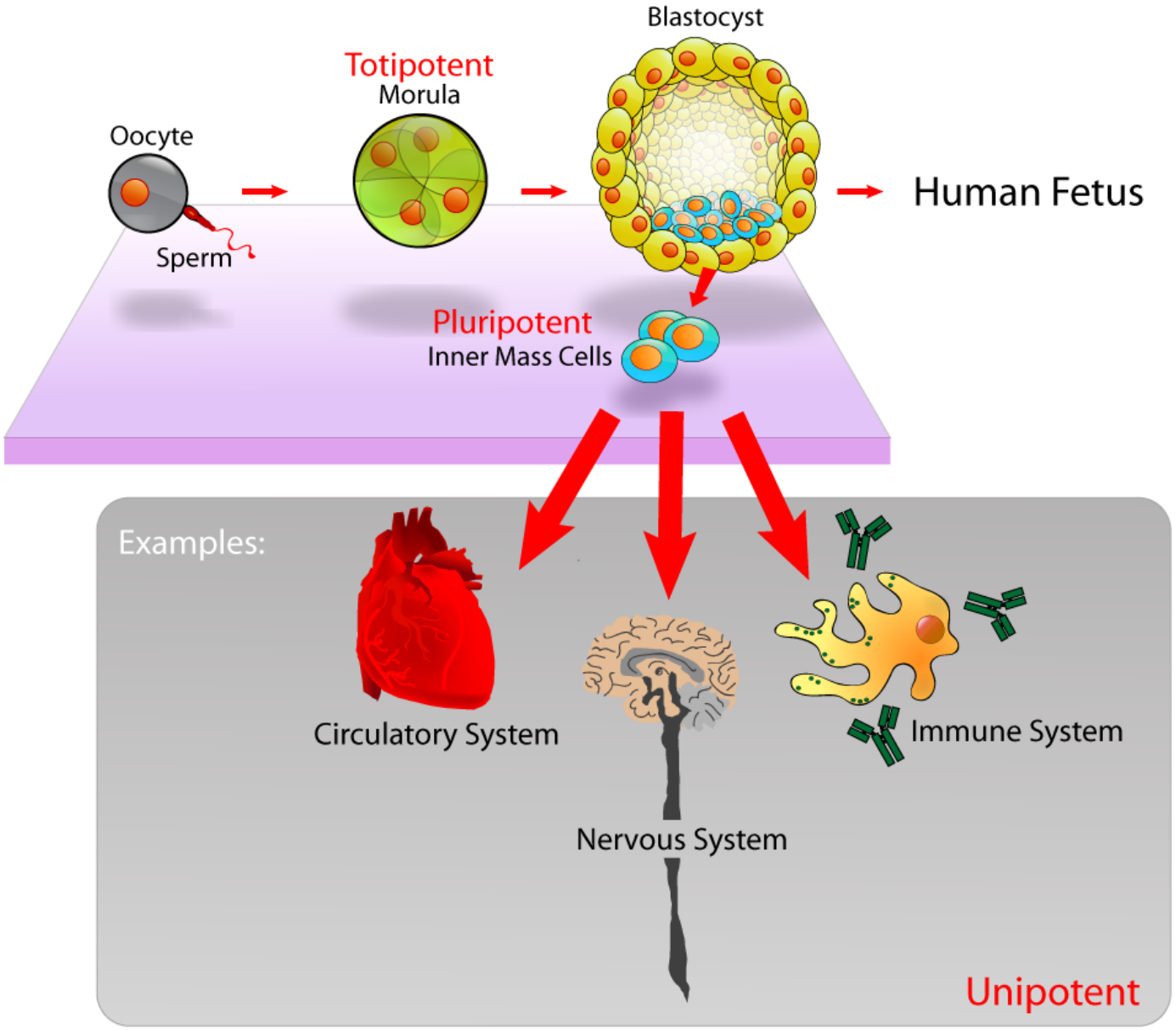


Oligo- a unipotent

- One or several cell types – hematopoietic, tissue precursors for renewal of intestinal epithelia, etc.

http://www.embryology.ch/anglais/evorimplantation/furchung01.html

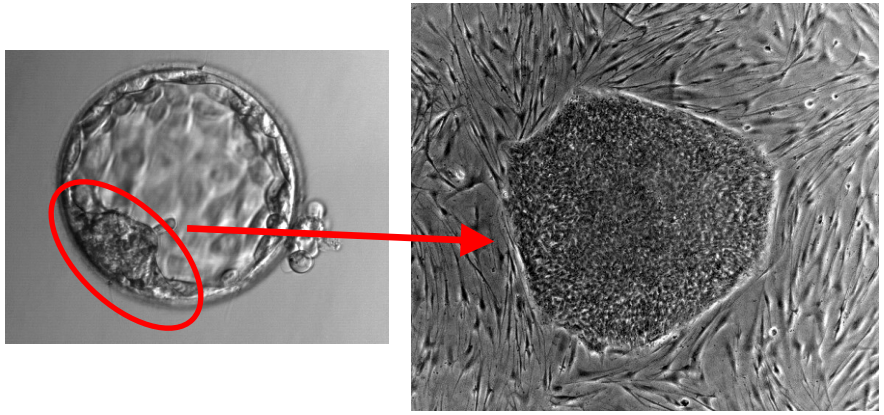
STEM CELLS


Blastocyst
Totipotent
Morula
Oocyte
Sperm
Human Fetus
Pluripotent
Inner Mass Cells
Examples:
Circulatory System
Nervous System
Immune System
Unipotent

STEM CELLS IN HUMAN BODY

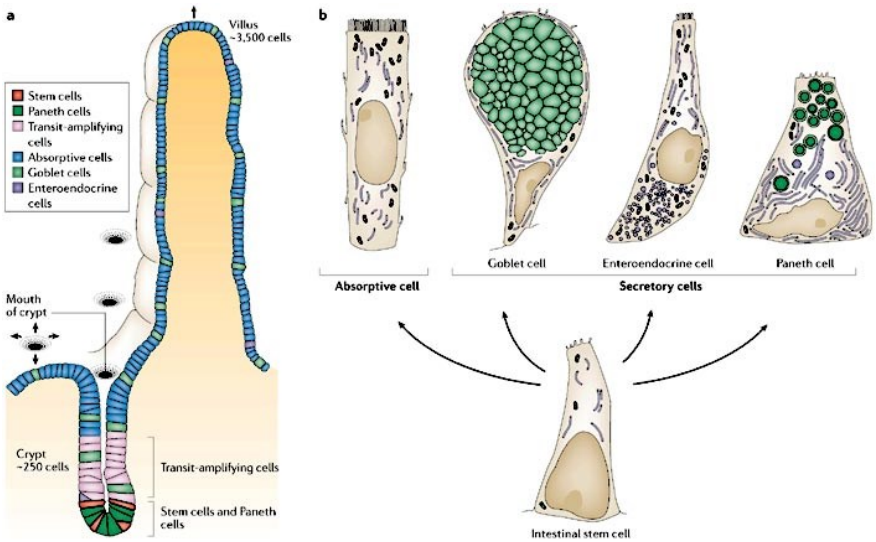
Embryonic stem cells (ESCs)

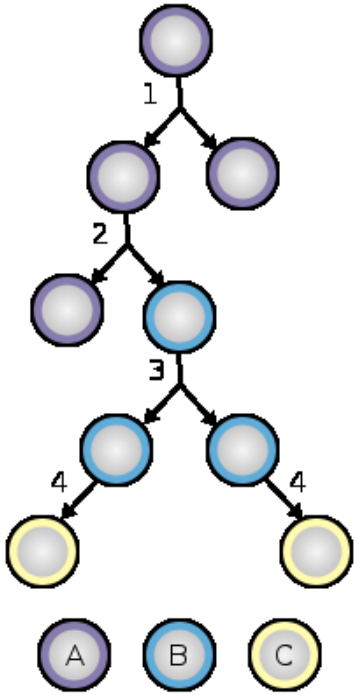
- embryoblast of blastocyst
- pluripotent
- modelling of early embryogenesis, regenerative medicine



Tissue (adult) stem cells

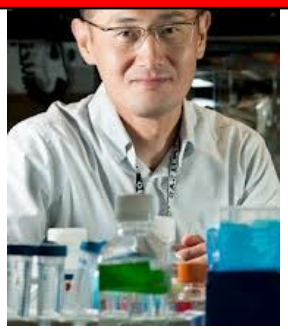
- regeneration and renewal of tissues
- GIT, CNS, mesenchyme
- regenerative medicine, cancer biology





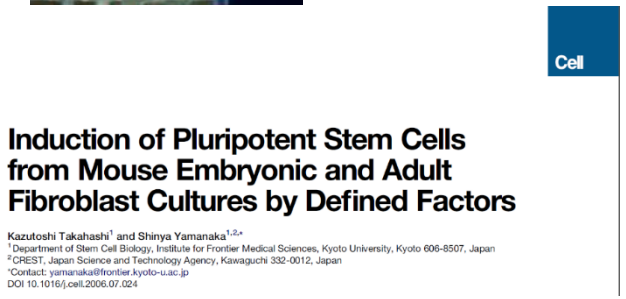
STEM CELLS AS RESEARCH TOOLS

Induced pluripotent stem cells (iPSc)



Nobel prize 2012

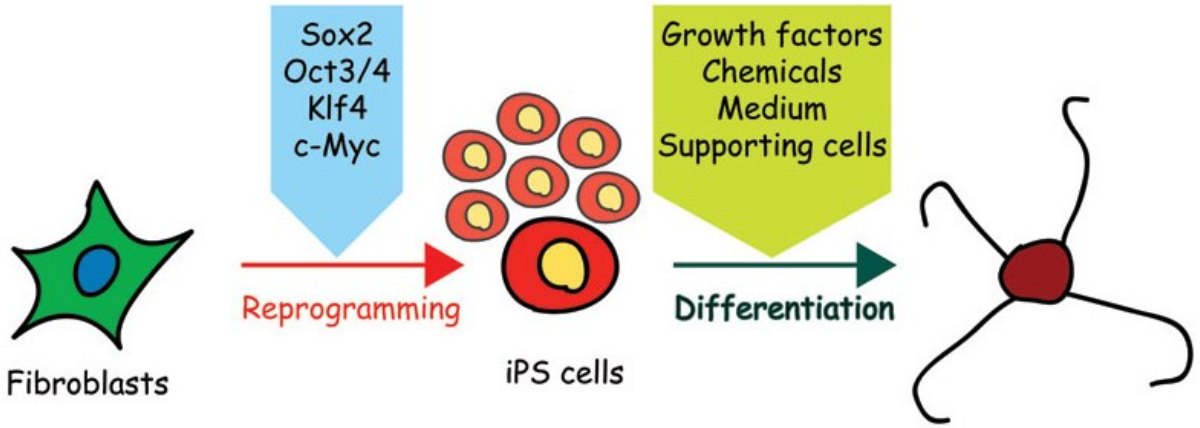
- adult differentiated cell (fibroblast) is reprogrammed into pluripotent state
- differentiation into desired cell type
- regenerative medicine, cell and gene therapy



Cell

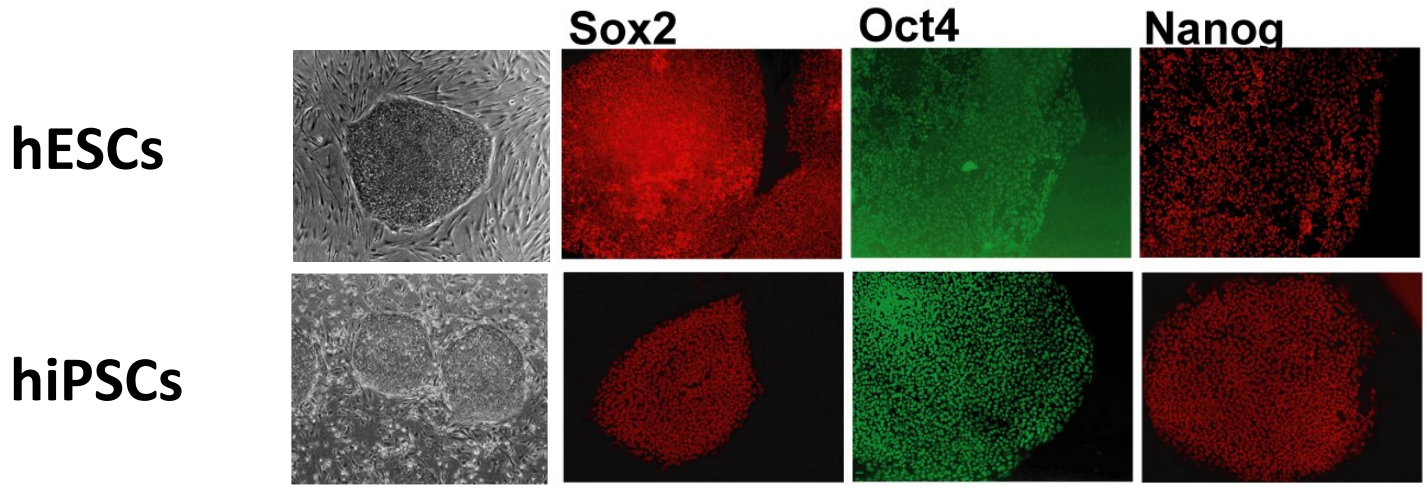
Induction of Pluripotent Stem Cells from Mouse Embryonic and Adult Fibroblast Cultures by Defined Factors

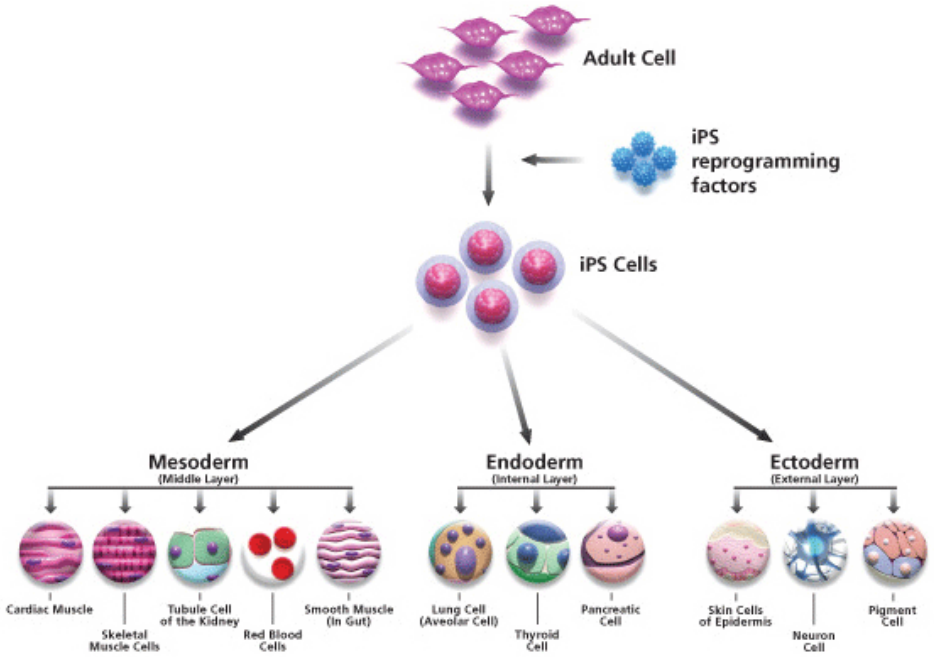
Kazutoshi Takahashi[1] and Shinya Yamanaka[1,2,*]
[1]Department of Stem Cell Biology, Institute for Frontier Medical Sciences, Kyoto University, Kyoto 606-8507, Japan
[2]CREST, Japan Science and Technology Agency, Kawaguchi 332-0012, Japan
*Contact: yamanaka@frontier.kyoto-u.ac.jp
DOI 10.1016/j.cell.2006.07.024



Disease modelling
Drug testing
Tissue replacement
…

iPSCs SHARE FUNDAMENTAL PROPERTIES WITH hESCs



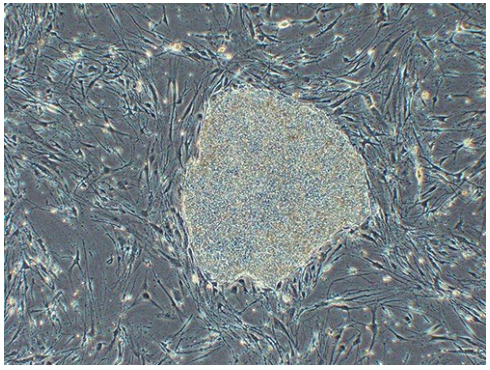


STEM CELLS AS THERAPY

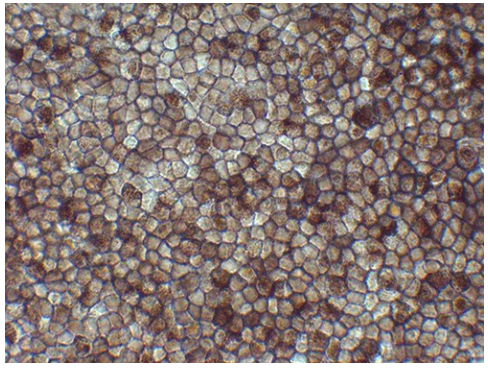
Age-related macular degeneration

neovascularisation

hiPSCs

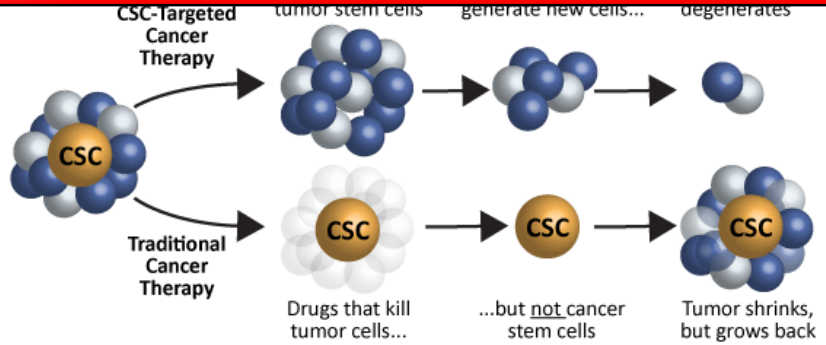


Retinal pigment epithelium



Clinical trial

STEM CELLS AS FOES



Cancer stem cells

- solid tumor is always heterogeneous

- small population of cells with stem cell character can repopulate tumor tissue after cytotoxic therapy

Tissue stem cells

Renewal

Quiescence

Multipotency

Low frequency (<1%)

Long life

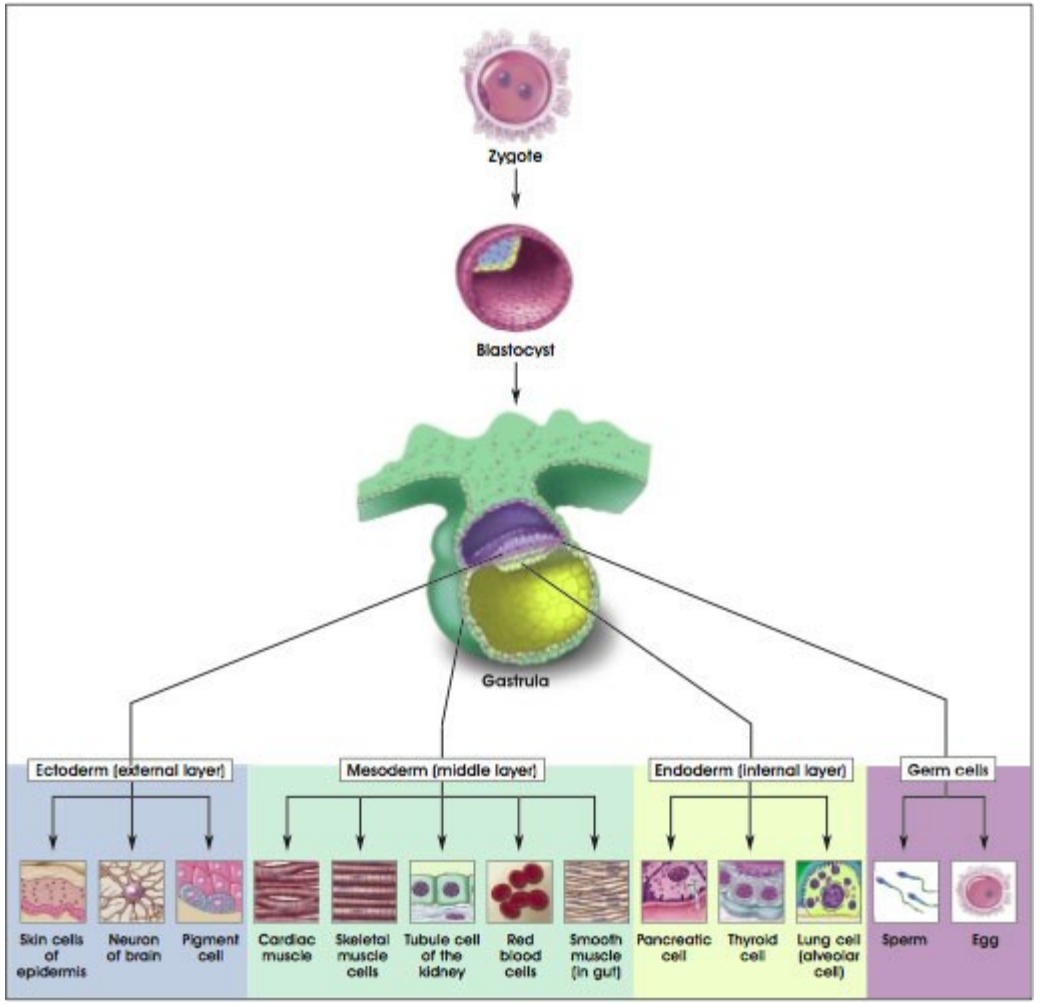
Resistence

Tumorigenicity

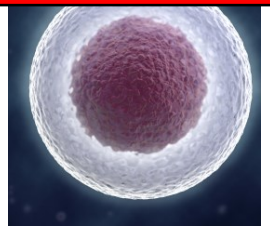
Proliferation capacity

Cancer stem cells

WHY ARE TISSUES DIFFERENT?



