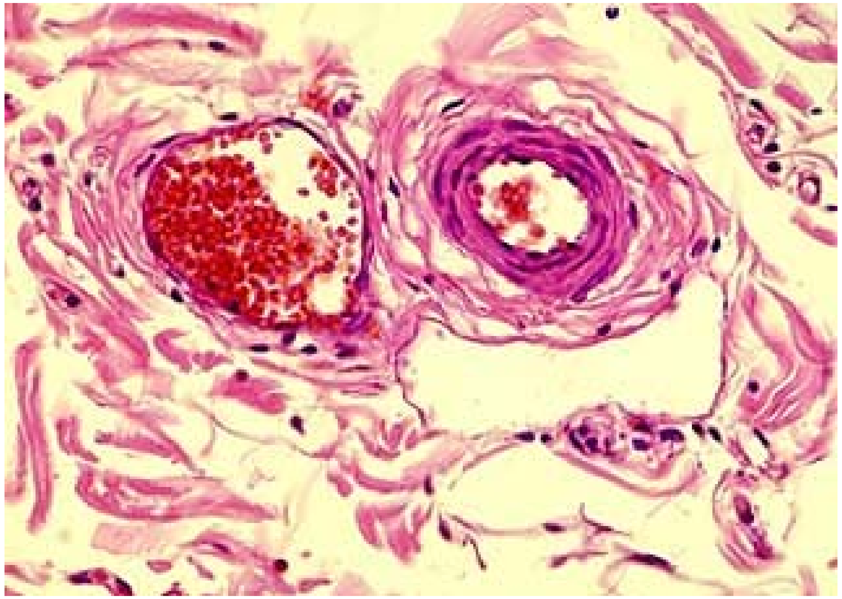
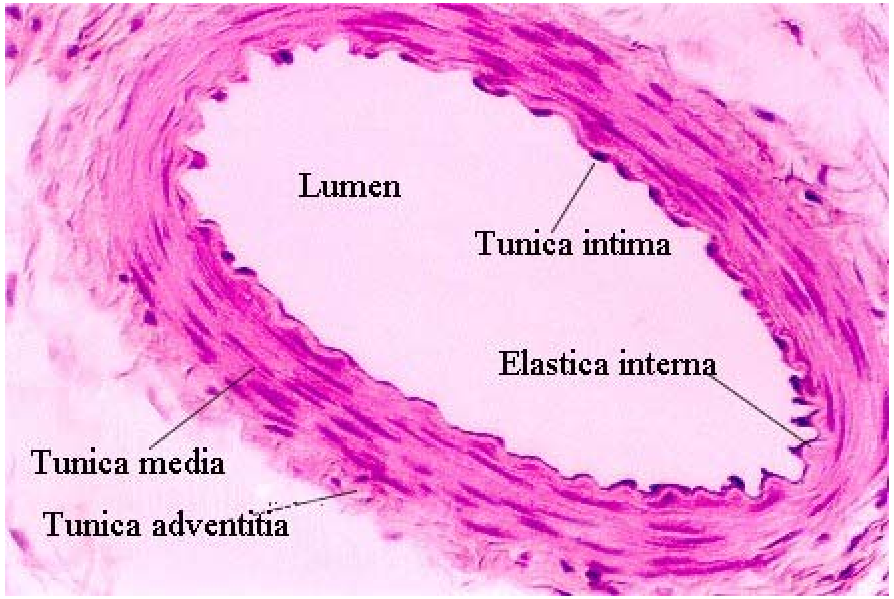
Blood Vessels