CELL DIFFERENTIATION



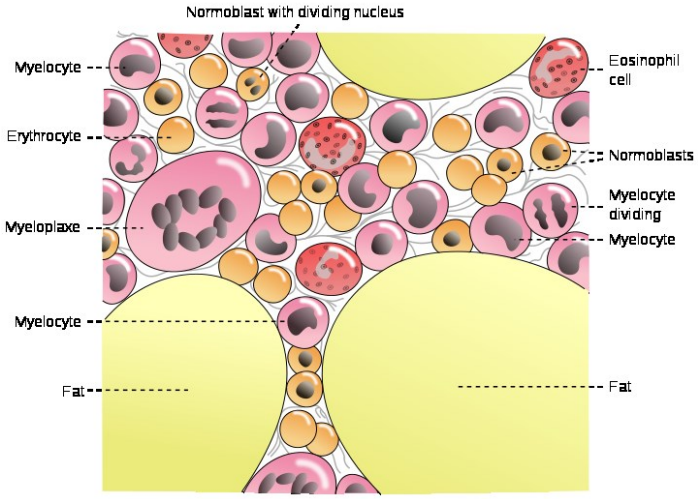
- **Induction of differentiation**

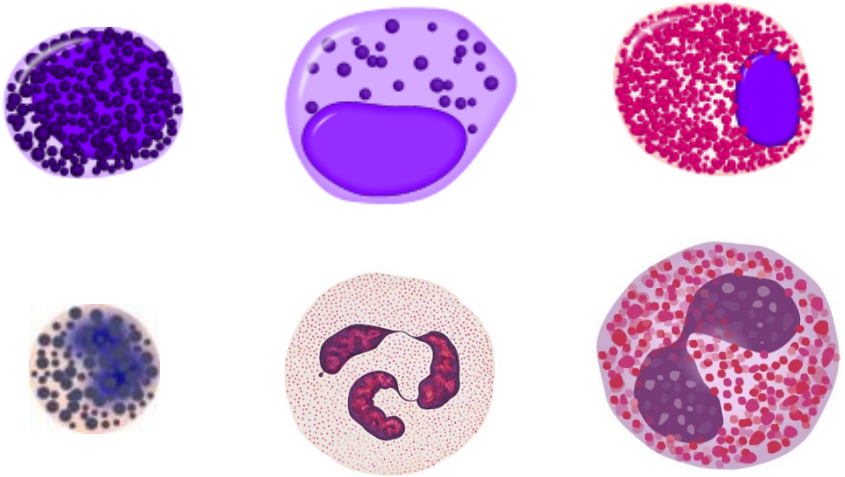
-blast

- **Determination and commitment**

eg. myeloblast

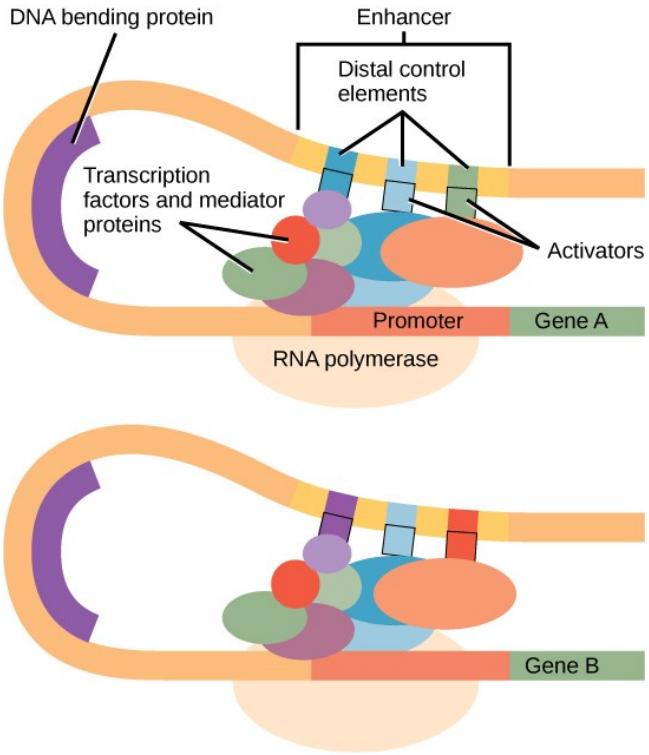
- **Terminal differentiation**

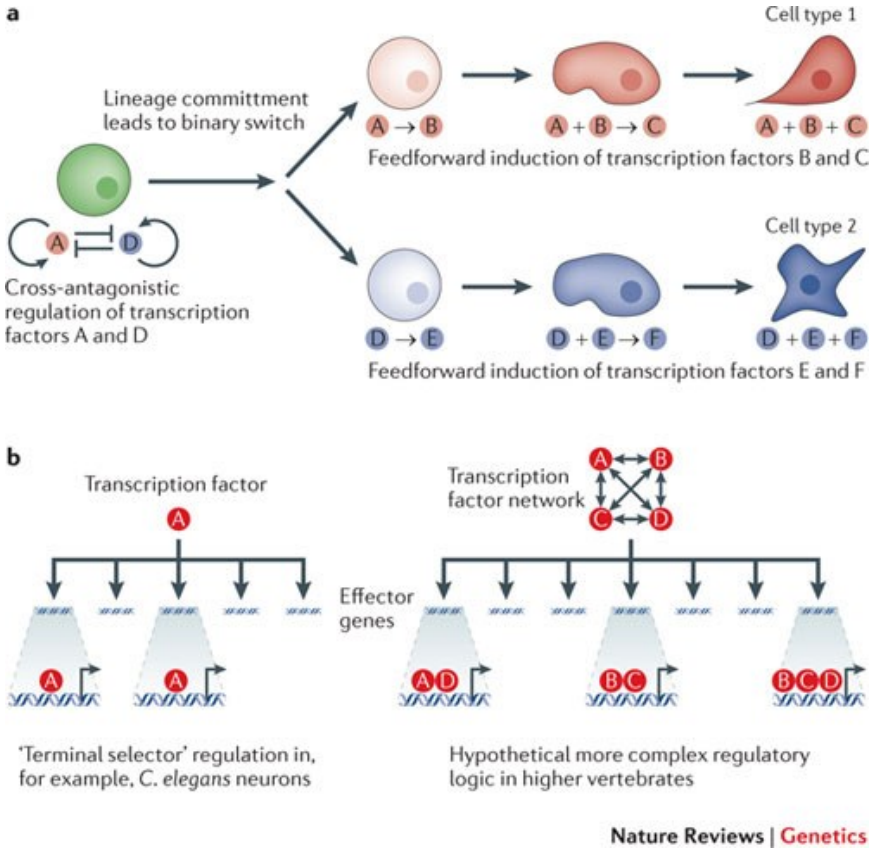


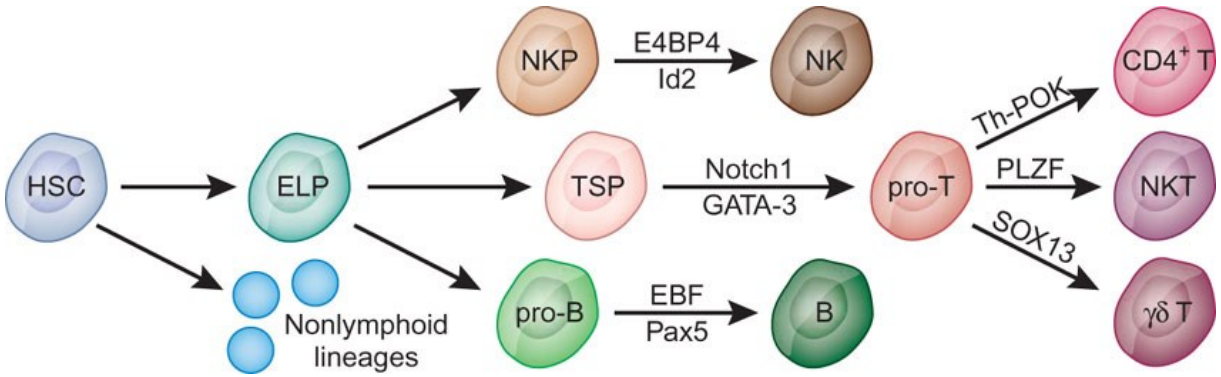


-cyte *granulocyte*

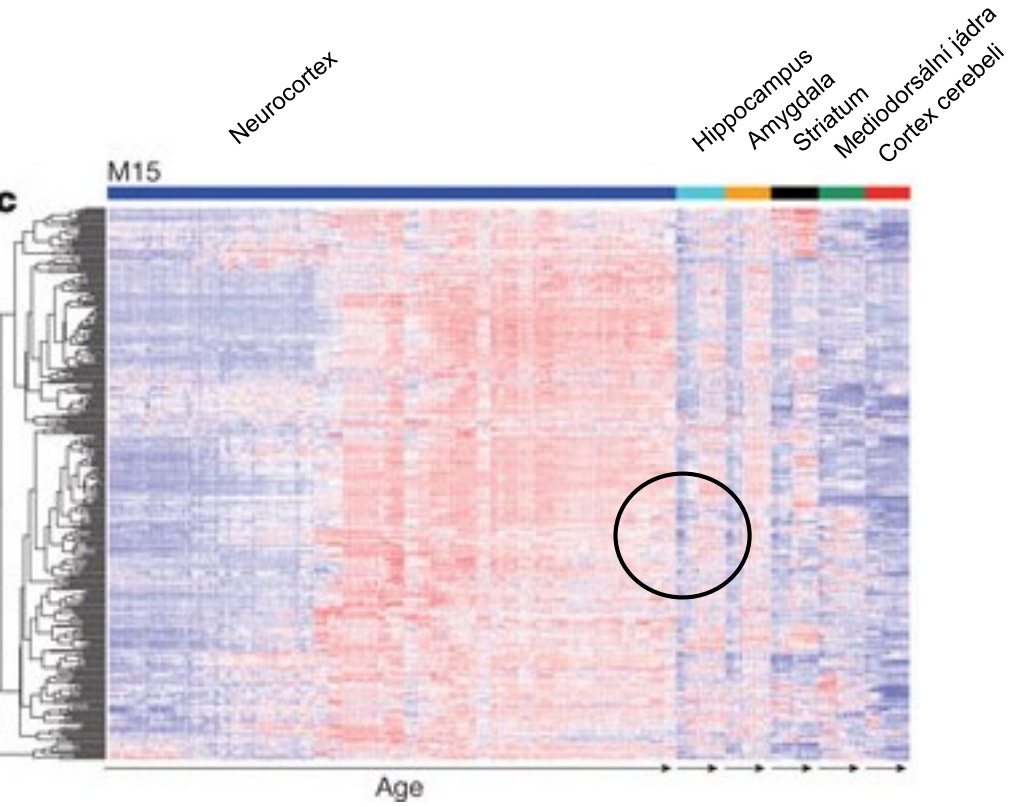
DIFFERENTIATION IS DRIVEN BY GENE TRANSCRIPTION

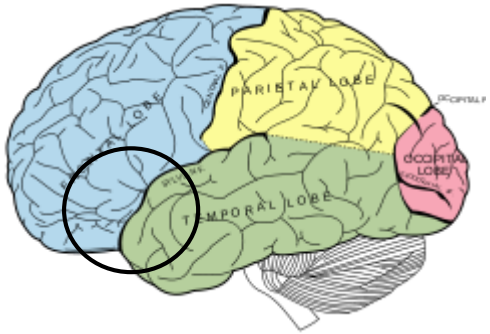


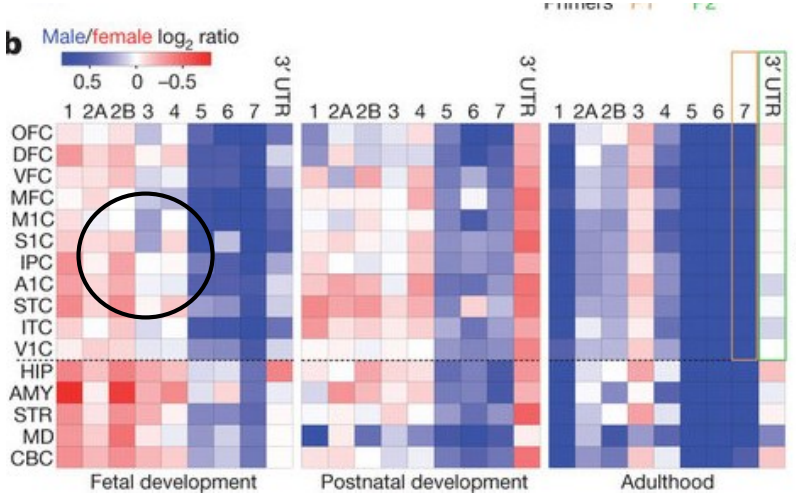




TISSUE DIFFER IN THEIR GENETIC AND EPIGENETIC PROFILES





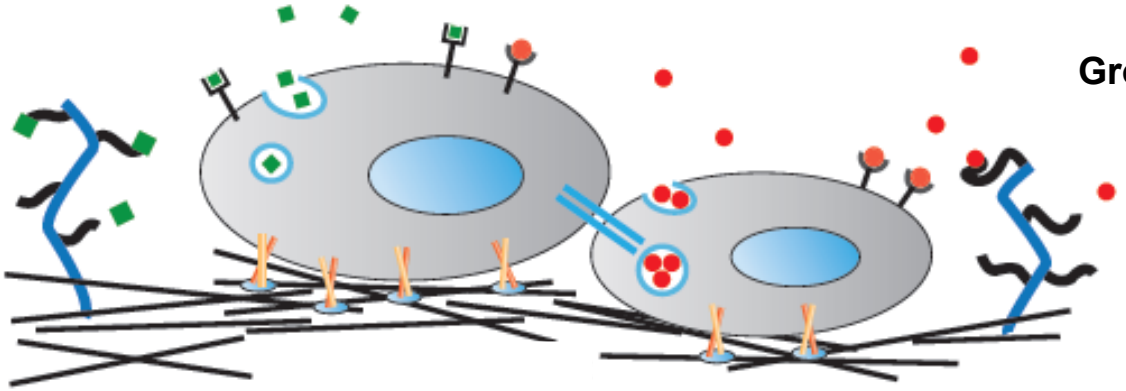


doi:10.1038/nature10523

CELLS CAN CREATE UNIQUE MICROENVIRONMENT

Metabolites

Cell interactions

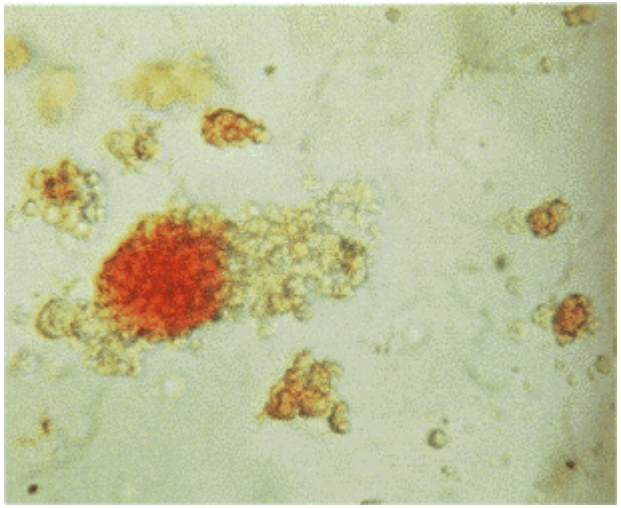


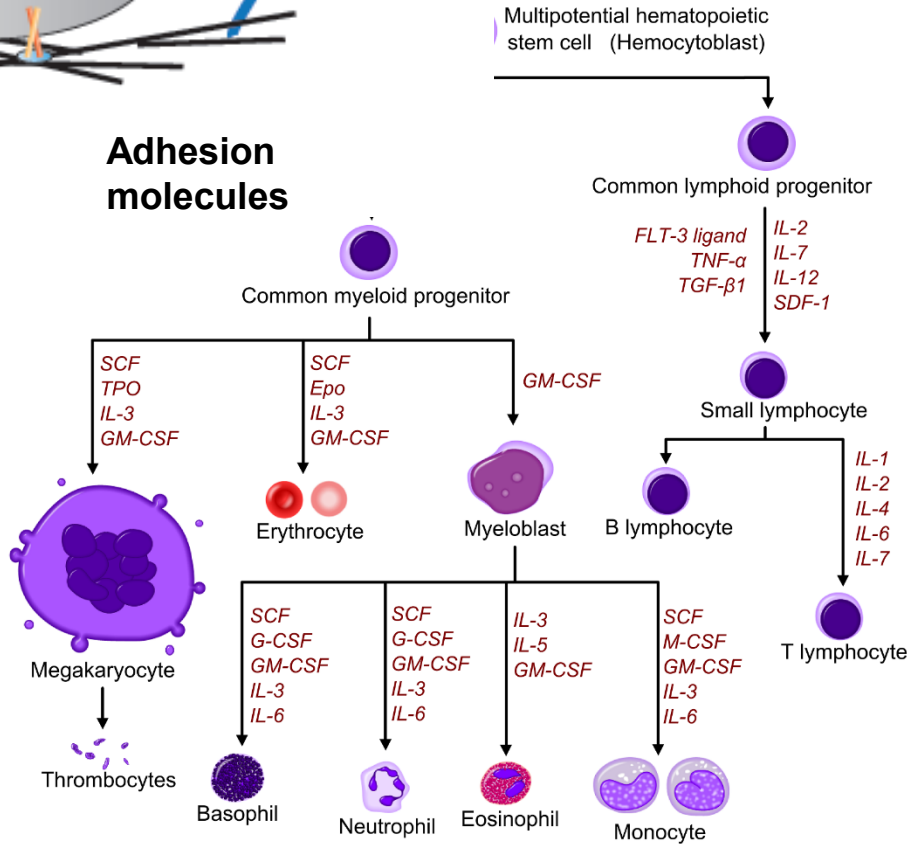
Growth factors

Immunity
Inflammation

ECM components

Adhesion molecules





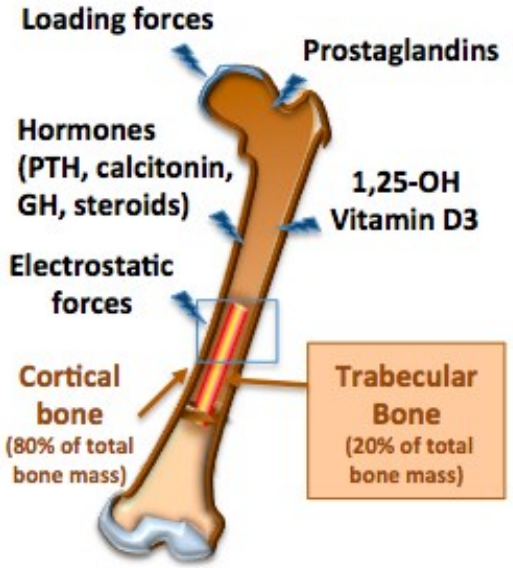
MICROENVIRONMENT REGULATES TISSUE FUNCTION

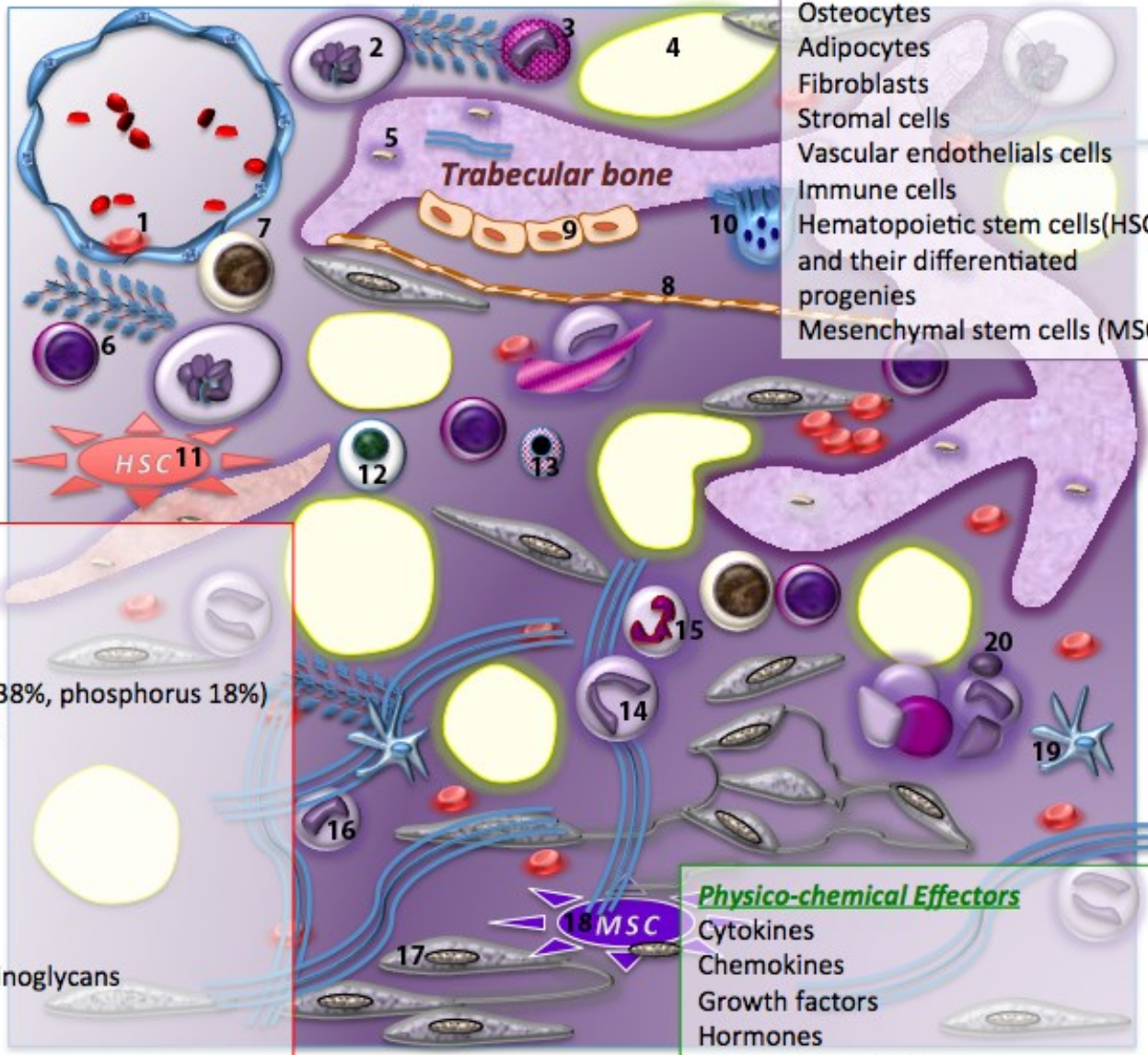
Huge number of **biological** and **physically-chemical** parameters

Stem cell niche

- Embryonic development
- Intercellular interaction
- Space organization (dimensionality)
- Gradient of morphogenes
- Epigenetic profile
- Gene expression dynamics
- Partial pressure of gases
- ECM composition
- Mechanical stimulation
- Perfusion and interstitial flows
- Local immunity response
- Metabolites

STEM CELL NICHE





Osteoclasts
Osteocytes
Adipocytes
Fibroblasts
Stromal cells
Vascular endothelials cells
Immune cells
Hematopoietic stem cells(HSC) and their differentiated progenies
Mesenchymal stem cells (MSC)

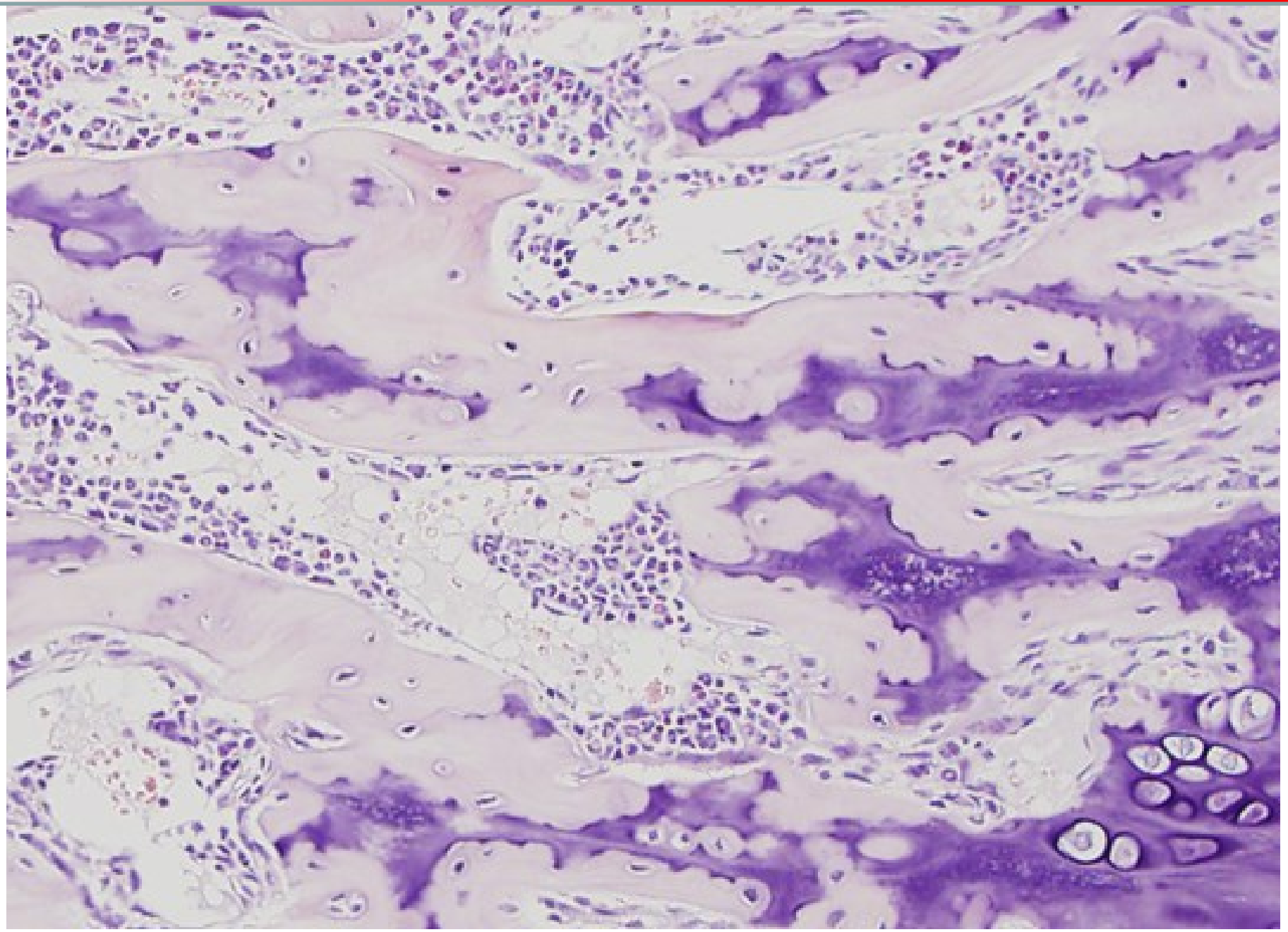
ECM components

Fibronectin
Laminin
Collagens
Apatite crystals (calcium 38%, phosphorus 18%)
Bone promoting proteins
Bone sialoproteins
Osteonectin
Osteoprotegerin
Osteocalcin
Integrins
Alcaline Phosphatase
Proteoglycans, Glycosaminoglycans
Osteopontin
MMPs & TIMPs
Receptors
Adhesion molecules

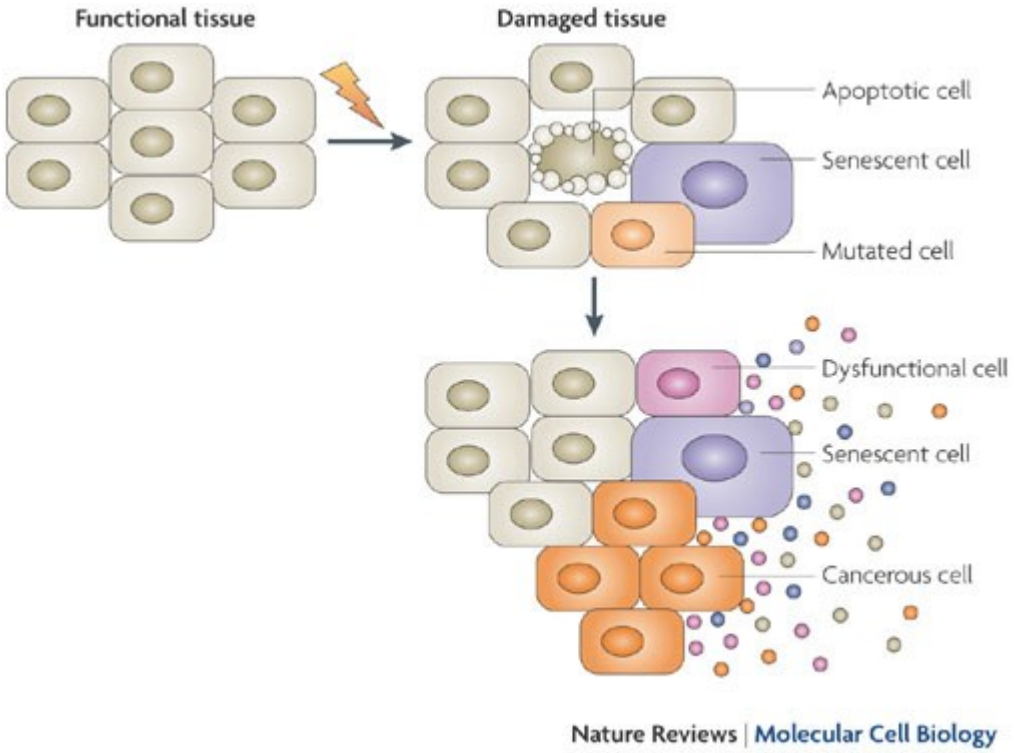
Physico-chemical Effectors

Cytokines
Chemokines
Growth factors
Hormones
Physico-mechanical forces
Biochemical regulators (pH, oxygen concentration, nutrients…)

HEMATOPOIETIC NICHE



MICROENVIRONMENT IS NECESSARY FOR TISSUE HOMEOSTASIS



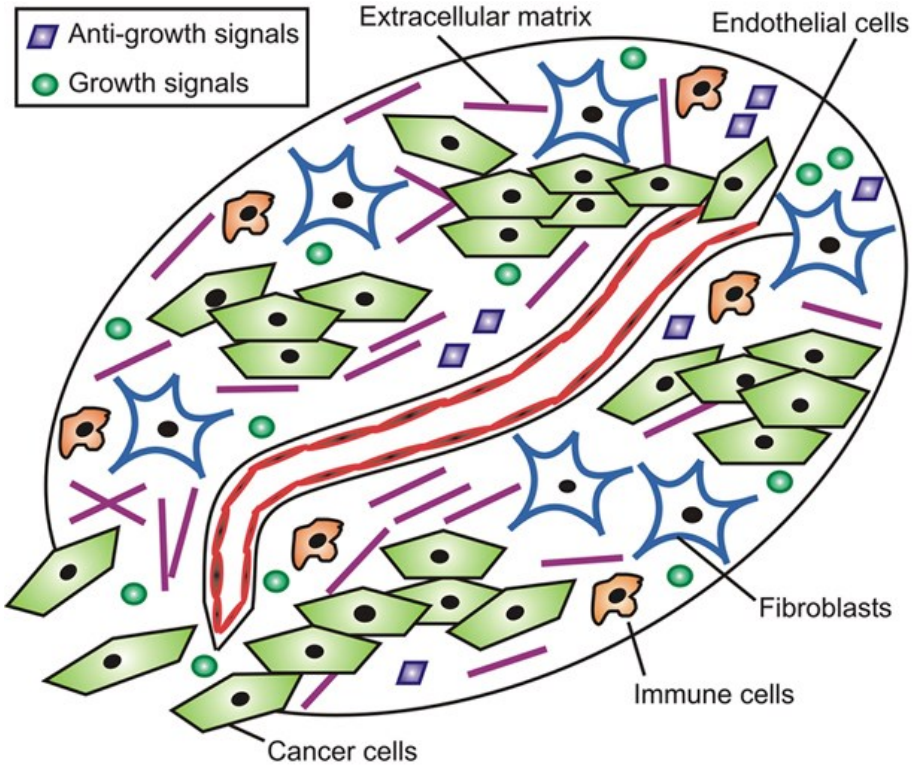
Apoptosis

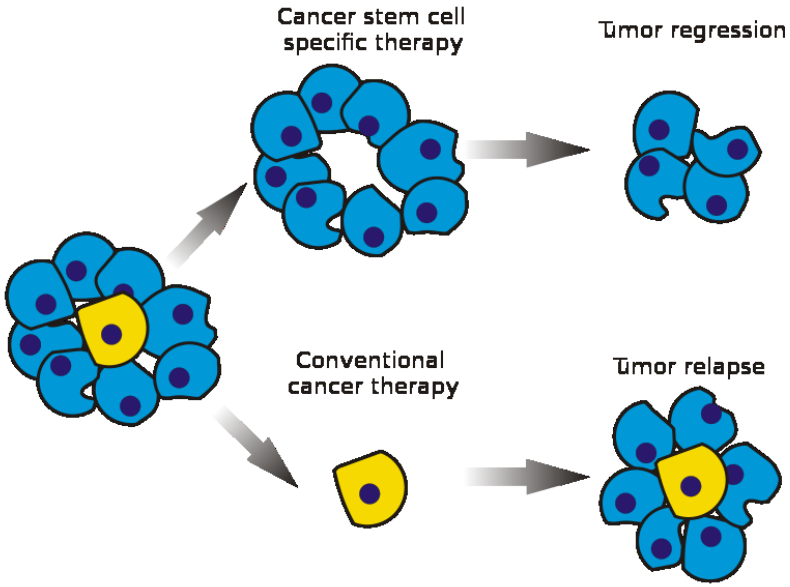
Regeneration

Senescence

Transformation

MICROENVIRONMENT IS OF CLINICAL IMPORTANCE





Angiogenesis

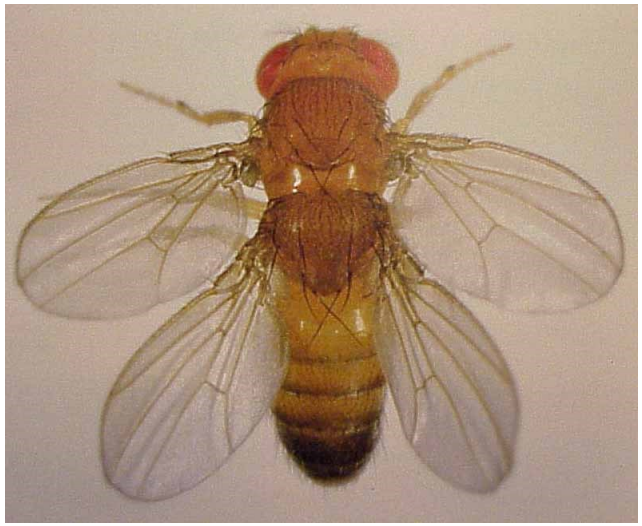
Inflammation

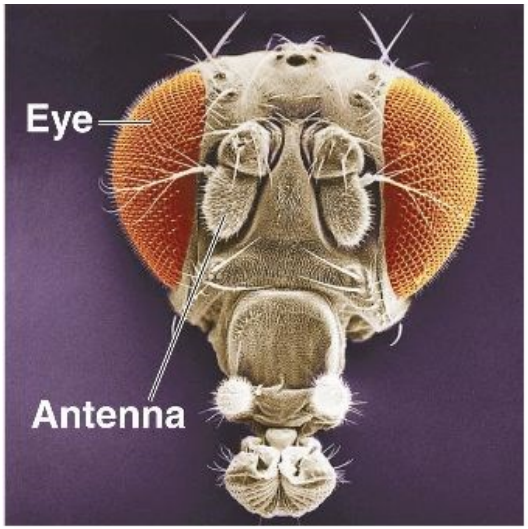
Invasion and metastasis

Self-sufficiency in growth signals

Insensitivity to anti-growth signals

MOLECULAR PRINCIPLES OF HISTOGENESIS

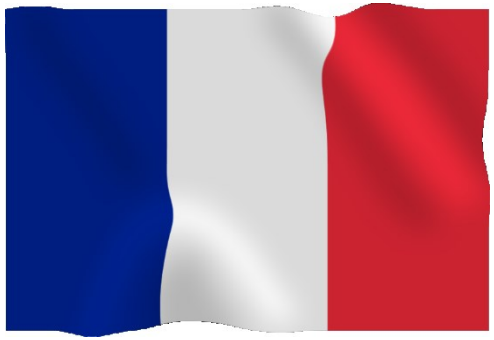




Wild type

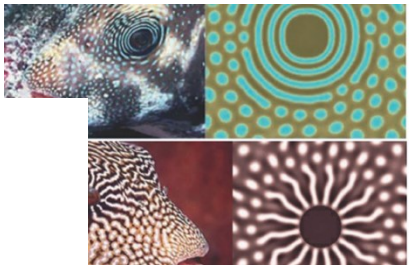
Mutant

LEWIS WOLPERT AND FRENCH FLAG MODEL



WHY DO TIGERS HAVE STRIPES?

Reakčně-difúzní systém

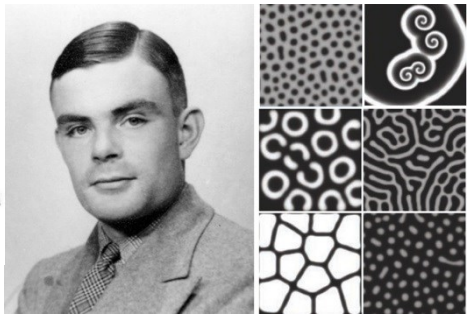


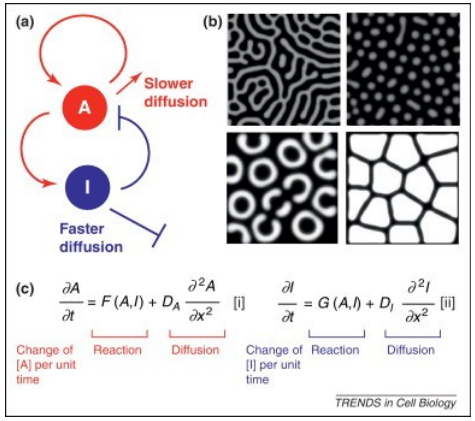
$$\frac{\partial u}{\partial t} = F(u,v) - d_u v + D_u \Delta u$$

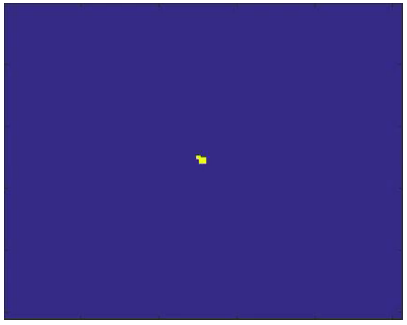
$$\frac{\partial v}{\partial t} = G(u,v) - d_v v + D_v \Delta v$$

Rate of concentration change | Production | Degradation | Diffusion

Reaction







THE CHEMICAL BASIS OF MORPHOGENESIS

By A. M. TURING, F.R.S. *University of Manchester*

(*Received* 9 *November* 1951—*Revised* 15 *March* 1952)

It is suggested that a system of chemical substances, called morphogens, reacting together and diffusing through a tissue, is adequate to account for the main phenomena of morphogenesis. Such a system, although it may originally be quite homogeneous, may later develop a pattern or structure due to an instability of the homogeneous equilibrium, which is triggered off by random disturbances. Such reaction-diffusion systems are considered in some detail in the case of an isolated ring of cells, a mathematically convenient, though biologically unusual system. The investigation is chiefly concerned with the onset of instability. It is found that there are six essentially different forms which this may take. In the most interesting form stationary waves appear on the ring. It is suggested that this might account, for instance, for the tentacle patterns on *Hydra* and for whorled leaves. A system of reactions and diffusion on a sphere is also considered. Such a system appears to account for gastrulation. Another reaction system in two dimensions gives rise to patterns reminiscent of dappling. It is also suggested that stationary waves in two dimensions could account for the phenomena of phyllotaxis.

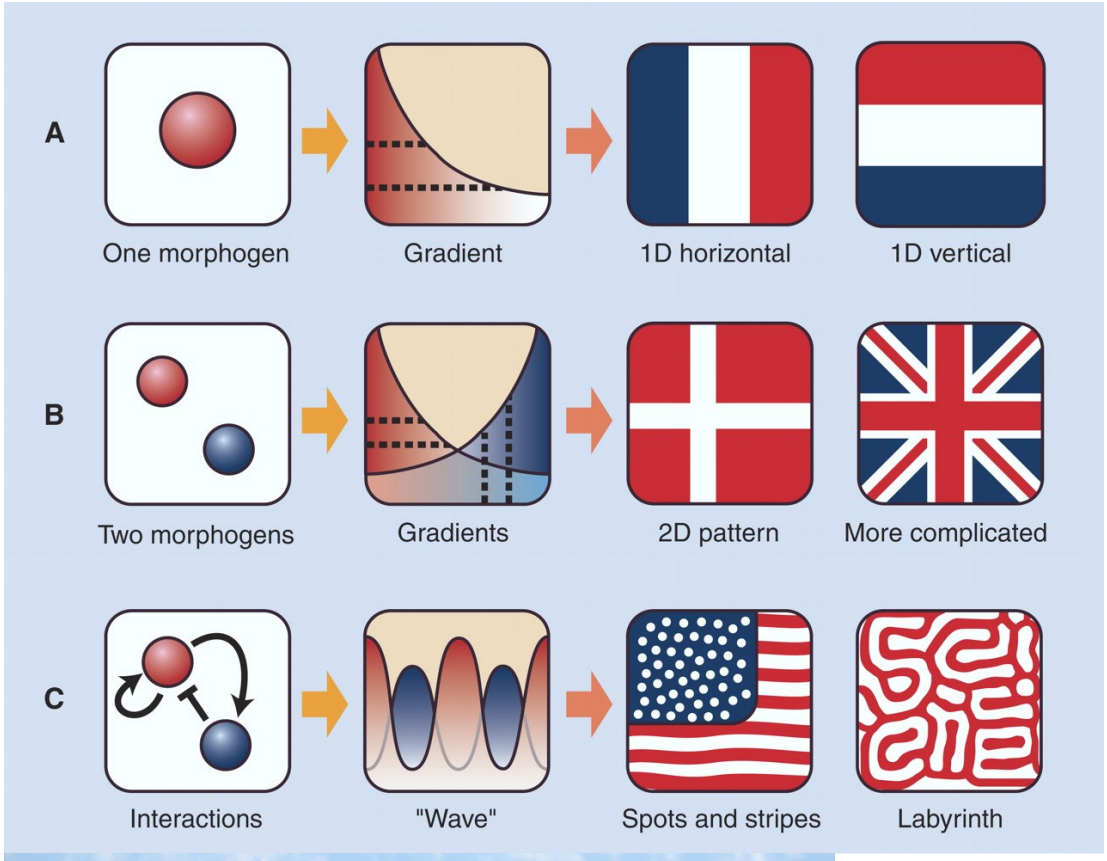
The purpose of this paper is to discuss a possible mechanism by which the genes of a zygote may determine the anatomical structure of the resulting organism. The theory does not make any new hypotheses; it merely suggests that certain well-known physical laws are sufficient to account for many of the facts. The full understanding of the paper requires a good knowledge of mathematics, some biology, and some elementary chemistry. Since readers cannot be expected to be experts in all of these subjects, a number of elementary facts are explained, which can be found in text-books, but whose omission would make the paper difficult reading.

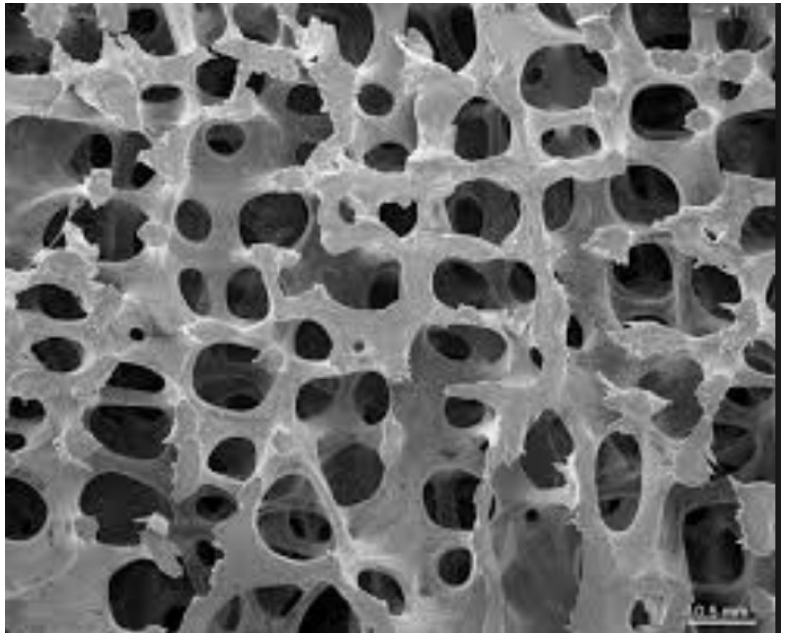
1. A model of the embryo. Morphogens

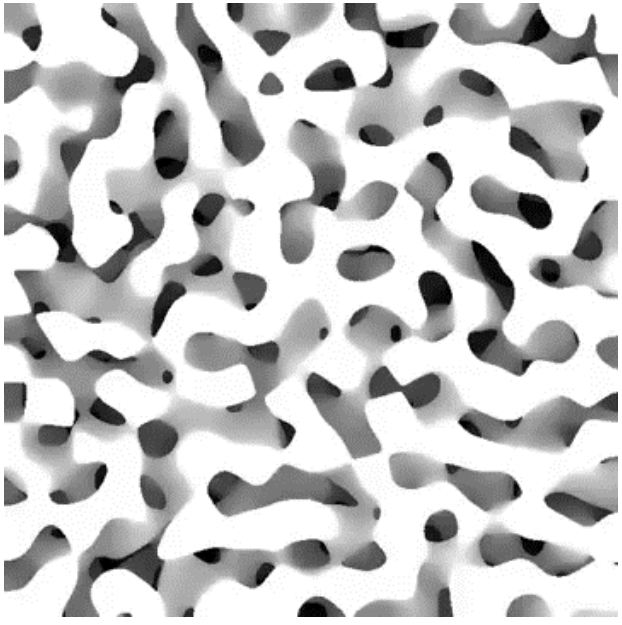
In this section a mathematical model of the growing embryo will be described. This model will be a simplification and an idealization, and consequently a falsification. It is to be hoped that the features retained for discussion are those of greatest importance in the present state of knowledge.

The model takes two slightly different forms. In one of them the cell theory is recognized but the cells are idealized into geometrical points. In the other the matter of the organism is imagined as continuously distributed. The cells are not, however, completely ignored, for various physical and physico-chemical characteristics of the matter as a whole are assumed to have values appropriate to the cellular matter.

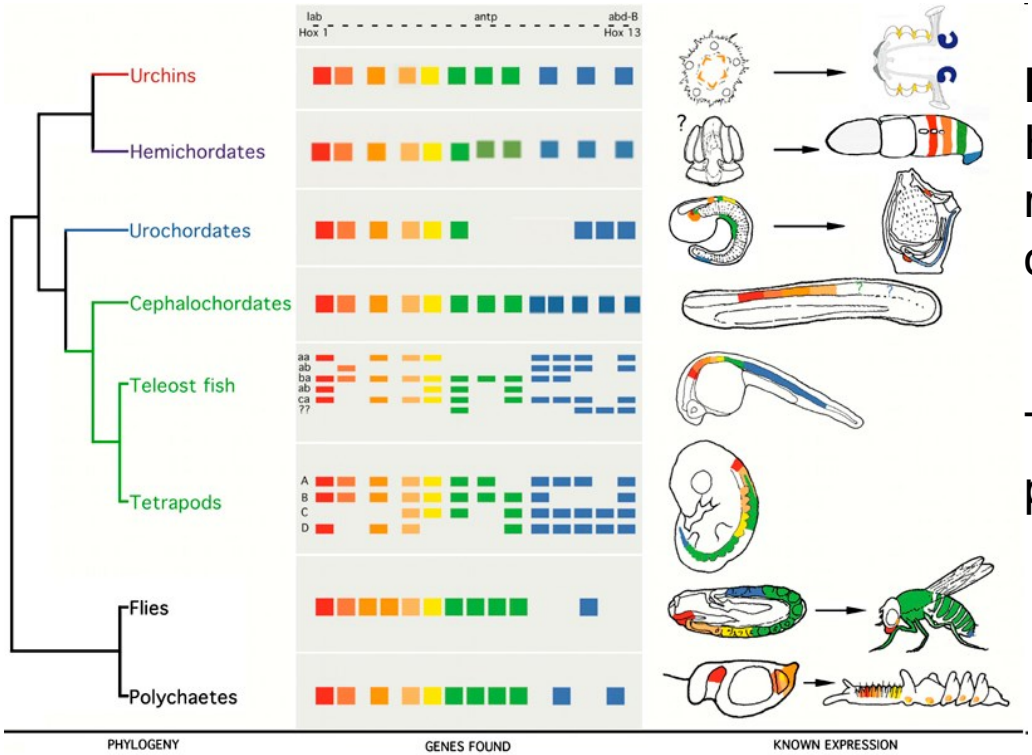
TISSUE PATTERNS ARE DRIVEN BY GRADIENTS OF MORPHOGENES







HOX COMPLEX

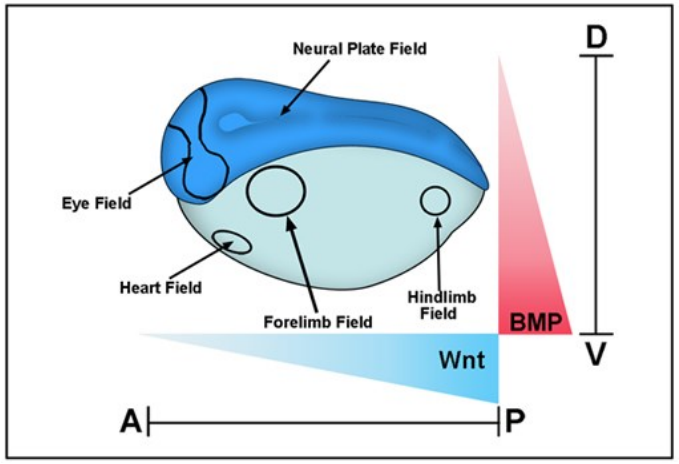


Hox genes

Highly conserved family of transcription regulators that determine body polarity, orientation and axis

Tissue differentiation along anterio-posterior axis

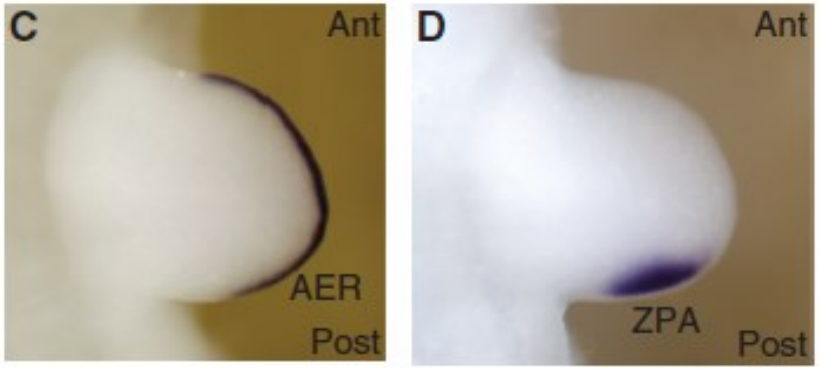
doi:10.1038/sj.hdy.6800872

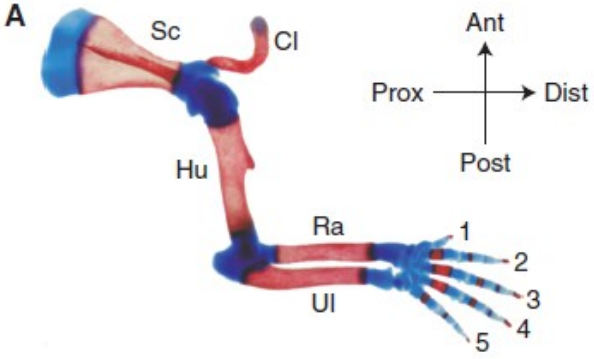


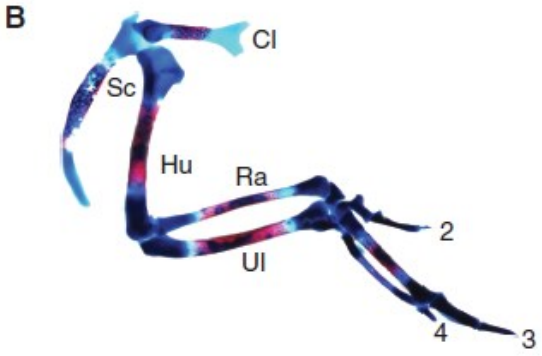
Human (39 genes)