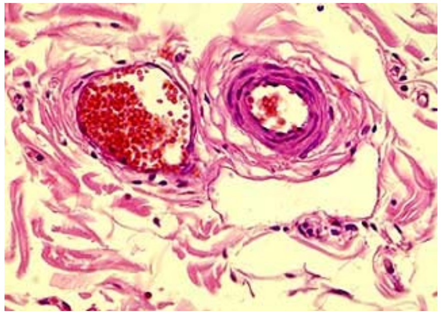
Vein and artery

www.indigo.com



Muscular artery

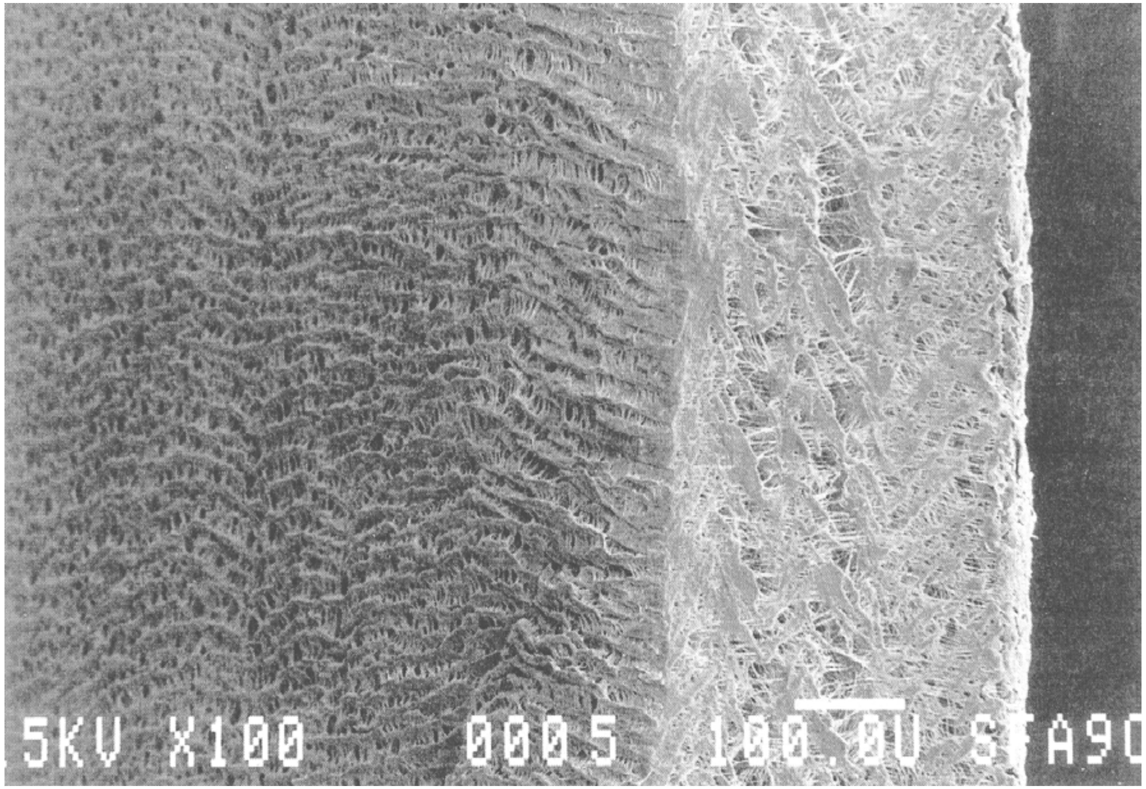
http://cellbio.utmb.edu/microanatomy/cardiovascular/cardiovascular_system.htm#Elastic%20Artery



Blood vessels Implant materials

- PTFE, PET due to the high resistance against biodegradation
- PTFE
  - Original used as fabric
  - Disadvantage: blood vessel expansion on the joints by fraying$_{\text{Ausfransen}}$ on the cut surface of the fabric (depends on seam technique$_{\text{Nahttechnik}}$)
  - PTFE fabrics lead to worse results than PTFE knitted fabrics or PET fabrics and knitted fabrics:
    - A healing by regeneration of the intima does not occur by using of knitted PTFE implants, but
    - Long-term stability of PTFE is superior in comparison to other biological and artificial materials; therefore implant optimisation started by changing the implant design