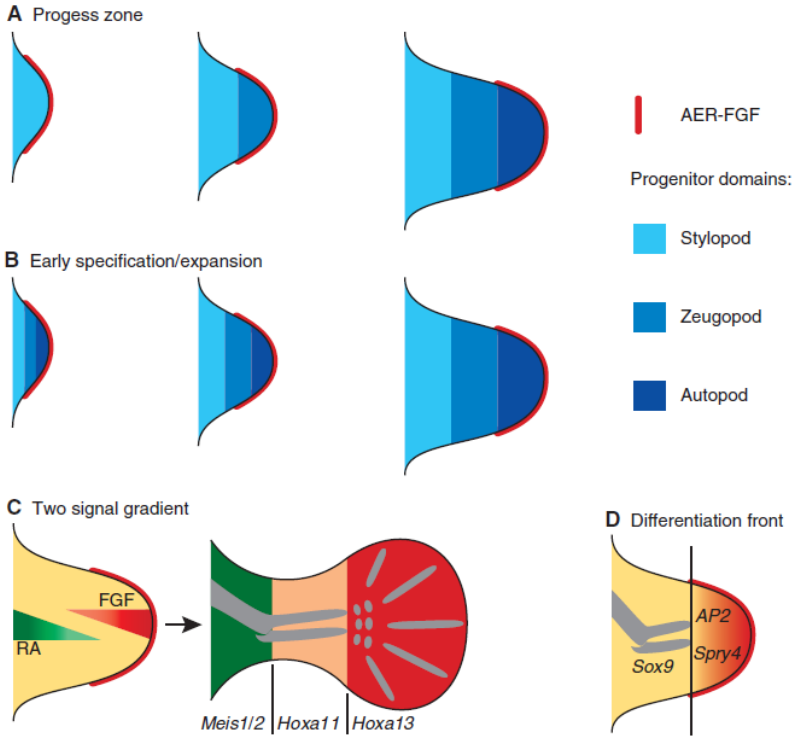
Cluster	Chromosome	# Hox genes
HoxA	7	11
HoxB	17	10
HoxC	12	9
HoxD	2	9

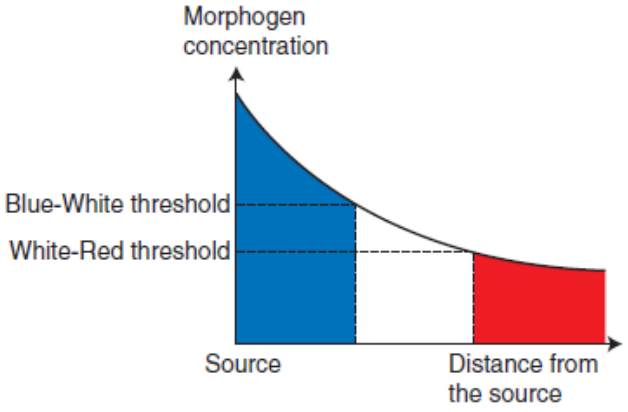
TEMPORO-SPATIAL EXPRESSSION OF MORPHOGENES DRIVES FINAL LOCALIZATION, ORIENTATION AND MORPHOLOGY OF TISSUES AND ORGANS



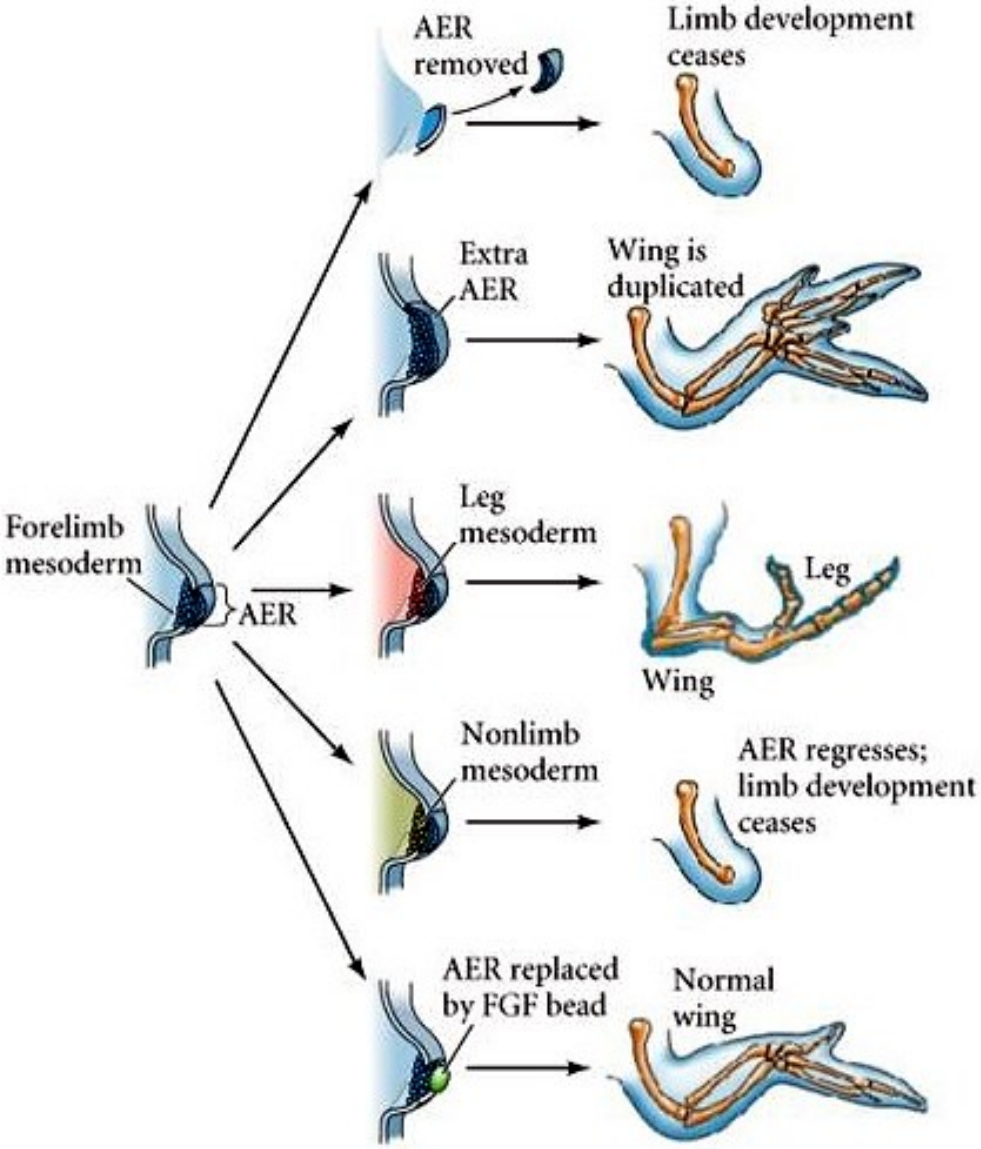




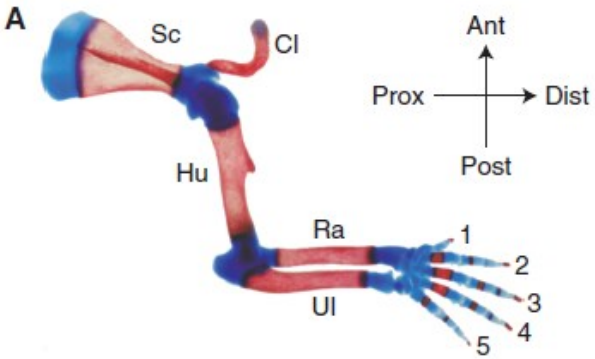


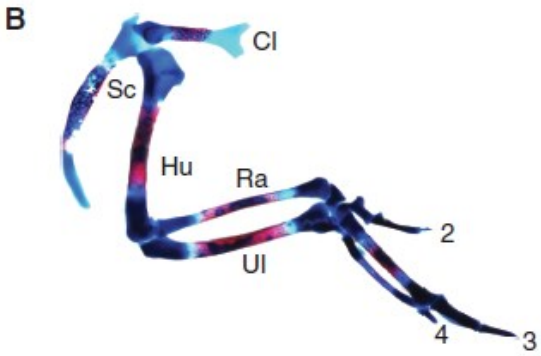


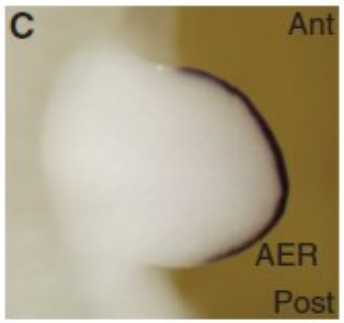
MANIPULATING AER ALTERS INSTRUCTIONS FOR LIMB DEVELOPMENT

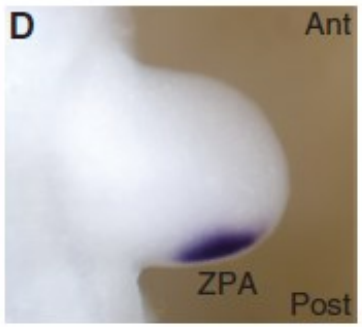


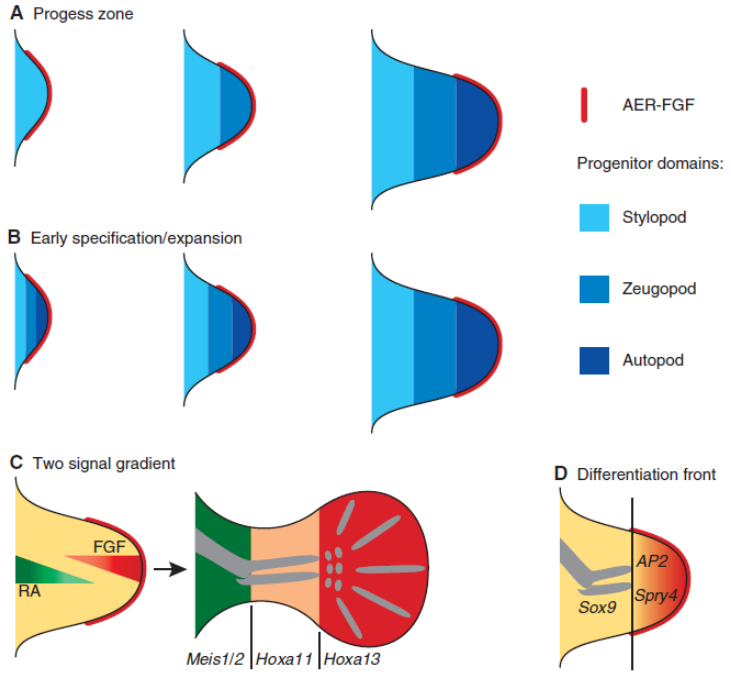
TEMPORO-SPATIAL EXPRESSION OF DIFFERENT REGULATORS DETERMINES FINAL LOCALIZATION, ORIENTATION AND MORPHOLOGY OF TISSUES AND ORGANS

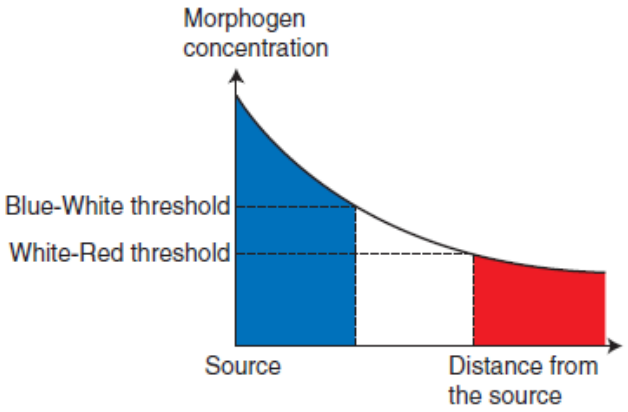




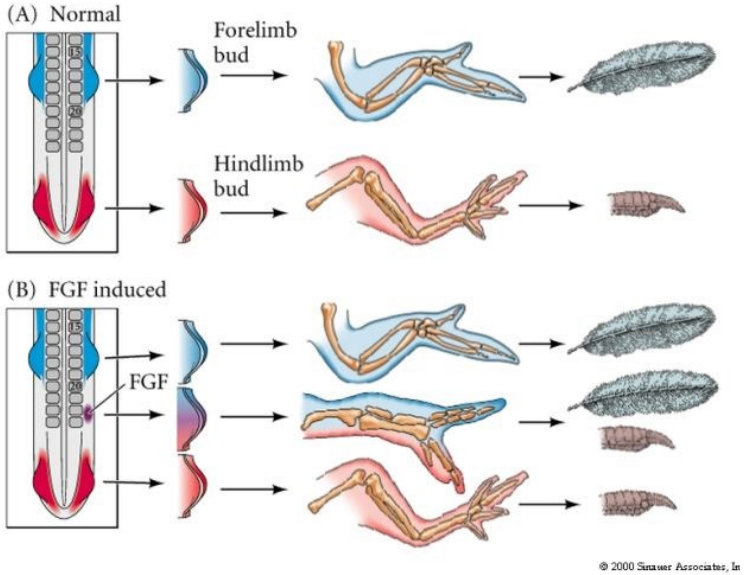


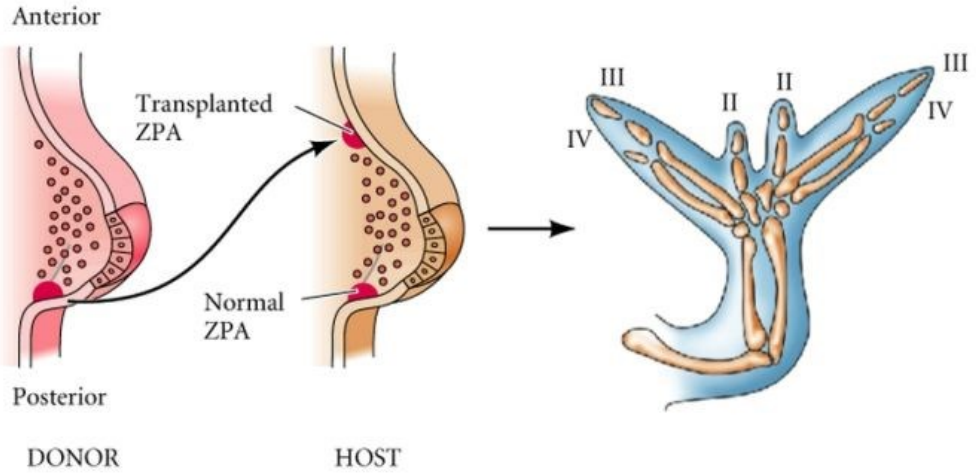


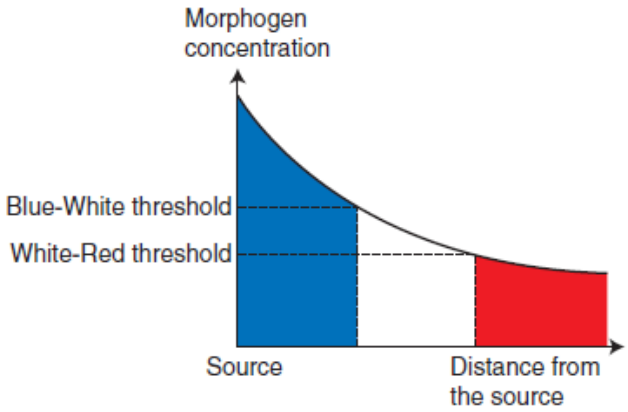




ZPA SPECIFIES POSITIONAL INFORMATION IN LIMB BUD

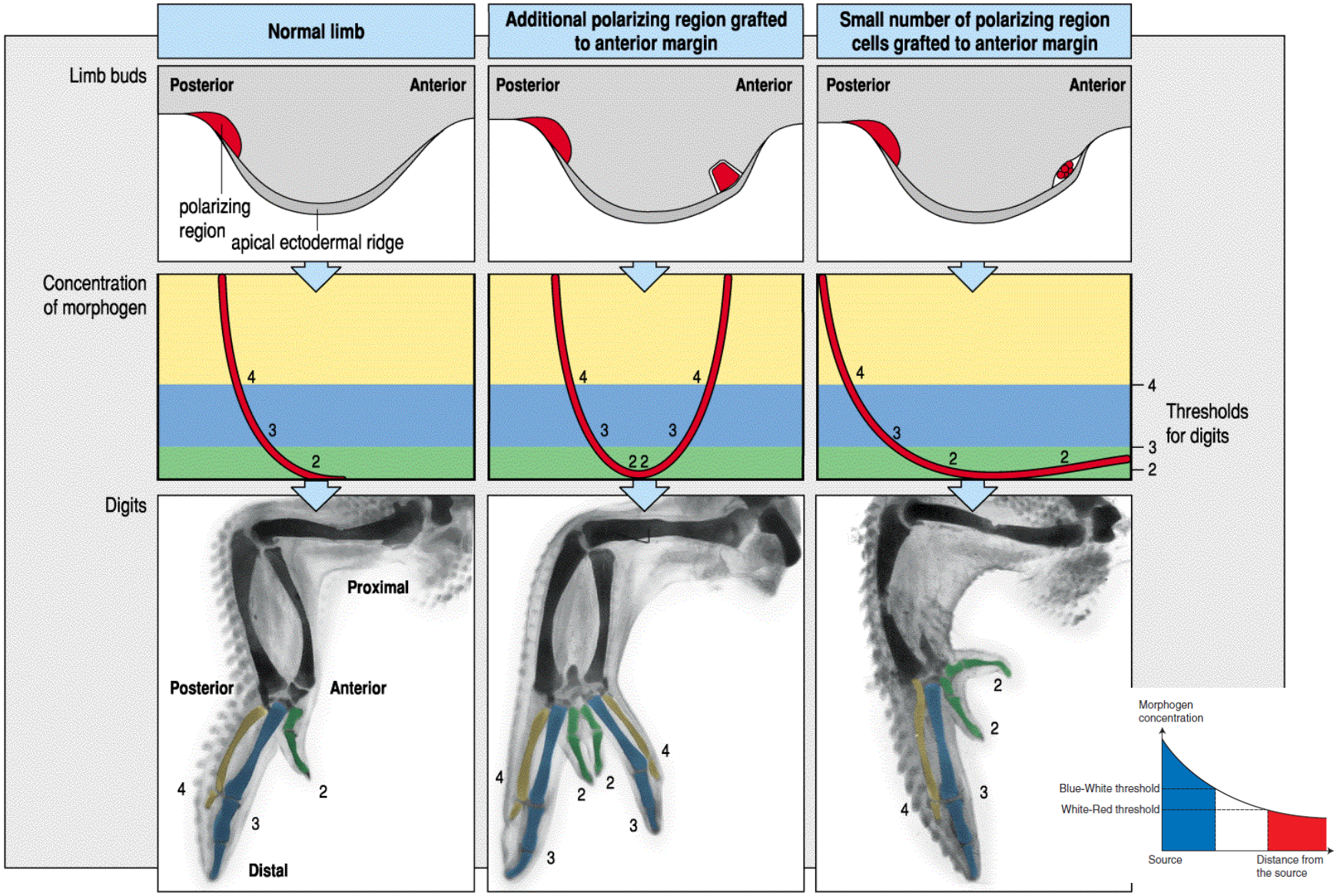




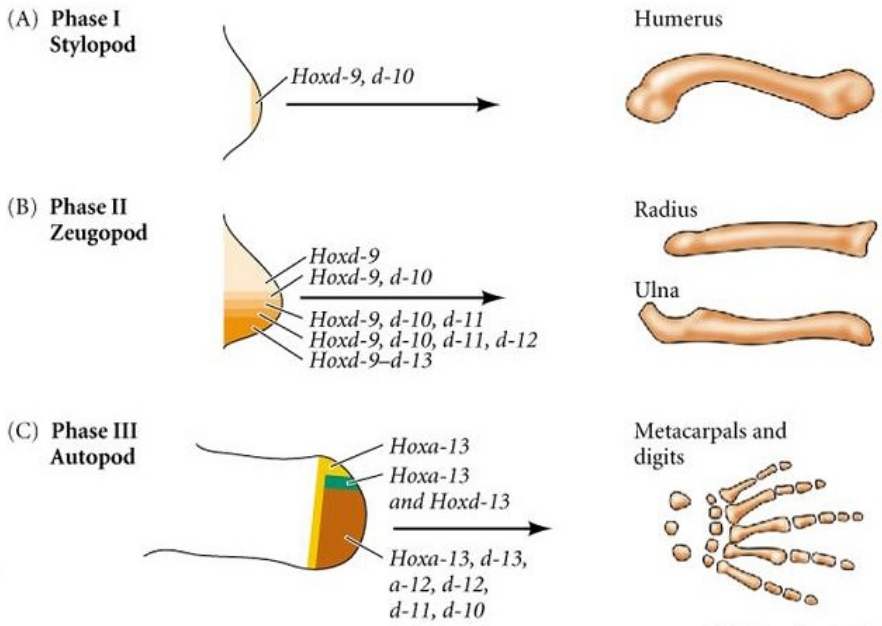


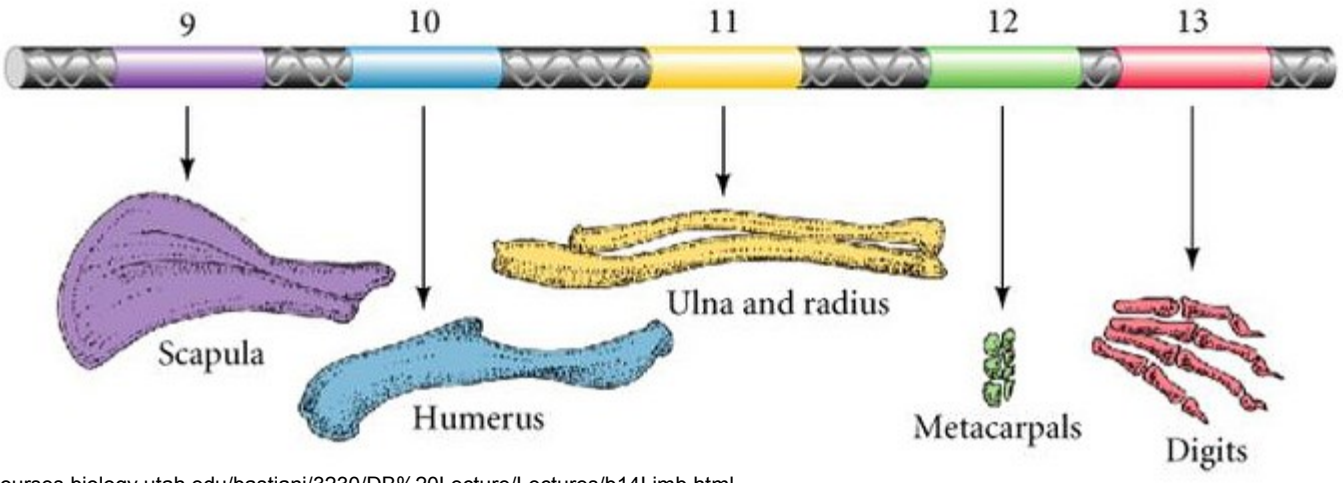
http://courses.biology.utah.edu/bastiani/3230/DB%20Lecture/Lectures/b14Limb.html

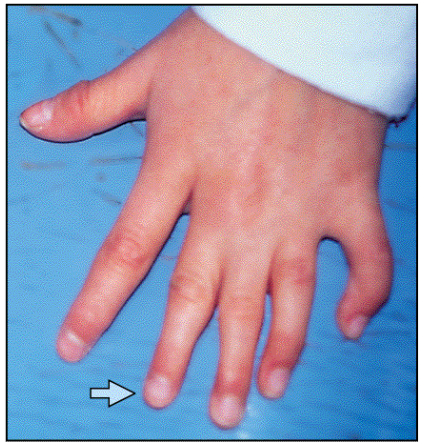
MORPHOGENES FROM AER AND ZPA DEFINES LIMB FORMATION



HOX PATTERN DRIVES TRANSCRIPTIONAL RESPONSE

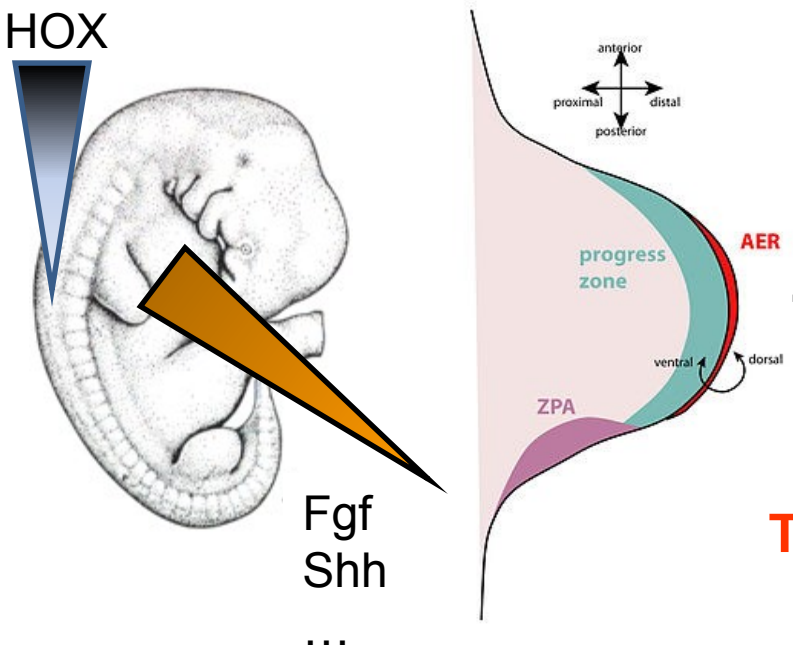






http://courses.biology.utah.edu/bastiani/3230/DB%20Lecture/Lectures/b14Limb.html

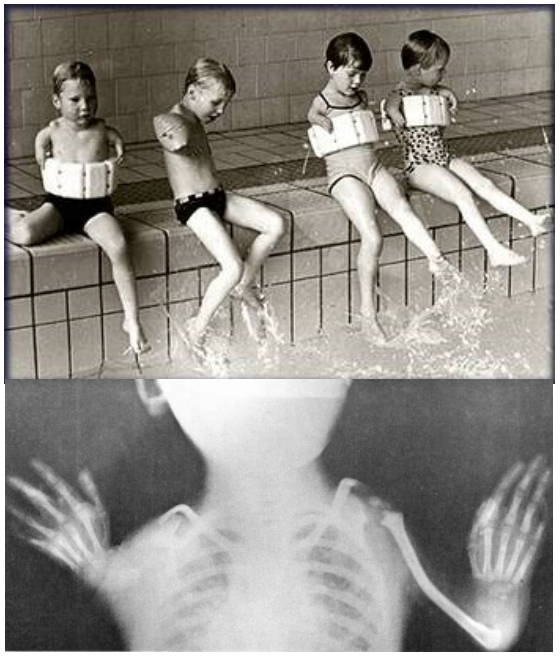
STORY OF THALIDOMID

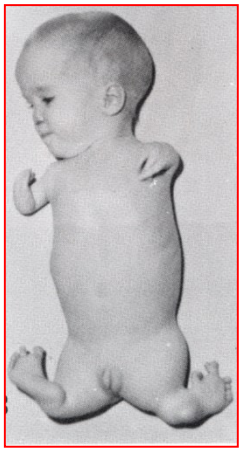


Proliferation

Vascularisation

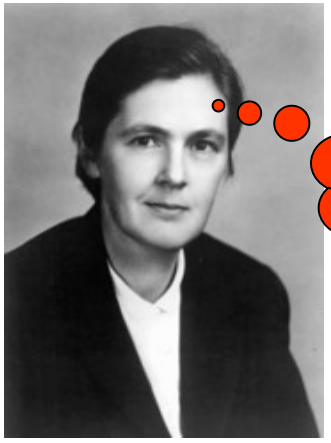
Thalidomid





Thalidomid embryopathy

- phocomelia
- amelia
- anophtalmia/microphtalmia
- abnormal kidneys, heart, GIT, genitalia

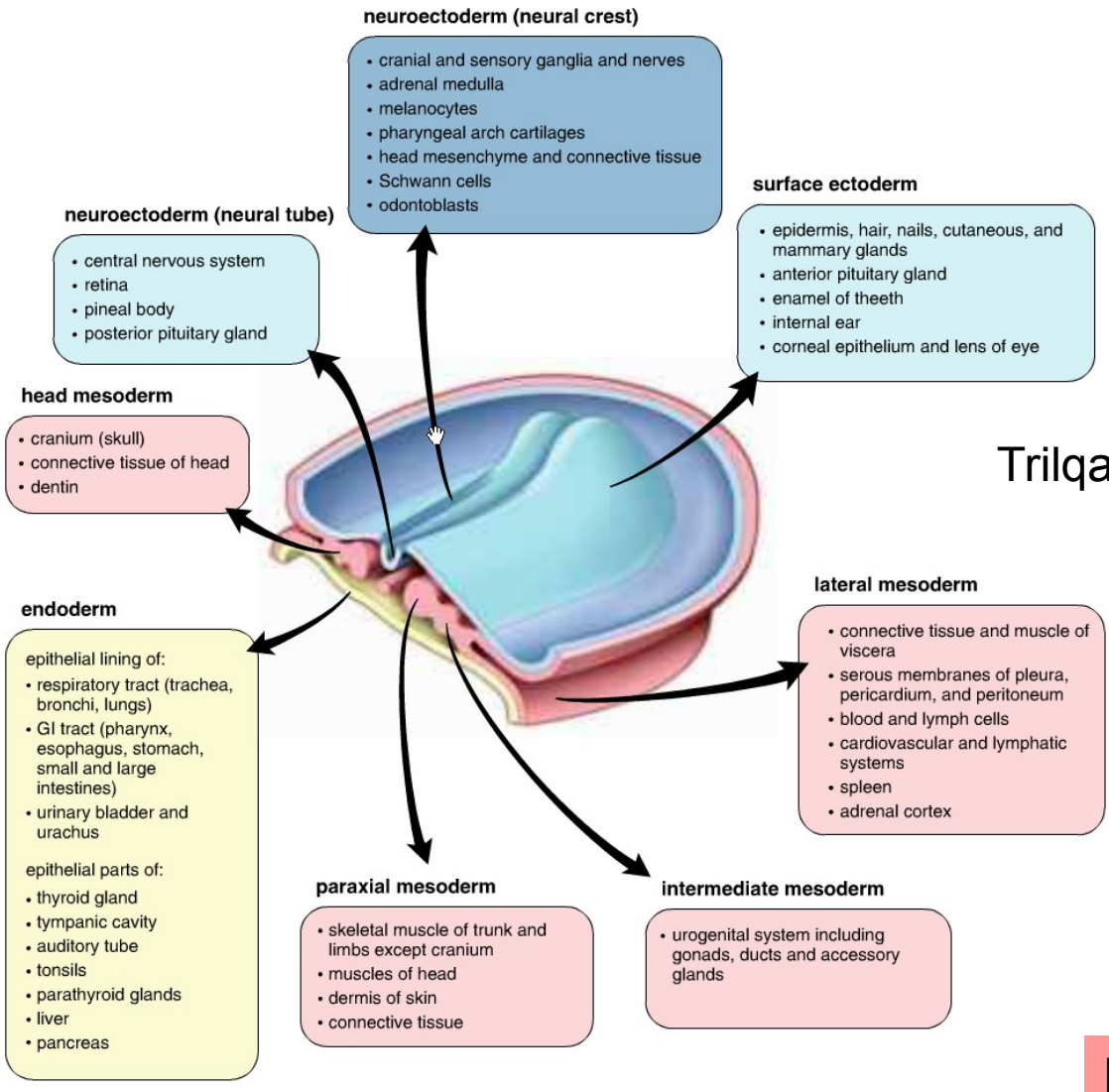


Frances Oldham Kelsey,
FDA USA

Untested drug to pregnant mothers?!! Not in U.S.!

HISTOGENESIS AND ORGANOGENESIS

Ectoderm



Trilqaminar germ disc

(3rd week)

Endoderm

Mesoderm

EMBRYONIC DEVELOPMENT

Ectoderm

Surface ectoderm

- Epidermis, hair nails, cutaneous and mammary glands
- Corneal epithelium and lens of eye
- Enamel of teeth
- Internal ear
- Anterior pituitary gland
- Epithelium of oral cavity and part of anal canal

Neuroectoderm

- **Neural tube** and derivatives
  - CNS
  - Retina
  - Posterior pituitary gland
  - Pineal body
- **Neural crest** and derivatives:
  - Cranial and sensory ganglia and nerves
  - Schwann cells
  - adrenal medulla
  - Enteroendocrinne cells
  - Melanocytes
  - Head mesenchyme and connective tissue
  - Odontoblasts

Mesoderm

head

- Connective tissue of head
- Cranium, dentin

Paraxial

- Skeletal muscle of trunk and limbs except cranium
- Dermis of skin
- Muscles of head

Intermediate

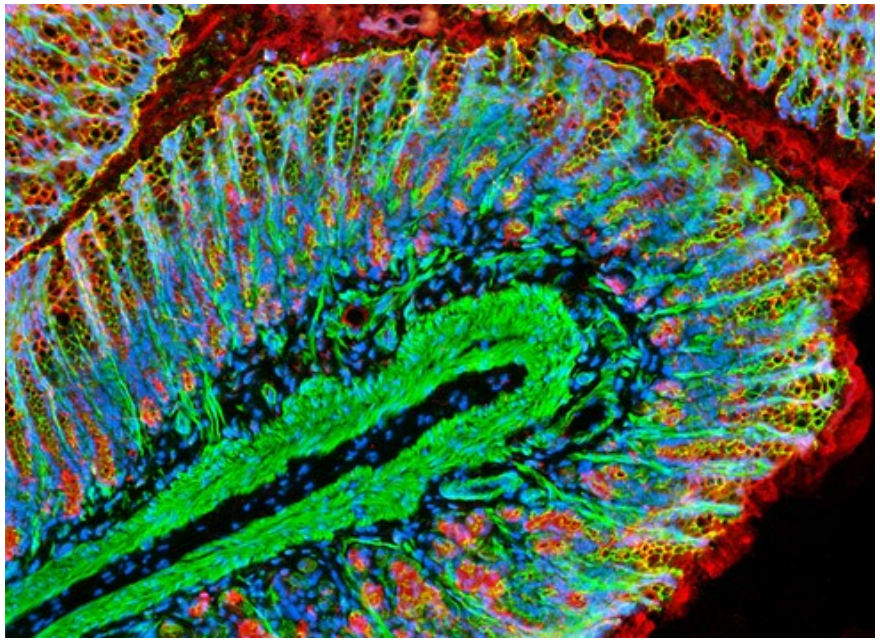
- Urogenital system + ducts, glands and gonads

Lateral

- Visceral muscle and connective tissue
- Serous membranes of pleura, peritoneum and pericardium
- Blood cells, leukocytes
- Cardiovascular and lymphatic system
- Spleen
- Adrenal cortex

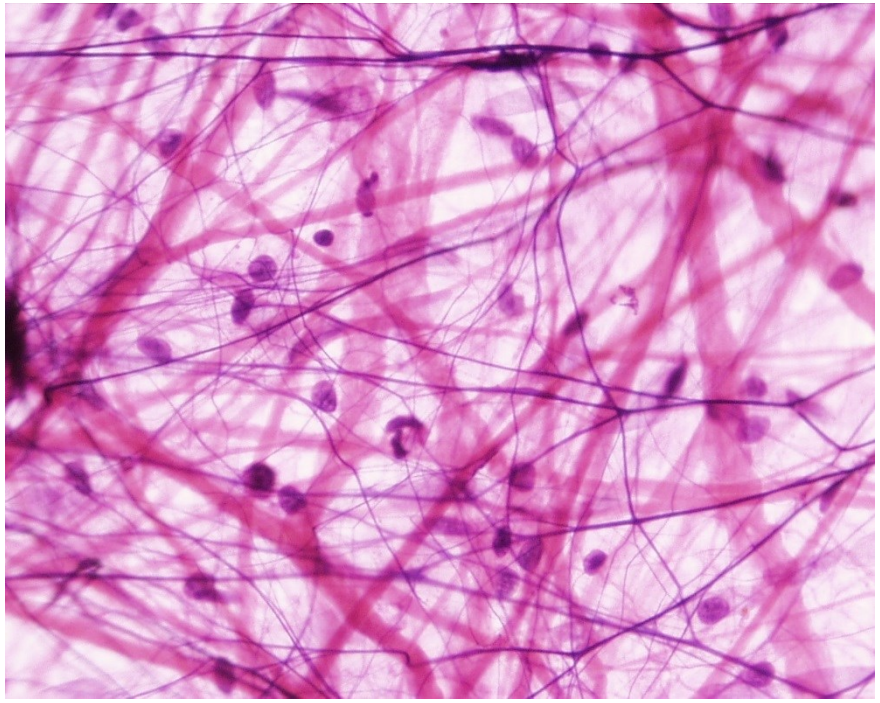
Endoderm

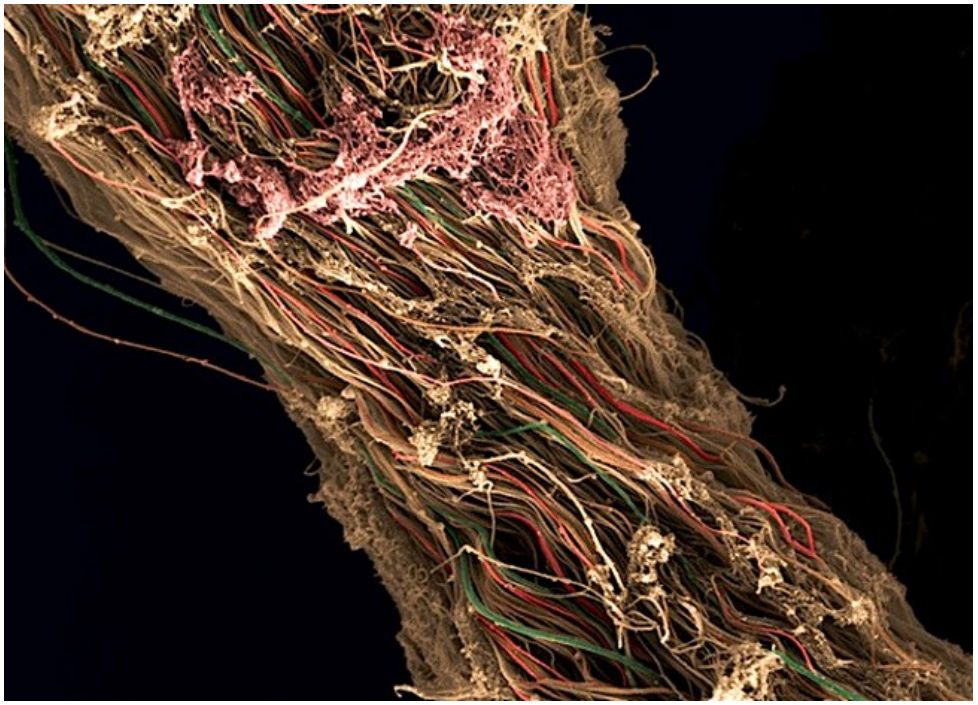
- GIT epithelium except oral cavity and part of anal canal
- Extramural glands of GIT
- Epithelium of bladder
- Epithelium of respiratory system
- Thyroid gland, parathyroid glands, thymus
- Tonsils
- Epithelium of cavum tympani and Eustachian tube



6. CONNECTIVE TISSUE

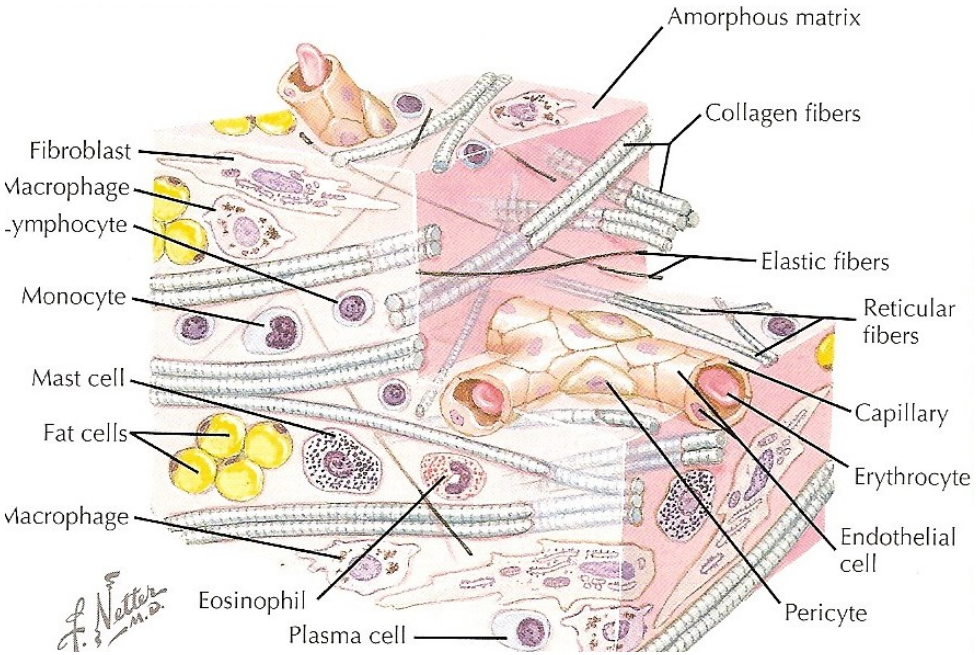
Not just a tissue glue…





Mechanical and biological properties

⟶ surrounds other tissues, compartmentalization, support, physico-chemical environment, immunological support, storage

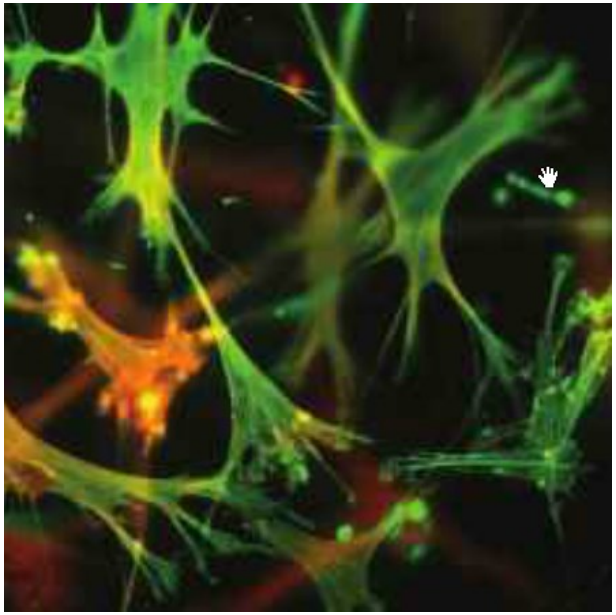


GENERAL COMPOSITION OF CONNECTIVE TISSUE

Cells and extracellular matrix

- **Cells**

Connective tissue – permanent and transient cell populations (fibroblasts/myofibroblasts, immune cells, adipocytes, adult stem cells)
Cartilage – chondroblasts/chondrocytes
Bone – osteoblasts/osteocytes/osteoclasts



- **Matrix** – fibrous and amorphous

Fibrous component
- collagen
- reticular
- elastic

Amorphous component (amorphous ground substance)
- Complex matrix consisting of glycosaminoglycans, glycoproteins and proteoglycans,

depending on tissue type (connective × ligament × cartilage × bone)

CLASSSIFICATION OF CONNECTIVE TISSUE

Embryonic CT
- Mesenchyme
- Jelly-like CT (Wharton jelly, dental pulp, stroma of iris)

Adult CT
- Areolar (loose, interstitial) CT
- Dense collagen irregular CT

} CT

- Dense collagen regular CT
- Fat (adipose tissue)
- Cartilage
- Bone

} Specialized CT

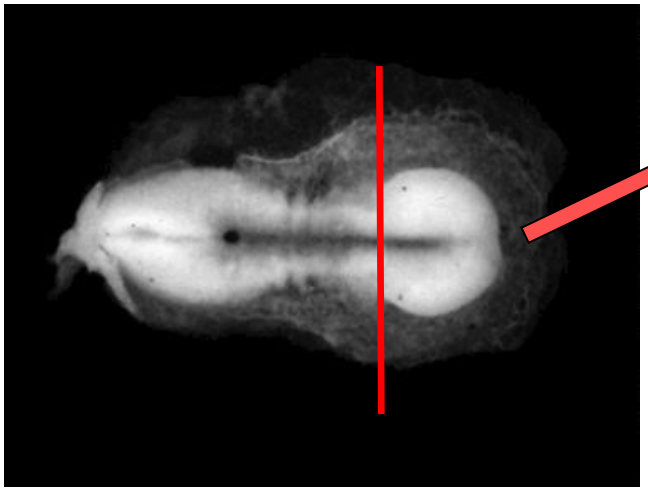
- Blood and hematopoietic tissue
- Lymphatic tissue

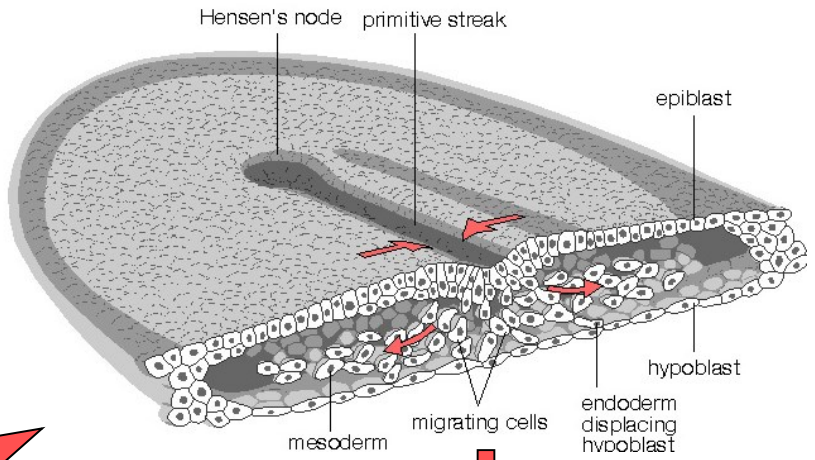
} Trophic CT (body liquids)

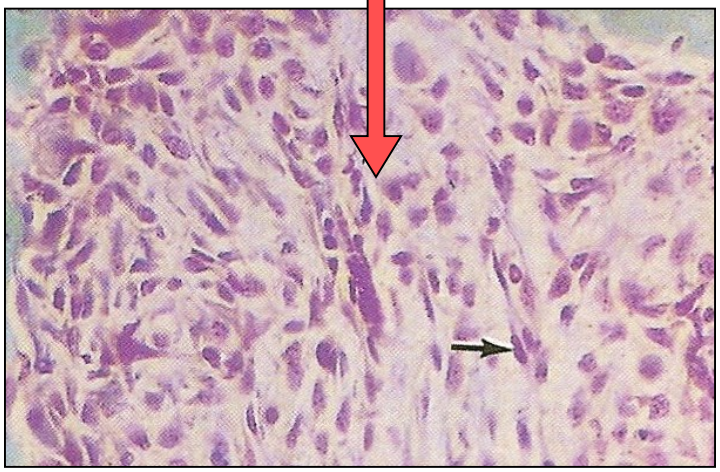
EMBRYONIC ORIGIN OF CONNECTIVE TISSUE

- Mesenchyme = loose tissue between germ layers
- Complex network of star- or spindle-shaped cells
- Jelly-like amorphous ground substance