PTFE Implant



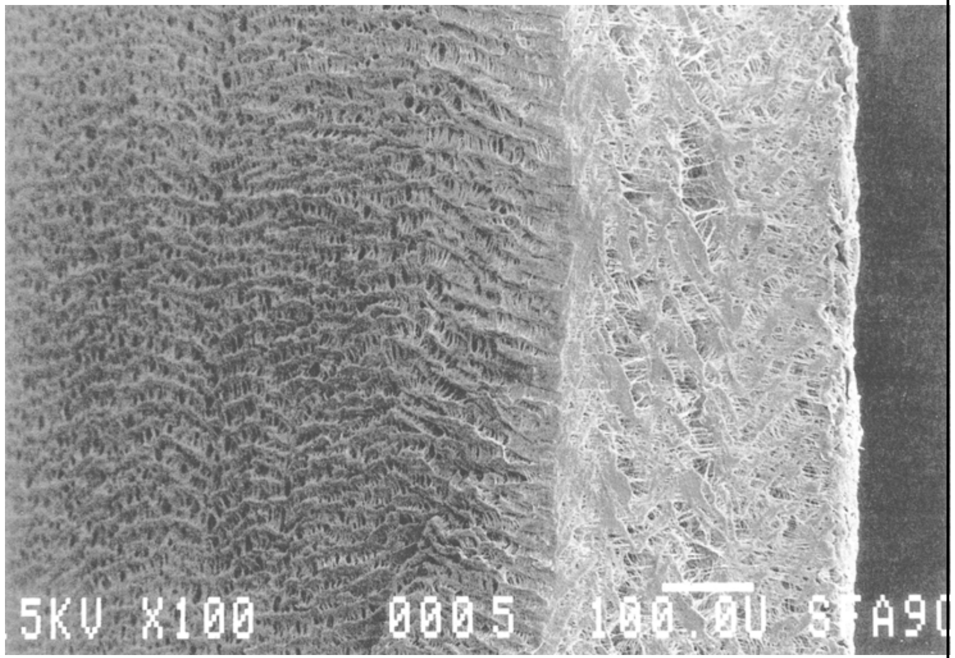
inner surface and implant wall cross-section, structure: knots connected by fibrils, produced by high-temperature stretching

Arterial replacement above the knee

(S. Dumitriu, 1994)

Disadvantages

- Responsible for cell proliferation on the inner surface of the vessel and on the bond regions
- no healing
- Cause for bacteria formation at the glycocalix (outer vessel surface)
- Under special conditions thrombus formation is initiated



(S. Dumitriu, 1994)