DAY 12 of embryonic development

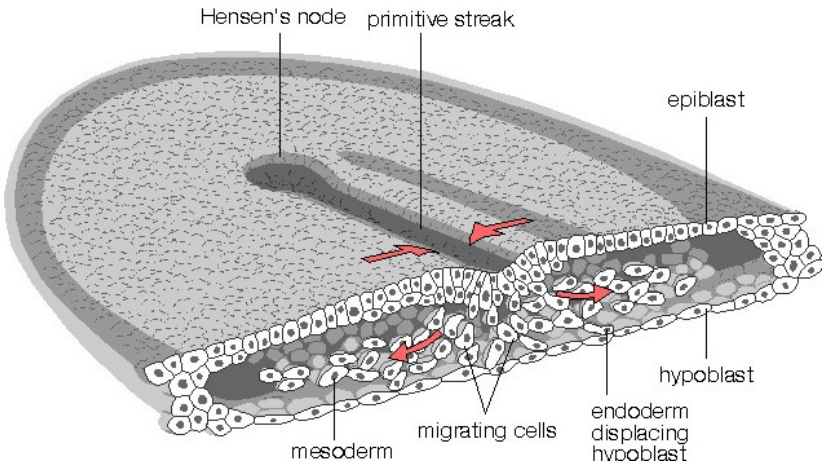


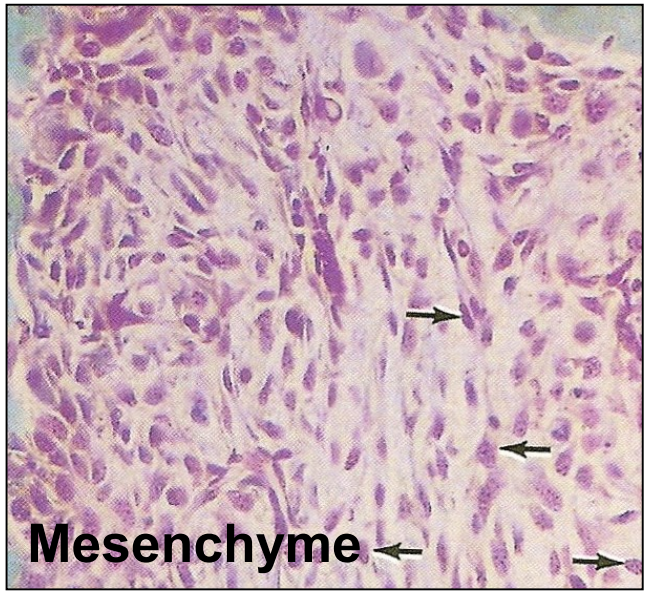


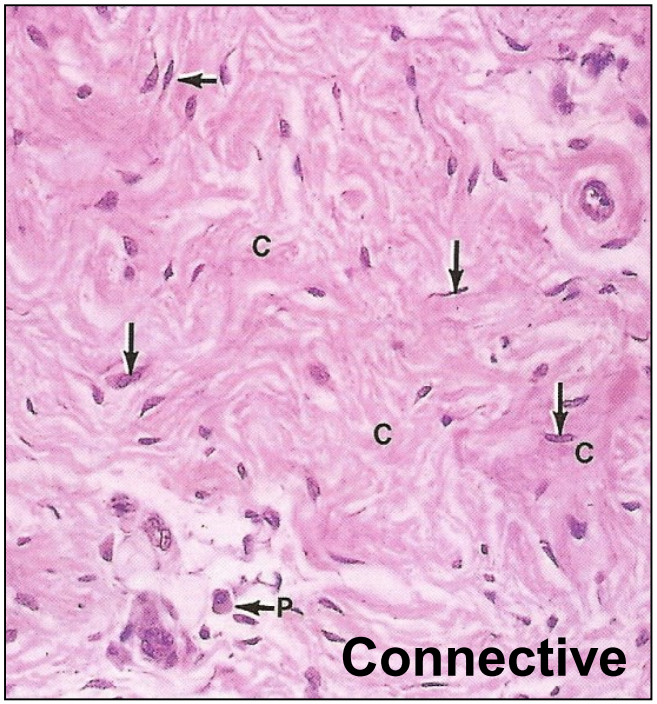


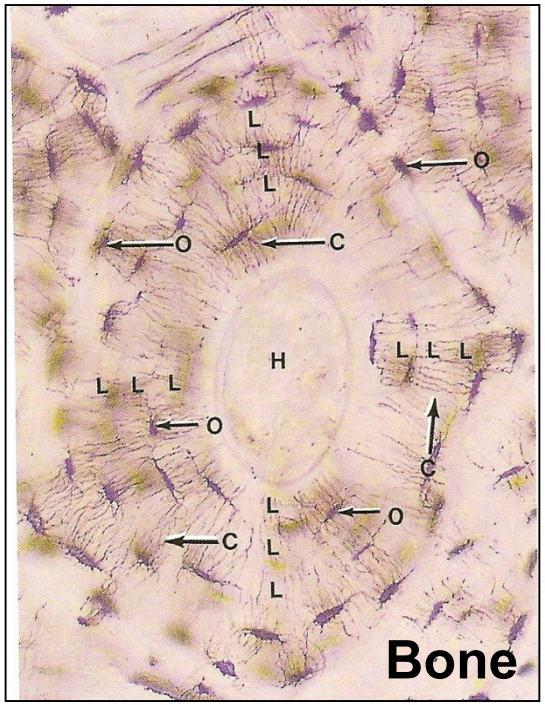
http://www.mun.ca/biology/desmid/brian/BIOL3530/DB_Ch02/DBNModel.html

DERIVATIVES OF CONNECTIVE TISSUE





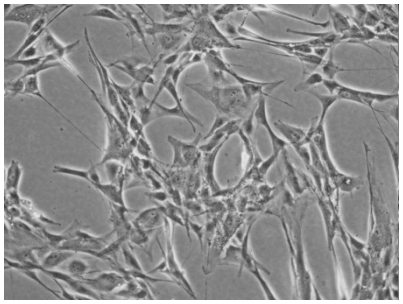


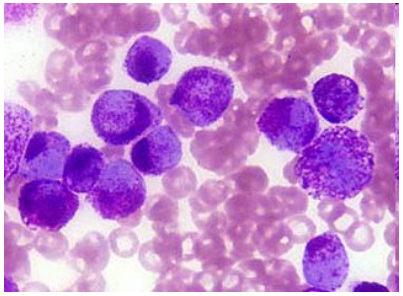


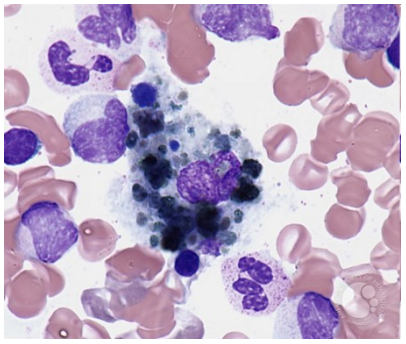
CELLS OF CONNECTIVE TISSUE

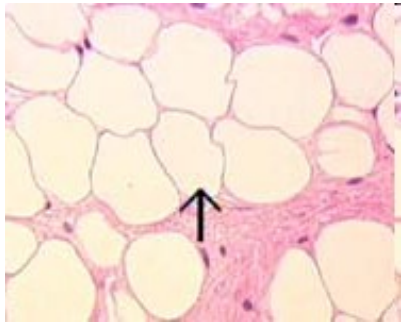
Cells

- Fibroblasts/fibrocytes/myofibroblasts
- Heparinocytes
- Macrophages of CT = histiocytes
- Plasma cells
- Lymphocytes
- Adipocytes
- Adult stem cells



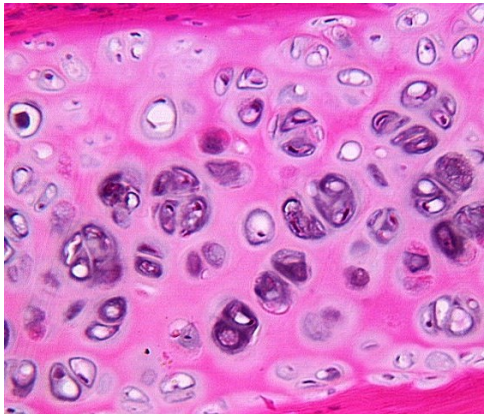


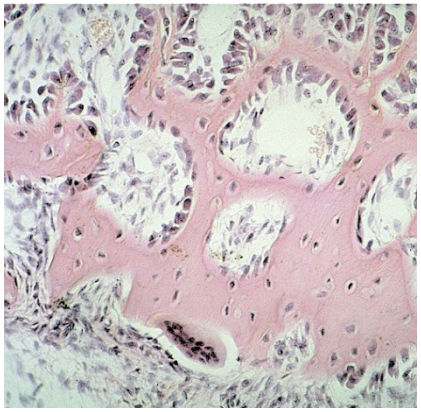


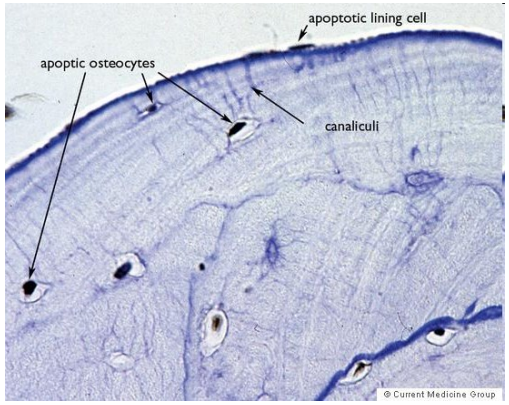


Extracellular matrix

- Fibrous compound
- Amorphous ground substance

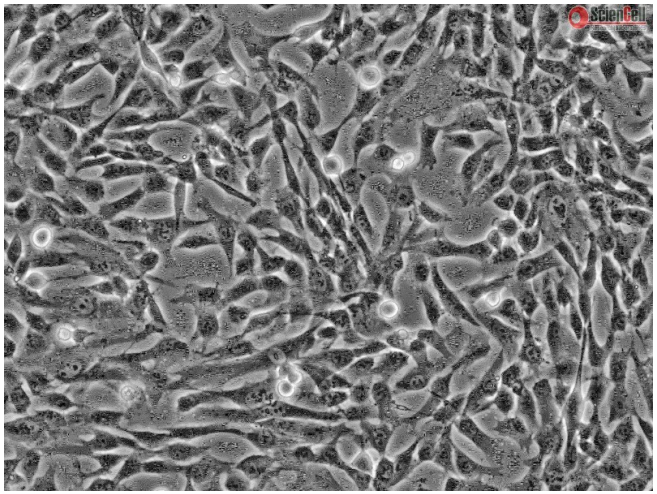


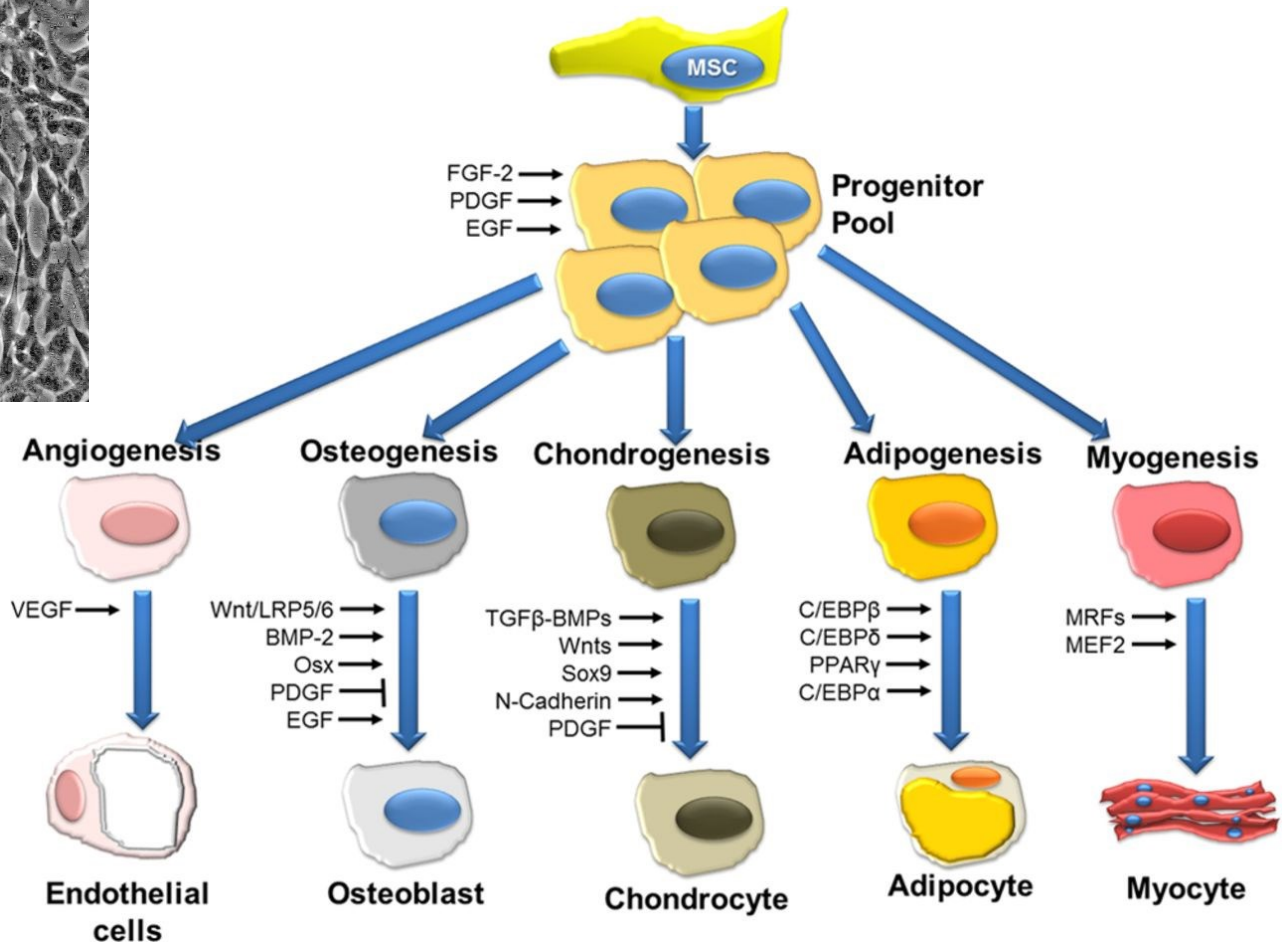




CELLS OF CONNECTIVE TISSUE

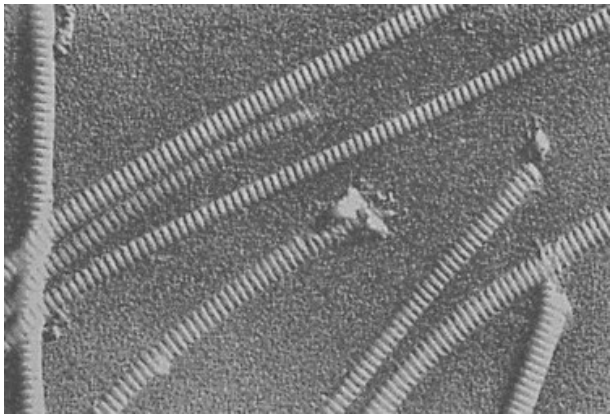
Mesenchymal (adult) stem cells

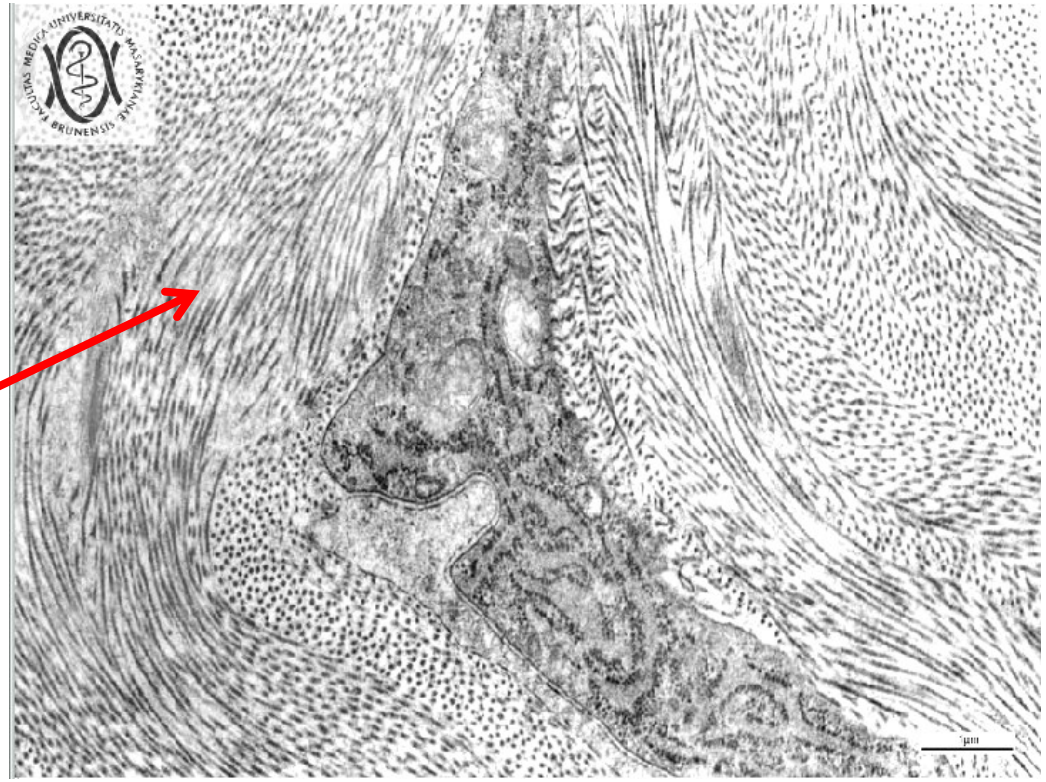




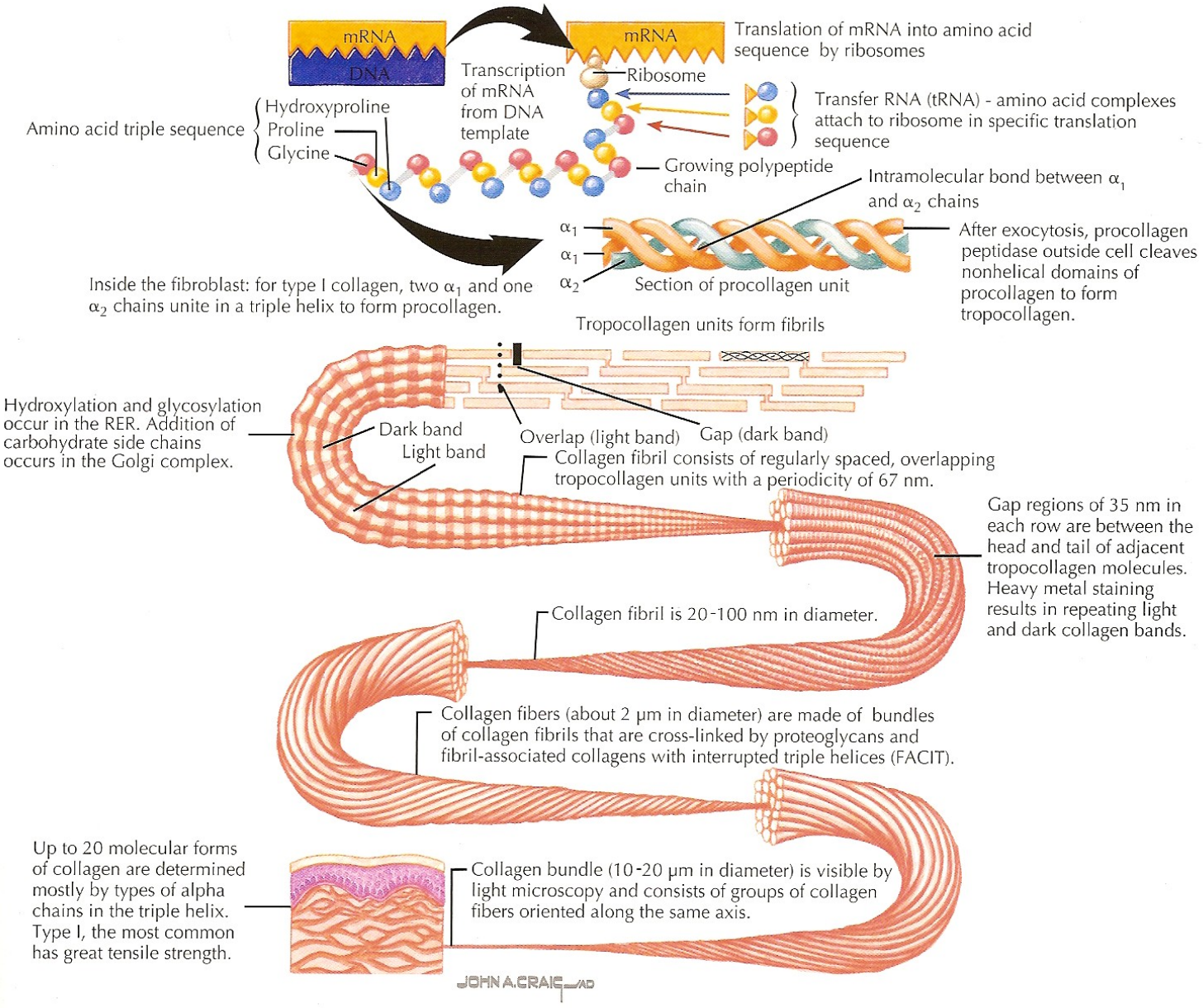
Collagen fibers

- family of fibrous proteins encoded by >35 genes (2013)
- polymer – subunit = tropocollagen; triple helix
- different structural and mechanical properties (strength, elasticity, pliability…)
- most abundant protein in human body (30% dry weight)





COLLAGEN


mRNA
DNA
Transcription of mRNA from DNA template
mRNA
Translation of mRNA into amino acid sequence by ribosomes
Ribosome
Transfer RNA (tRNA) - amino acid complexes attach to ribosome in specific translation sequence
Amino acid triple sequence
Hydroxyproline
Proline
Glycine
Growing polypeptide chain
Intramolecular bond between α_1 and α_2 chains
α_1
α_1
α_2
Section of procollagen unit
After exocytosis, procollagen peptidase outside cell cleaves nonhelical domains of procollagen to form tropocollagen.
Inside the fibroblast: for type I collagen, two α_1 and one α_2 chains unite in a triple helix to form procollagen.
Tropocollagen units form fibrils
Hydroxylation and glycosylation occur in the RER. Addition of carbohydrate side chains occurs in the Golgi complex.
Dark band
Light band
Overlap (light band)
Gap (dark band)
Collagen fibril consists of regularly spaced, overlapping tropocollagen units with a periodicity of 67 nm.
Gap regions of 35 nm in each row are between the head and tail of adjacent tropocollagen molecules. Heavy metal staining results in repeating light and dark collagen bands.
Collagen fibril is 20-100 nm in diameter.
Collagen fibers (about 2 μm in diameter) are made of bundles of collagen fibrils that are cross-linked by proteoglycans and fibril-associated collagens with interrupted triple helices (FACIT).
Up to 20 molecular forms of collagen are determined mostly by types of alpha chains in the triple helix. Type I, the most common has great tensile strength.
Collagen bundle (10-20 μm in diameter) is visible by light microscopy and consists of groups of collagen fibers oriented along the same axis.
JOHN A. CRAIG—AD

COLLAGEN

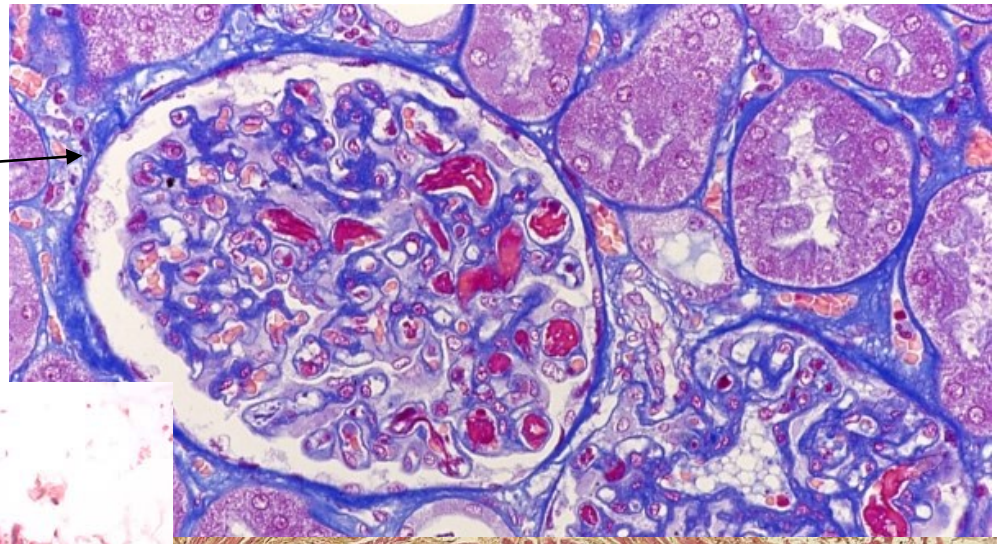
Type	Localization	Structure	Main function
I	Bone, tendons, meniscus, dentin, dermis, capsules of organs, loose CT 90% of type I	Fibrils (75nm) – fibers (1-20μm)	Resilience in pull
II	Hyaline and elastic cartilage	Fibrils (20nm)	Resilience in pressure
III	Skin, veins, smooth muscles, uterus, liver, spleen, kidney, lung	Like I, high content of proteoglycans and glycoprotiens, reticular network	Shape formation
IV	Basal lamina of epithelium and endtohelium, basal membranes	No fibrils or fibers	Mechanical support
V	Lamina of muscle cells and adipocytes, fetal membranes	Like IV	
VI	Interstitial tissue, chondrocytes – adhesion		Connecting dermis and epidermis
VII	Basal membrane of epithelium		
VIII	Some endothelia (Cornea)		
X	Growth plate, mineralized cartilage		Growth of bones, mineralization