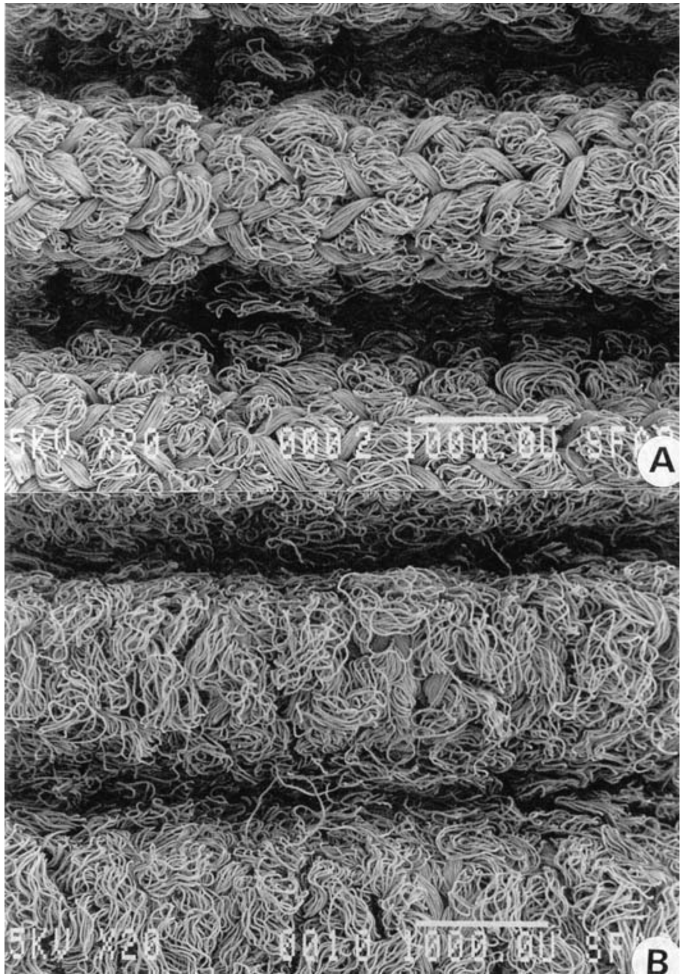
PET

- Basic requirements
  - Generation of an „intima“ inside
  - Integration with surrounding tissue
    - Big, textured surface
    - Lightweight implants:
      - Open fabric with big pores
      - Optimisation of porosity by H_2O permeability ⇒
      - Thinner and thinner fabric textures with finer and finer yarns
      - Higher permeability must lead to problems at a certain point especially concerning the hemostasis$_{\text{Blutstillung}}$ ⇒
      - Bleeding during surgery, formation of secondary haematomas followed by prosthesis dilatation and failure
      - This concept is not in further consideration
    - Velour-like implants

PET

- Velour-like implants
  - Weaving or knitting of unstretched (buckled) fibres
  - Rough, statistic, open inner and/or outer surface
  - Outside:
    - Better integration in the surrounding tissue
  - Inside:
    - Promotion of regeneration if the inner surface of the vessel; in human tissue a complete endothelium formation can not be monitored

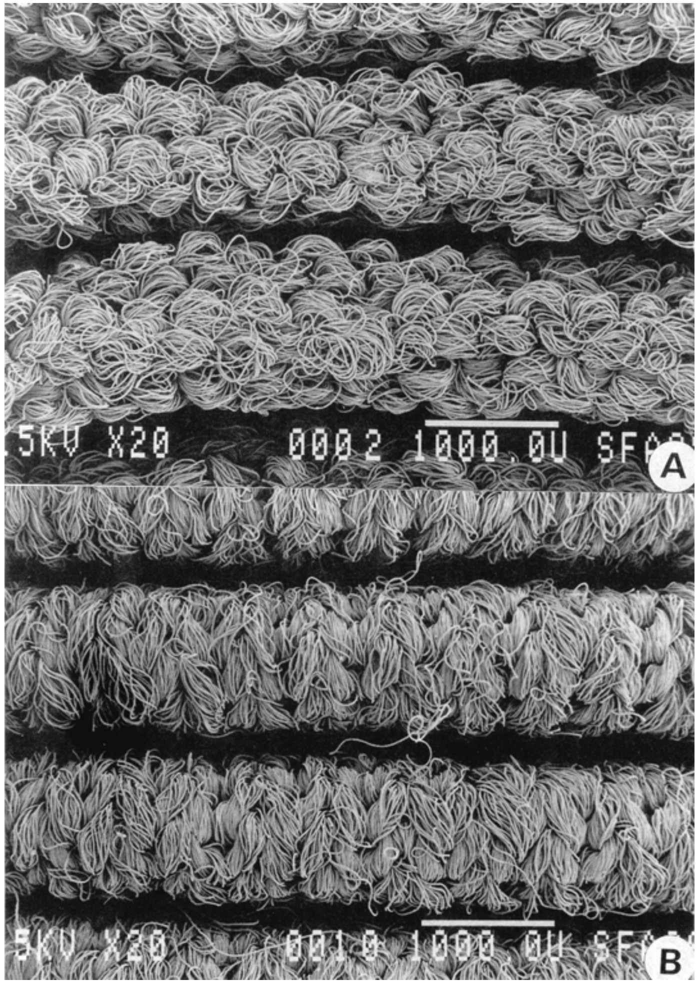
Knitted Fabric: Warp thread$_{\text{Kettfaden}}$ in longitudinal direction, made of polyester yarn (PET)



(S. Dumitriu, 1994)

good healing implant due to the high number of anchorage possibilities and the good possibilities for tissue ingrowth in the surface
(A … inside, B …outside)

Knitted Fabric: Warp thread$_{\text{Kettfaden}}$ in transverse direction, made of polyester yarn (PET)



(S. Dumitriu, 1994)

(A … inside, B …outside)

Procedures for Improving Implant Properties

- Increasing biocompatibility by impregnating or coating with crosslinked proteins
  - Healing just little influenced, protein coating maybe causes a slowdown
- At slow absorption of the coating additional antibiotics and growth factors can be incorporated $\rightarrow$ decrease of the infection risk

Degradable Implants

- Basic principle corresponds with the degradable cranial implant
  - Stepwise disintegration after implantation and simultaneous replacement by natural tissue
  - Materials on the basis of polyglycolide acids and polylactide acids
  - Example: PUR-Poly-L-Lactide:
    - Microporous, biodegradable, sufficient mechanical properties
    - Degradation by penetration of cells in the micropores
    - Cell stimulation: release of collagen and elastin
    - Hydrolysis of the Poly-L-Lactide
    - Requirement for functionality: ability of the cells to form appropriate artery cells

Coronary stents

- Indication: blocked coronary circulation
- Requirements
  - biocompatible (no haemotoxicity, thrombogenicity, ...)
  - flexible and supportive
  - expandable
- Design: meshlike, slotted tubes inserted into the prior delated vessel
  - balloon-expandable
  - self-expanding
  - covered and non-covered
  - coated and non-coated
  - with drug delivery and without delivery

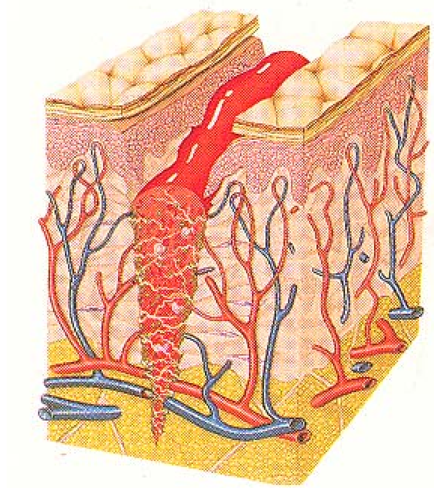
http://www.youtube.com/watch?v=9FPapBbbS4o

Coronary stents – Metal materials

- Non degradable
  - Stainless steel (SS)
    - least expensive material
    - problems with some medical imaging (NMR), restenosis and thrombosis
  - CoCr alloy
  - Ti / Ti alloy
    - Nitinol (55% Ni and 45% Ti) -> SMA
  - Ta / Ta alloy
  - PtCr alloy
  - PtIr alloy
- Degradable
  - Pure Fe
    - oxidation of Fe into ions that can be dissolved
  - Mg alloy
    - low elastic modulus -> poor radial strength
    - radiolucent