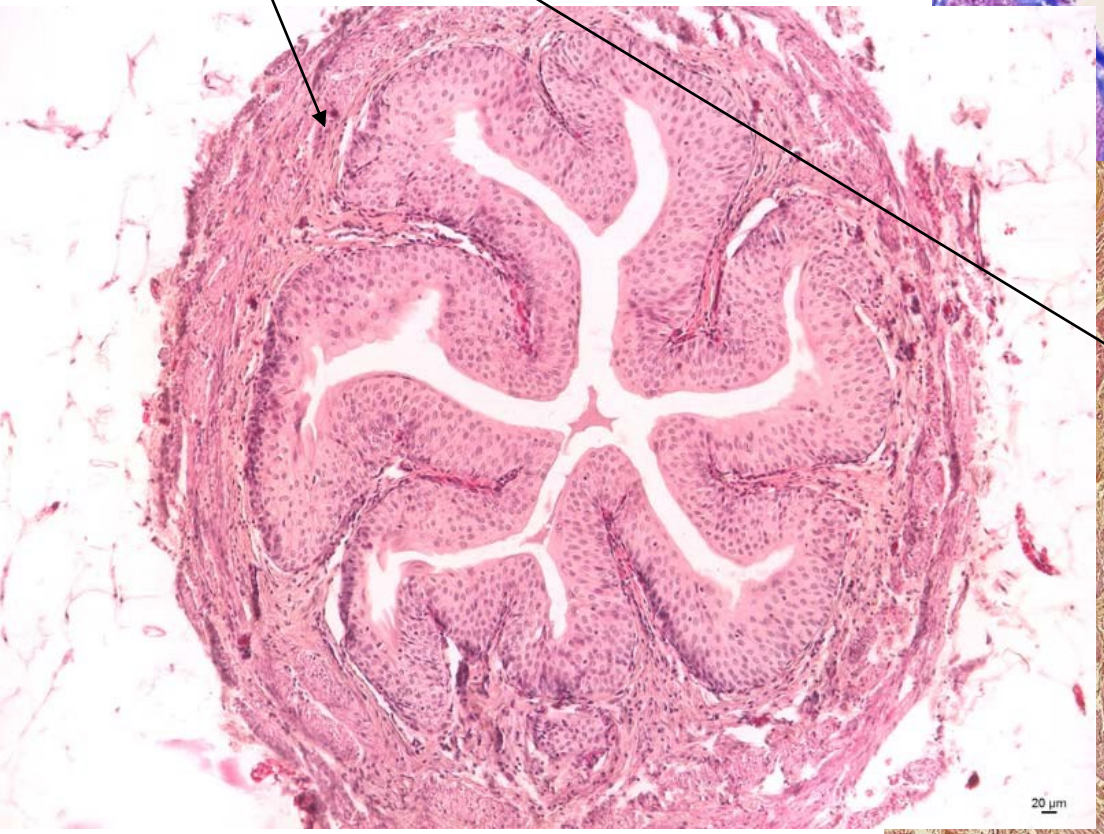
COLLAGEN IN LIGHT MICROSCOPE

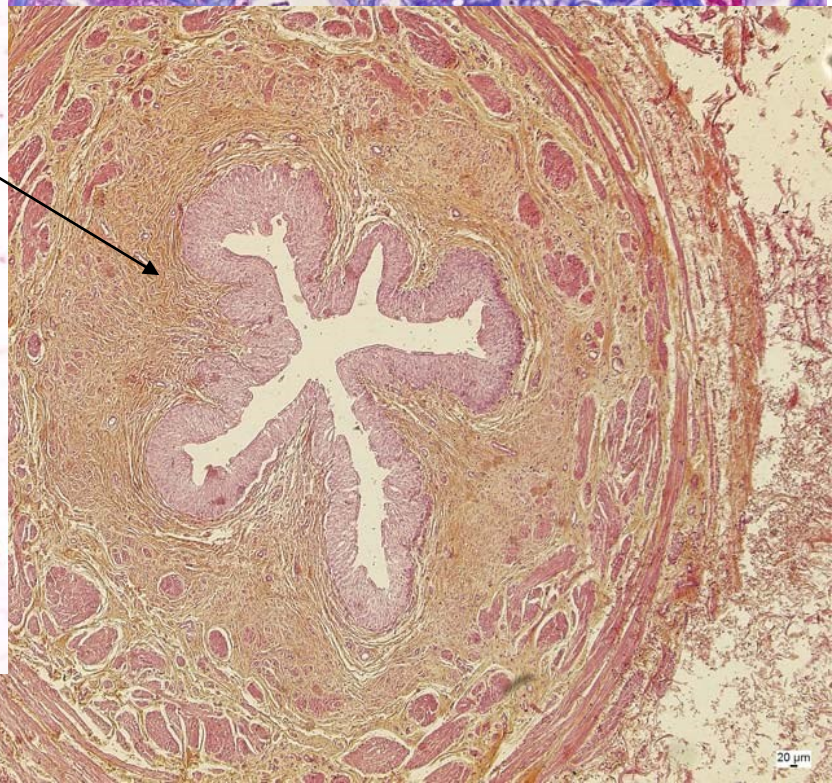
AZAN

HE

HES







COLLAGEN IN ART

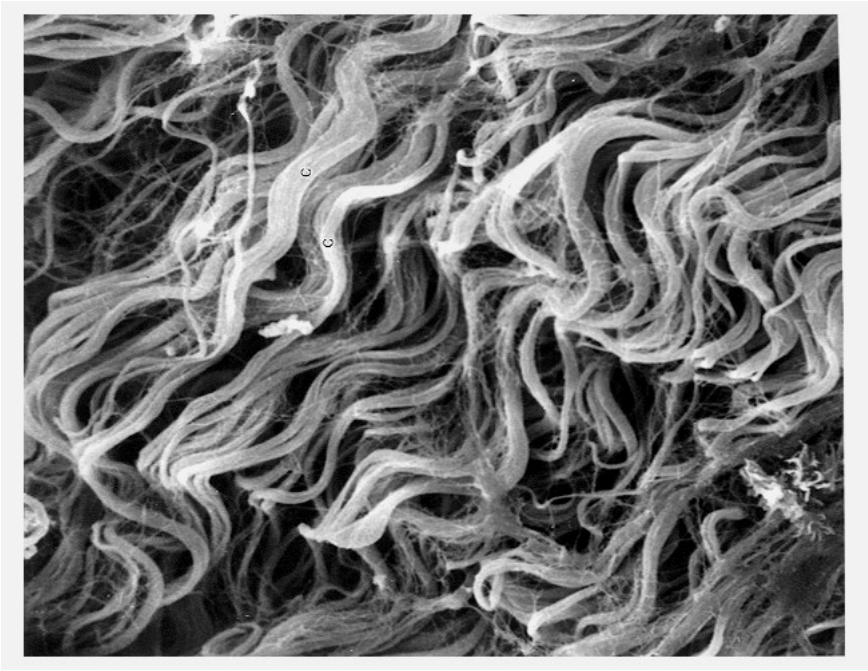
Julian Voss-Andreae
"Unraveling Collagen"

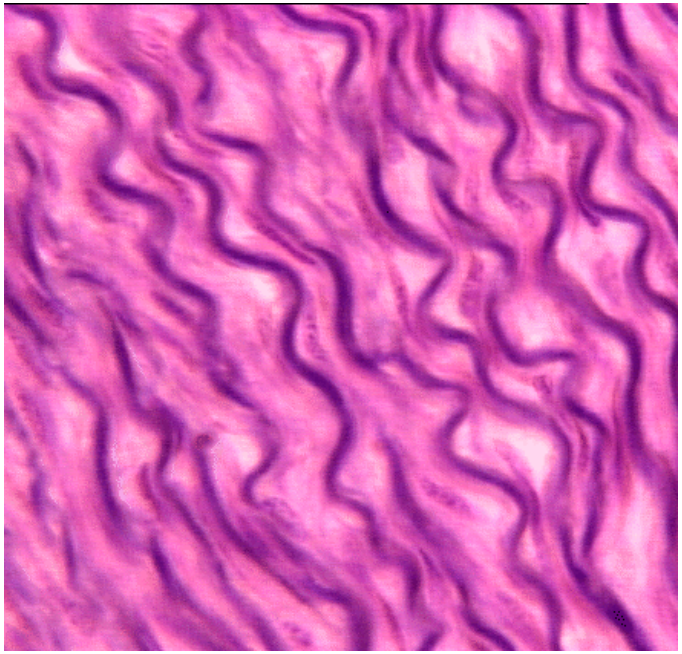
2005

Orange Memorial Park
Sculpture Garden, City of
South San Francisco, CA

ELASTIC FIBERS

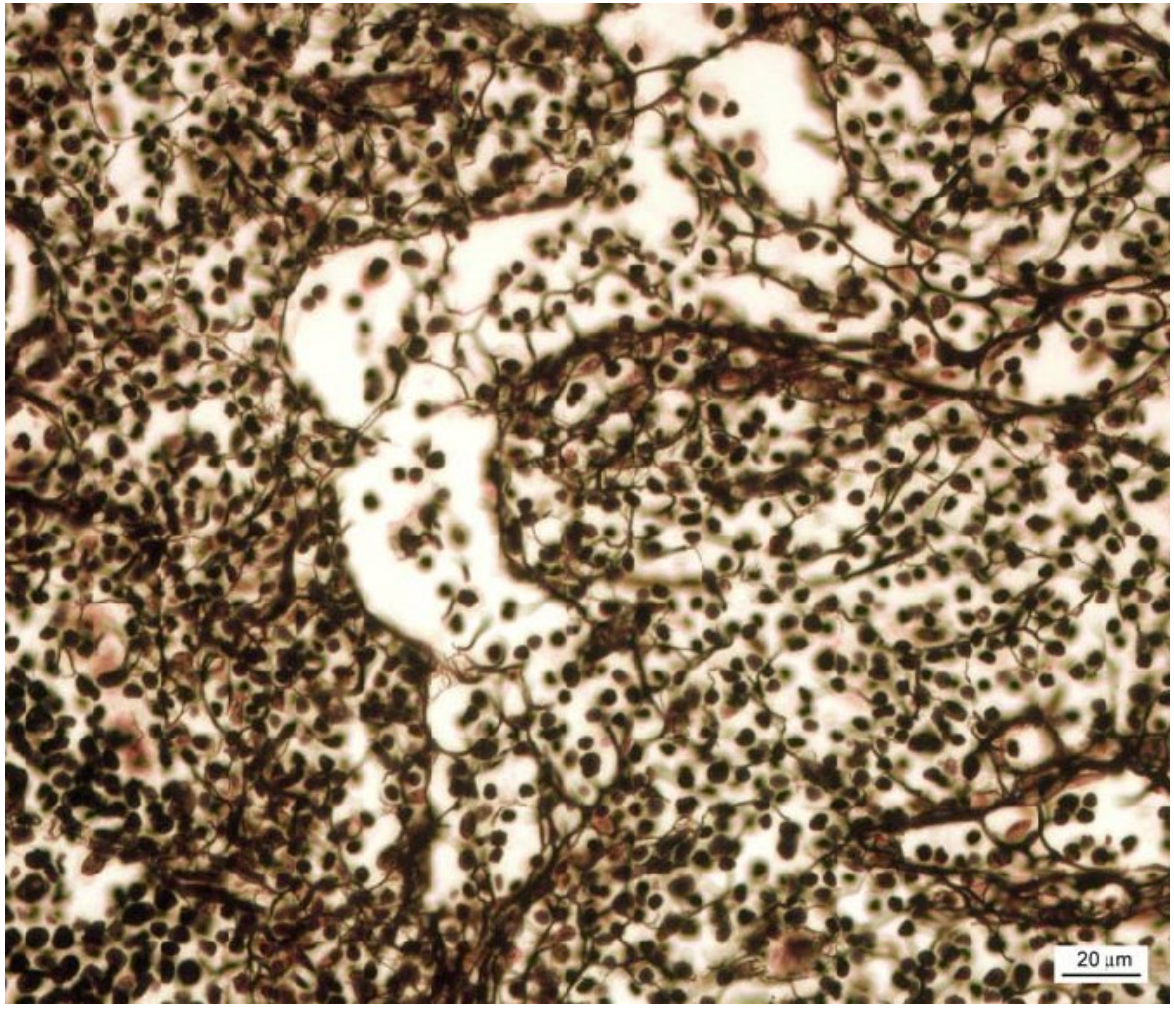
- less abundant than collagen
- polymer – tropoelastin
- minimal tensile resistance, loss of elasticity if overstretched
- reduction of hysteresis = allow return back to original state after mechanic change





RETICULAR FIBERS

- collagen 3D meshwork
- bone marrow, spleen, lymphatic nodules
- microenvironment for e.g. hematopoietic stem cells and progenitors

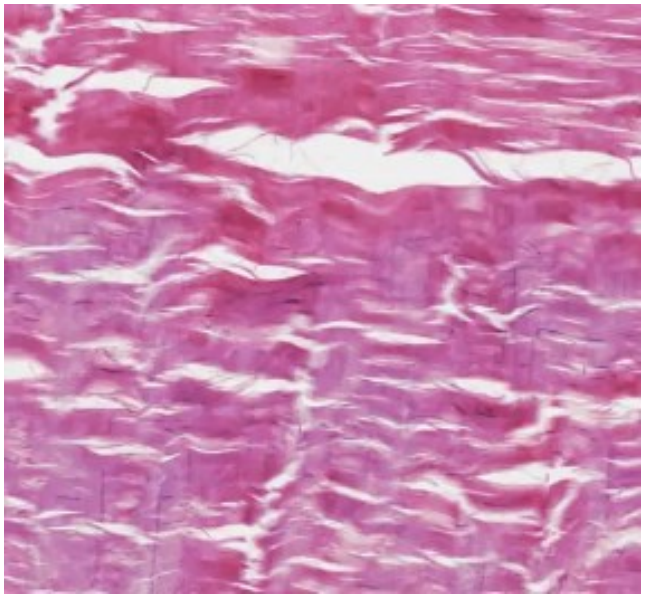


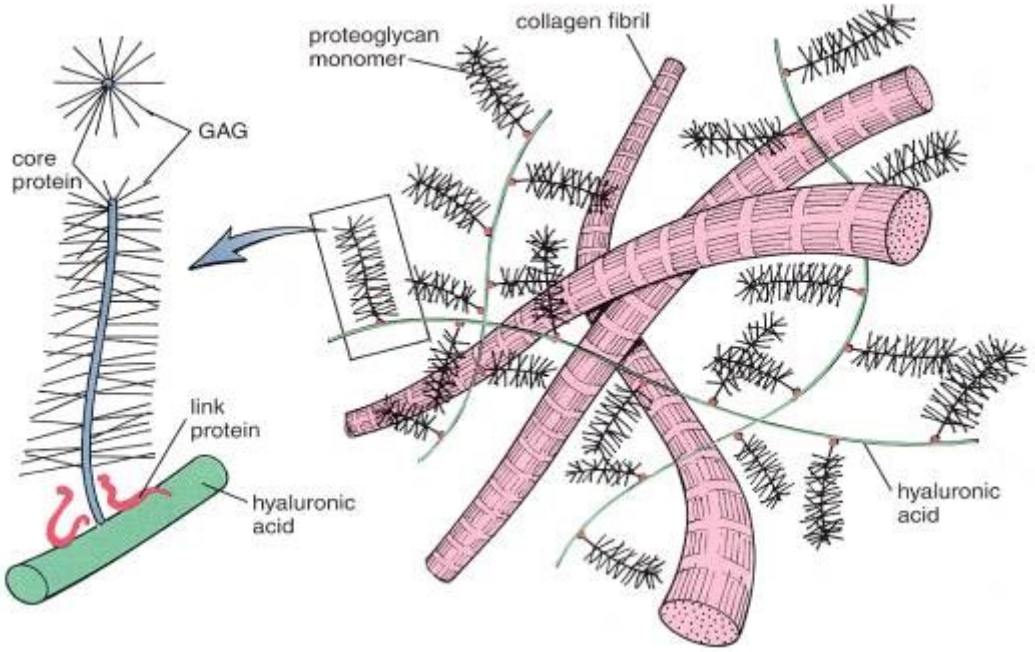
RETICULAR CONNECTIVE TISSUE

EXTRACELLULAR MATRIX – GROUND SUBSTANCE

Amorphous extracellular matrix

Colorless, transparent, homogenous substance consisting of glycosaminglycans, proteoglycans and structural glycoproteins



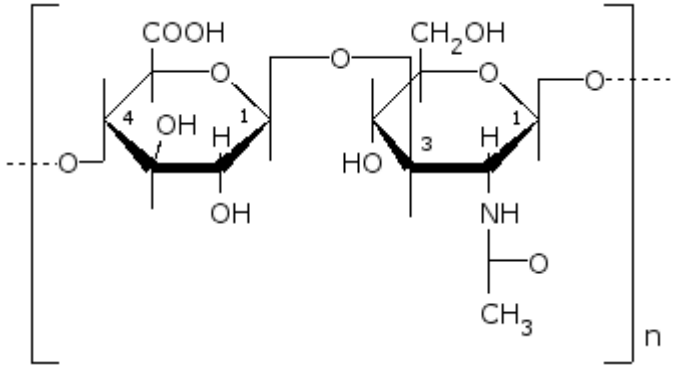


GLYCOSAMINOGLYCANS

linear polysaccharides composed of two disaccharide subunits
– uronic acid and hexosamine

polysaccharides rich in hexosamines = acid mukopolysaccharides

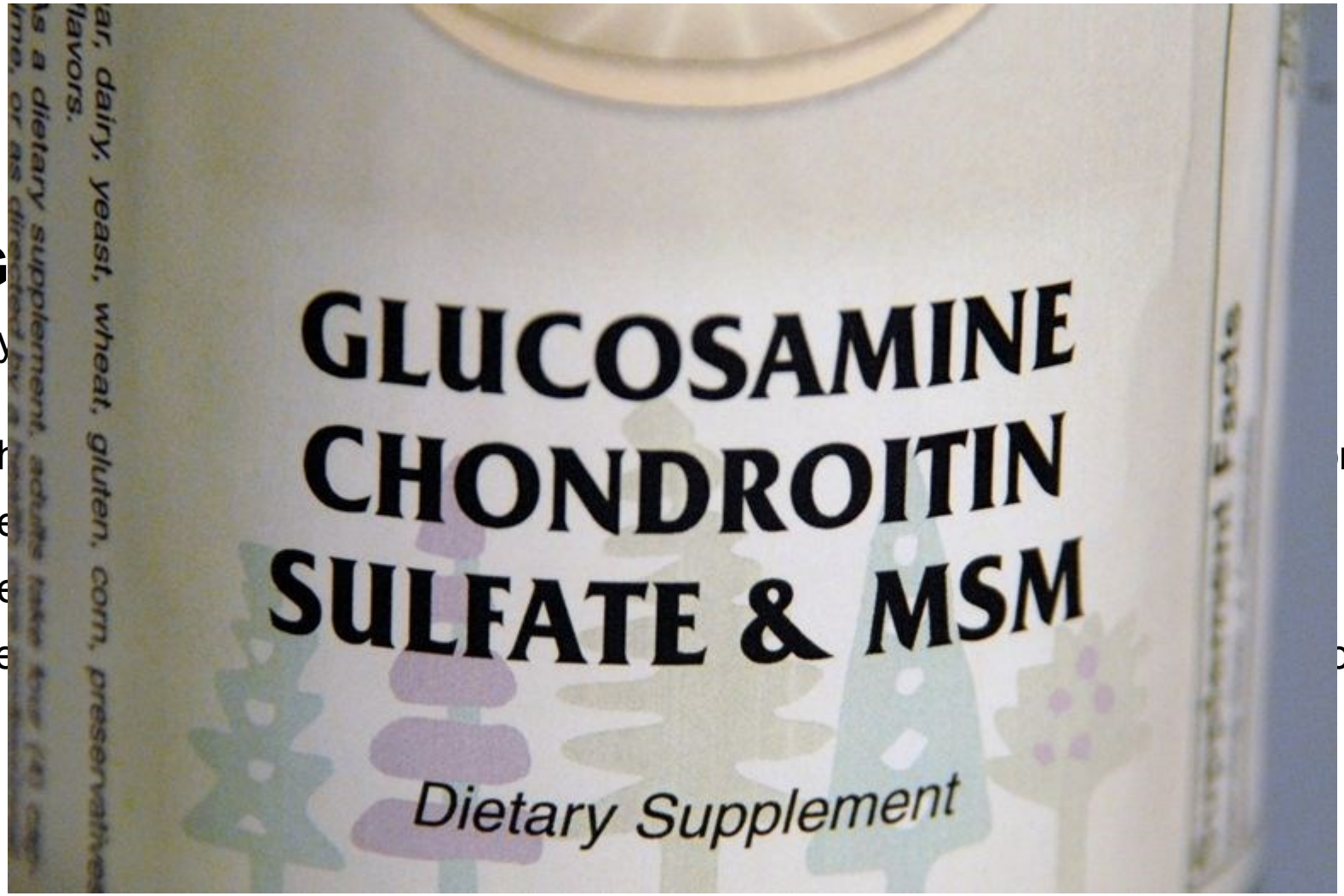
glucuronic or iduronic acid



glucosamin or galactosamin

GLYCOSAMINOGLYCANS

They bind to protein structures (except for hyaluronic acid)



G

Hy vitreum,

Ch rta

De

He

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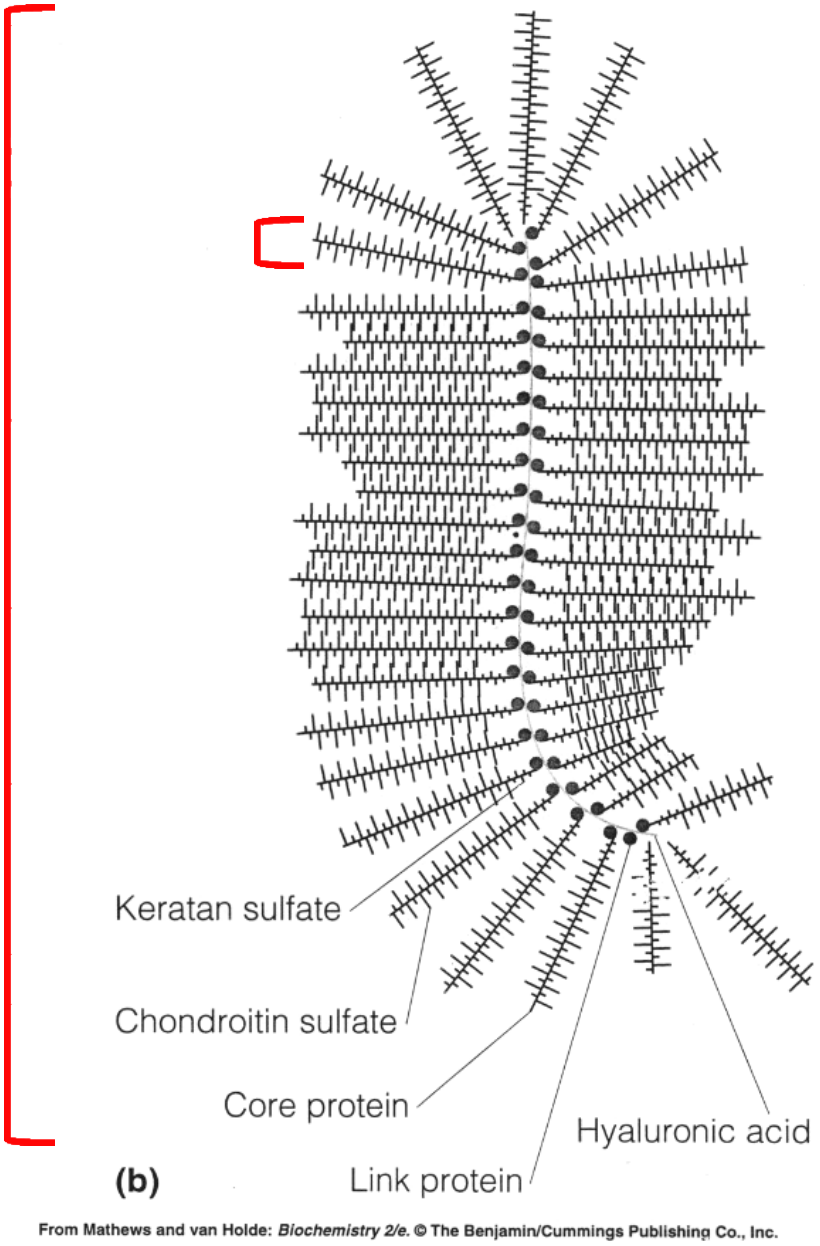
PROTEOGLYCANS

— protein + dominant linear saccharide component

— proteoglycan aggregates

— water-binding, volume dependent of hydratation

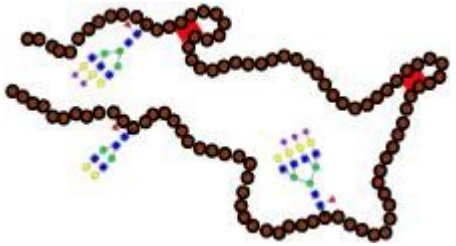
— aggrecan (cartilage)
— syndecan
— fibroglycan



From Mathews and van Holde: *Biochemistry 2/e.* © The Benjamin/Cummings Publishing Co., Inc.

STRUCTURAL GLYCOPROTEINS

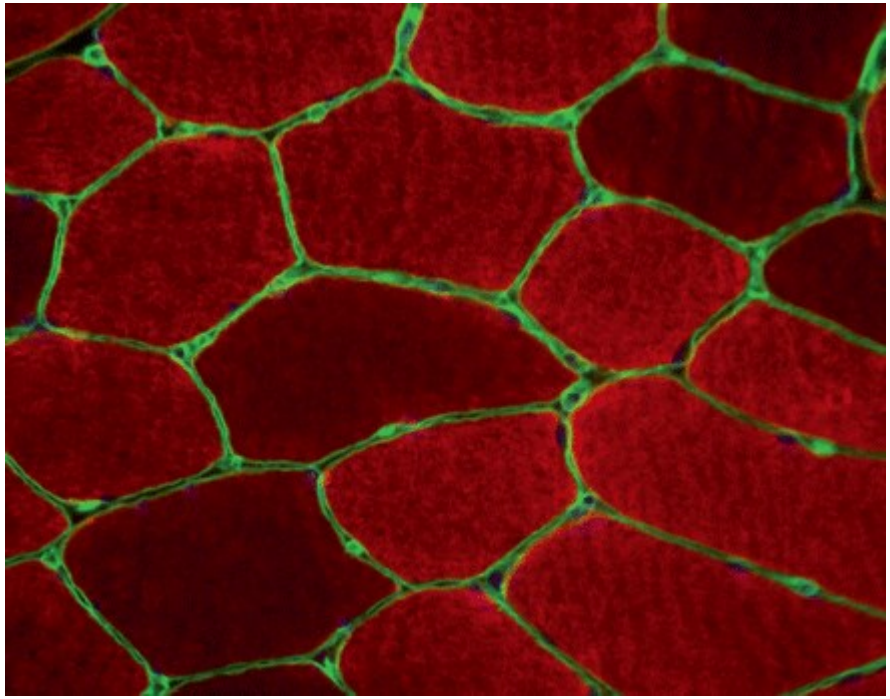
- dominant protein + branched saccharide component
- interaction between cells and ECM



— **fibronectin** – connects collagen fibers and glykosaminoglycans, cell adhesion and migration

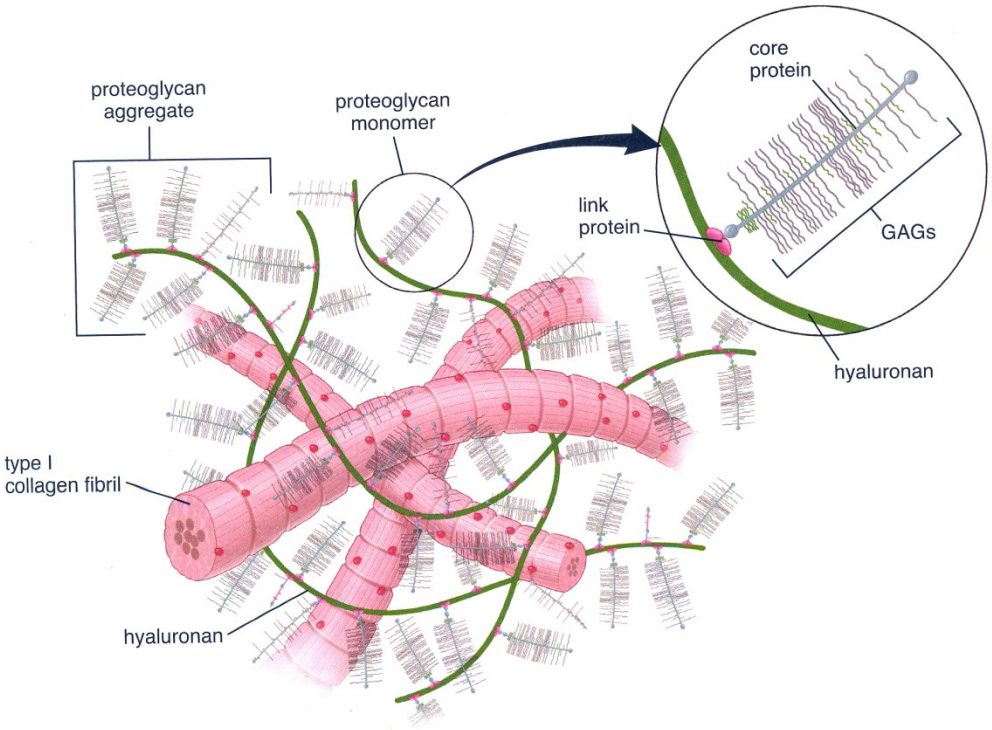
— **laminin** – basal lamina – epithelial integrity

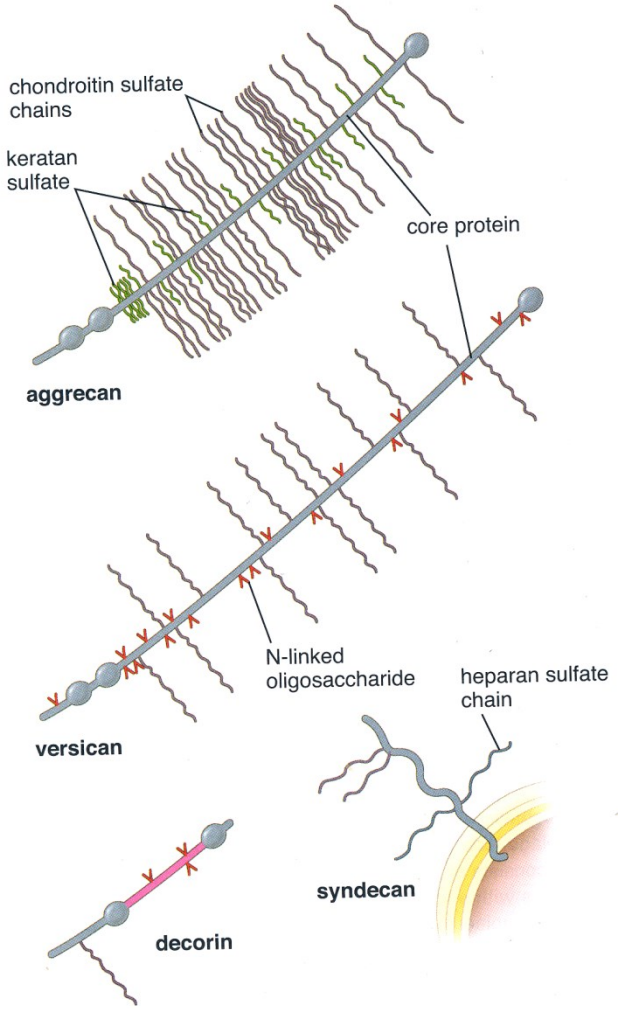
— **chondronectin** – cartilage – adhesion of chondrocytes to collagen



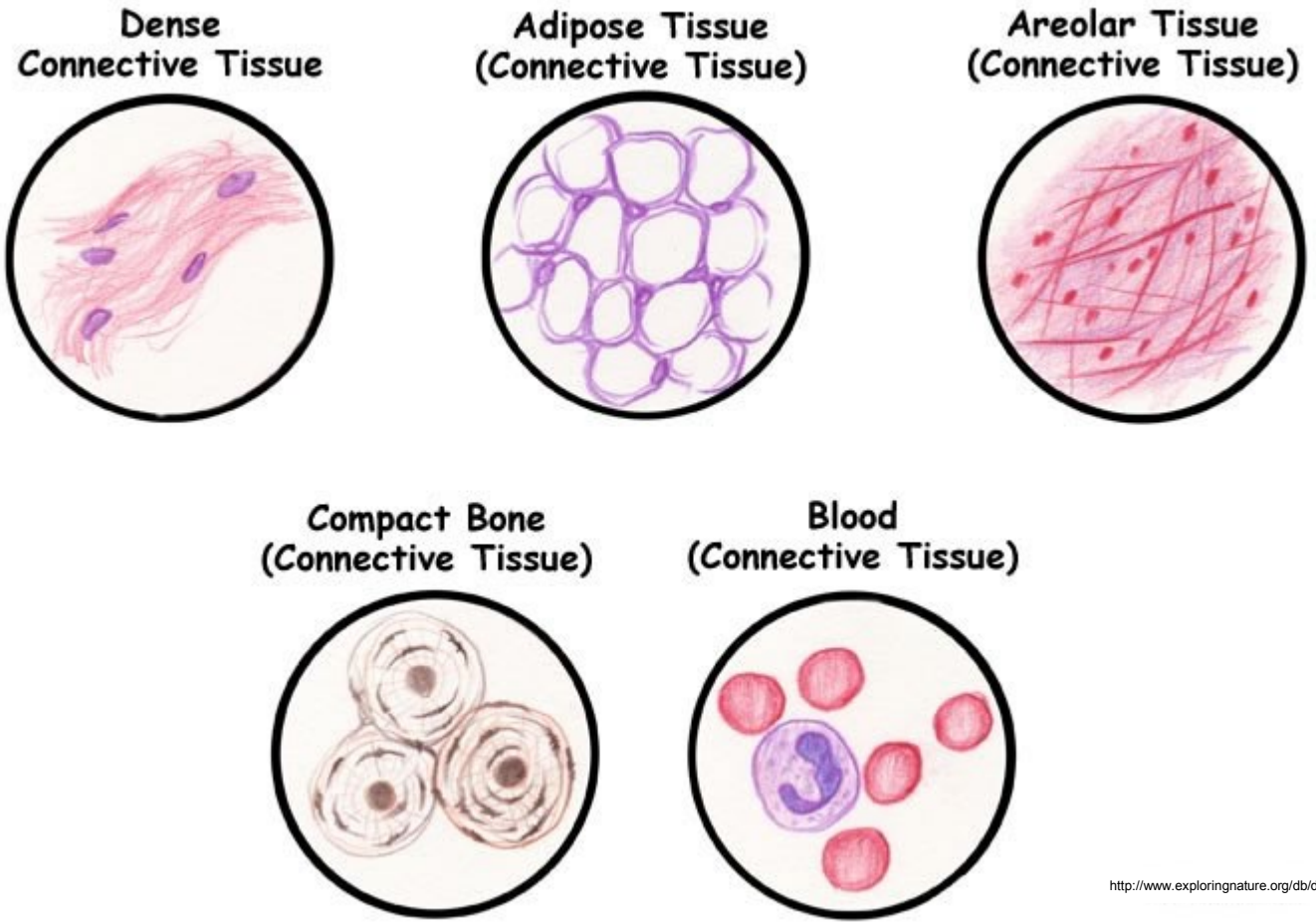
(J. Nutr. 136:2123-2126, 2006)

COMPOSITION OF ECM





CLASSIFICATION OF SPECIALIZED CONNECTIVE TISSUE



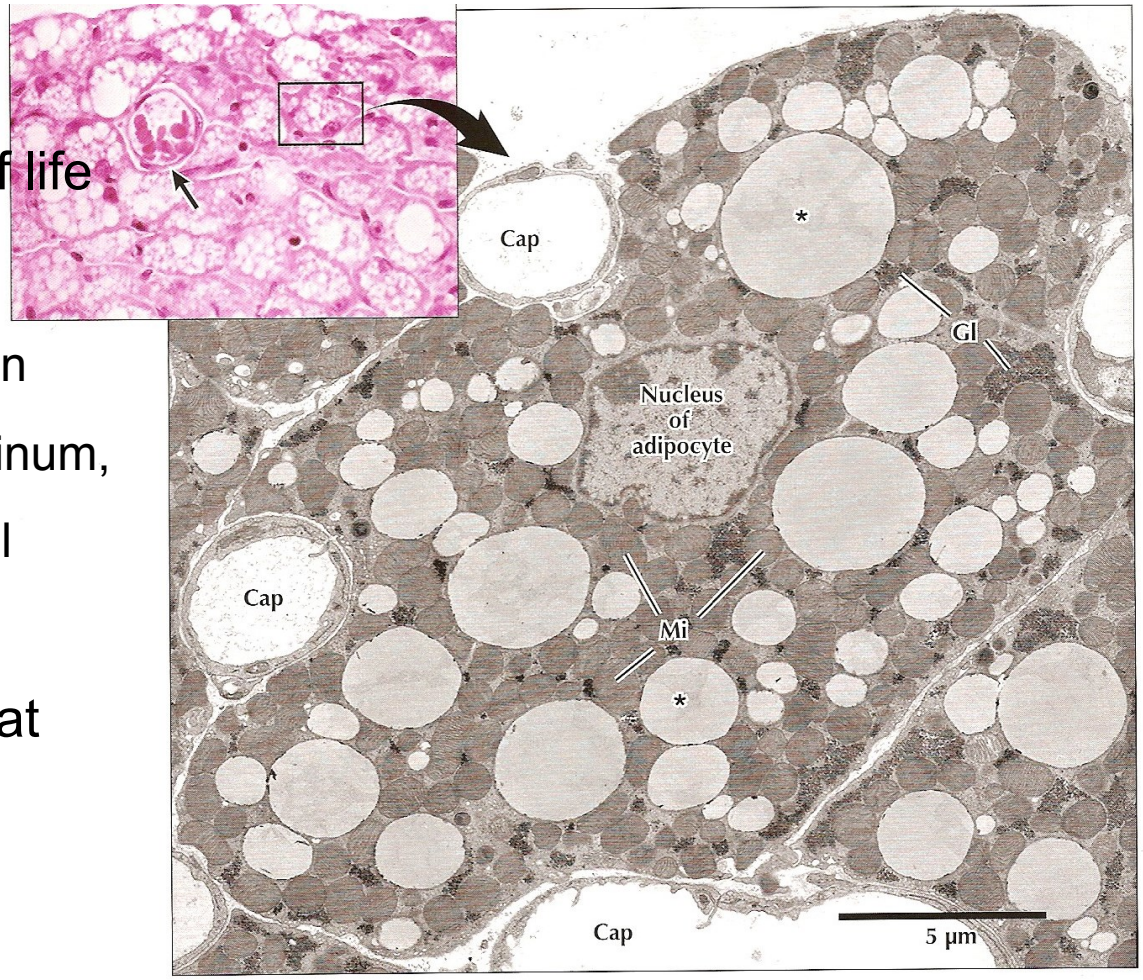
http://www.exploringnature.org/db/detail.php?dbID=21&detID=691

ADIPOSE TISSUE

- Adipocytes, fibroblasts, reticular, collagen and elastic fibers, capillaries
- White and brown adipose tissue

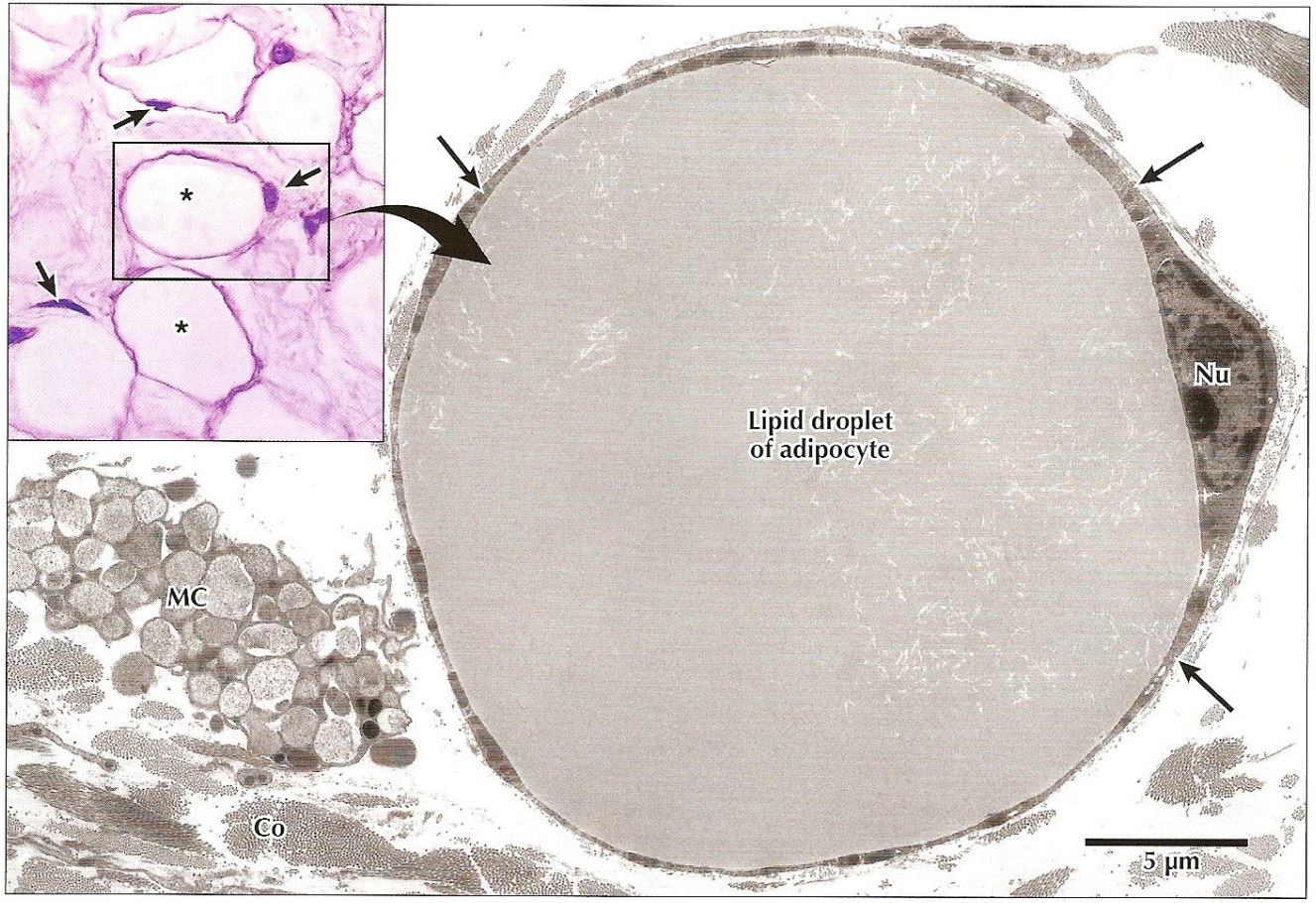
BROWN ADIPOSE TISSUE

- fetus and child to 1st year of life
- fast source of energy
- typical localization – between shoulder blades, axilla, mediastinum, around kidneys, pancreas, small intestine
- small cells with numerous fat droplets

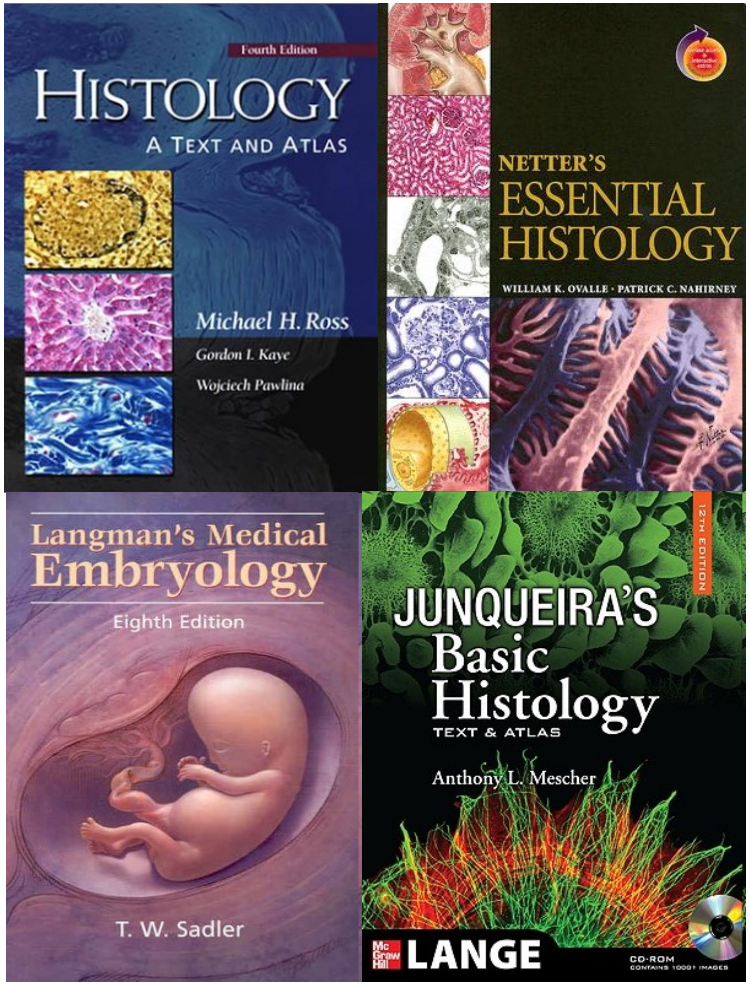


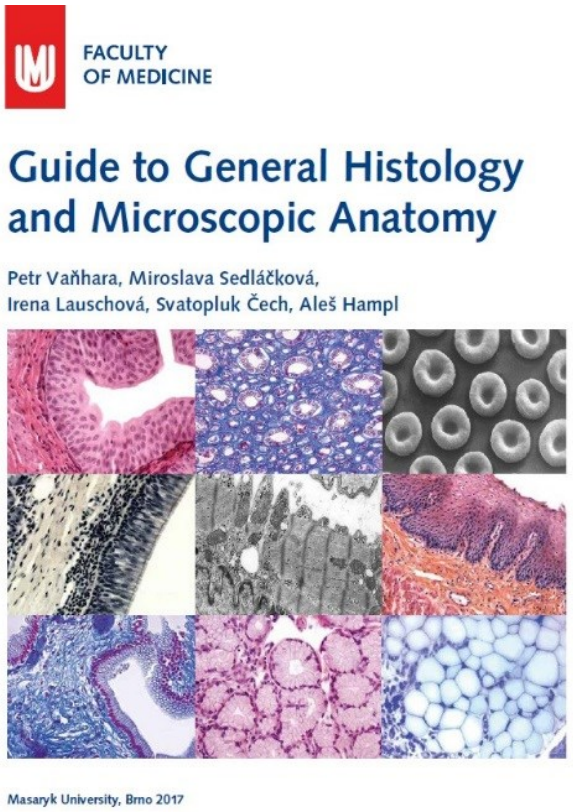
WHITE ADIPOSE TISSUE

- adipocytes are actively formed until 2nd year of life
- no innervations, but rich vascularisation
- adipocytes with only one lipid droplet
- leptin (adipokinins)

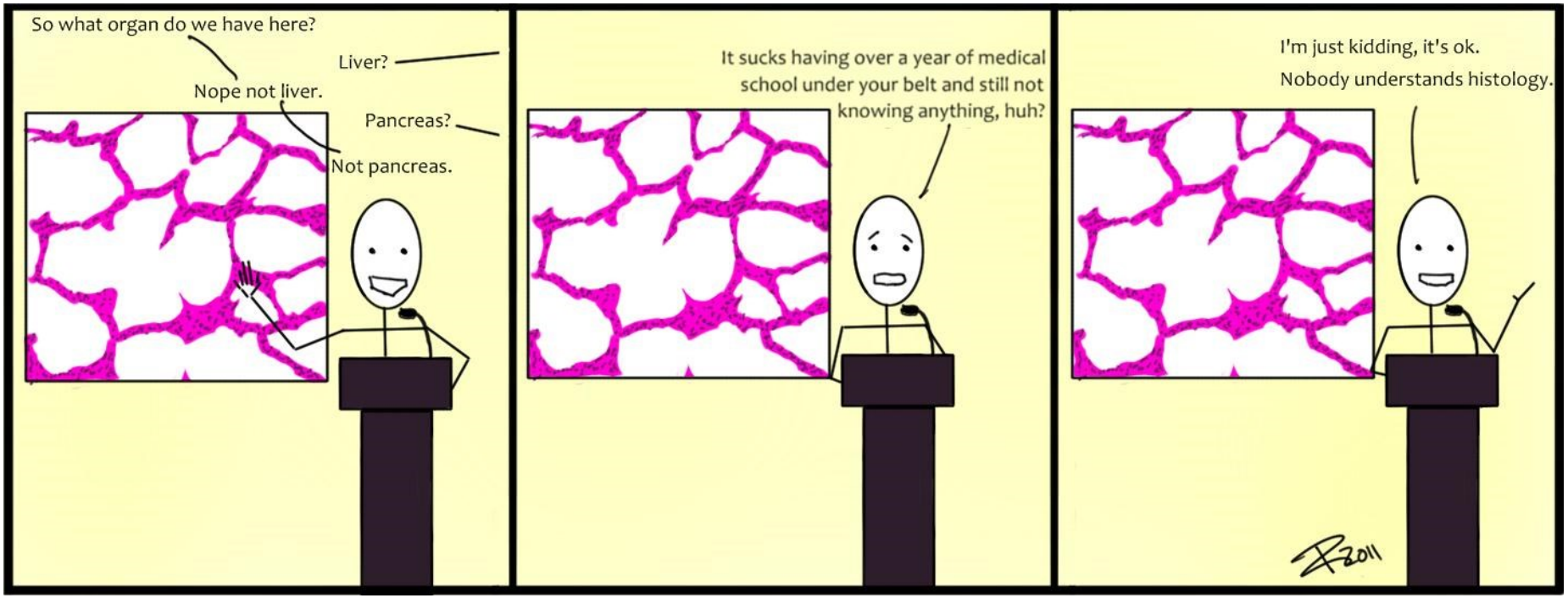


FURTHER STUDY





http://www.med.muni.cz/histology



Thank you for attention

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