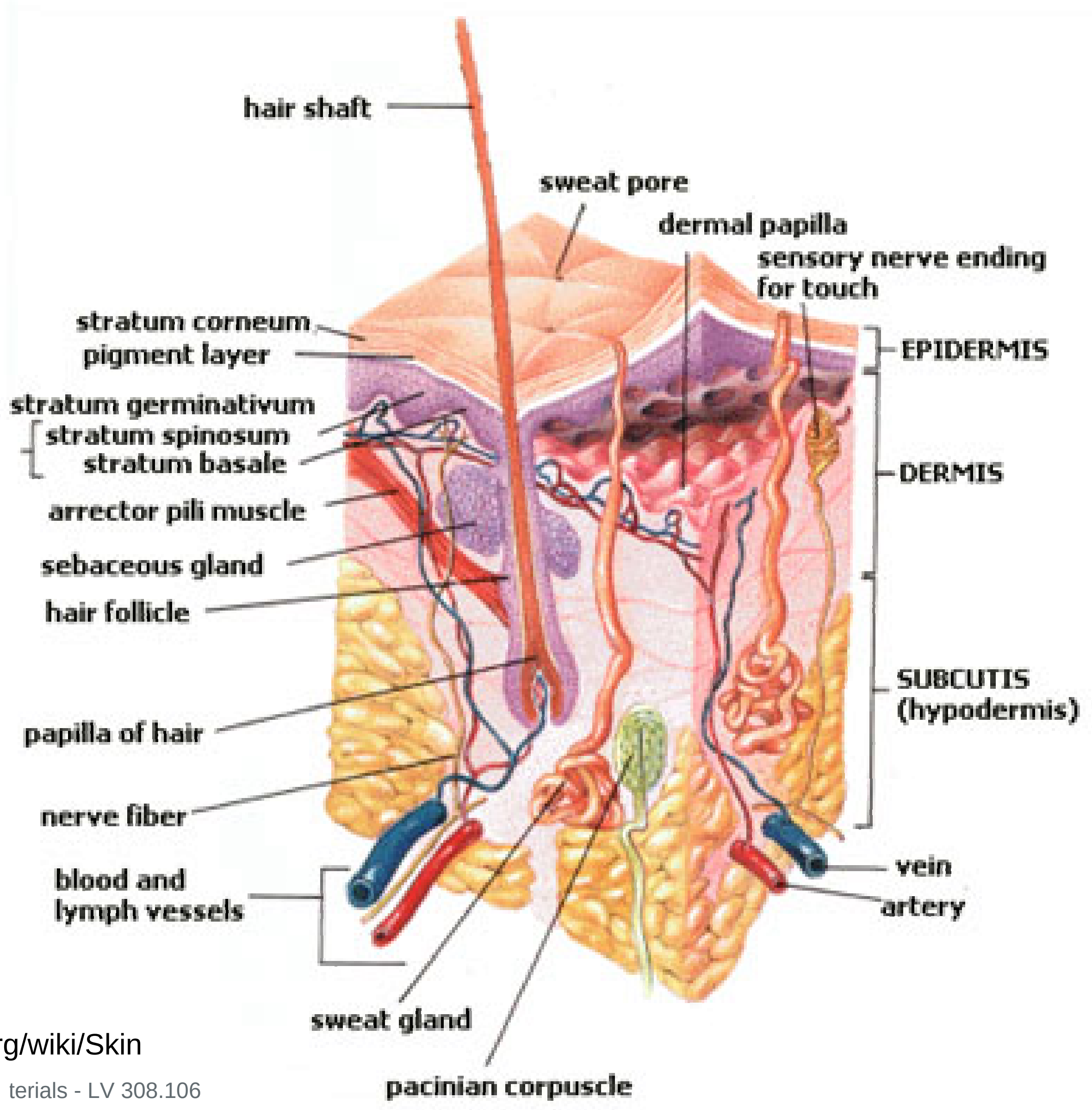
Coronary stents – Polymeric materials

- Non degradable
  - Silicones
    - challenges: coil strength and durability
  - PE, PUR
    - Problems with protein adhesion and biofilm formation
  - PET
    - braided mesh similar radial pressure than with SS
- Biodegradable polymers for coatings/drug delivery
  - PLGA (PLA and PGA)
  - P3HB/PHV
  - EVA
  - MMA/HEMA
  - Laurylmethacrylate/Methacryloylphosphorylcholine
  - Phosphorylcholine
  - Hyaluronic acid
  - Fibrin



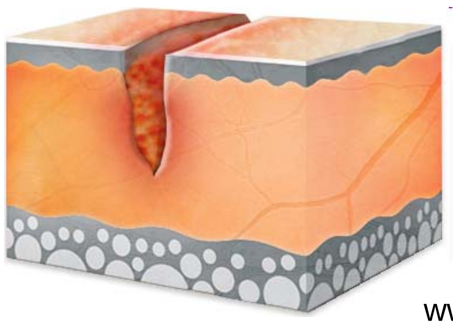
Wound Dressings

The skin



en.wikipedia.org/wiki/Skin

Wound



www.narbeninfo.de/narben/

An injury in which the skin
e.g.,

- is torn
- is cut
- is punctured

or

- has a contusion

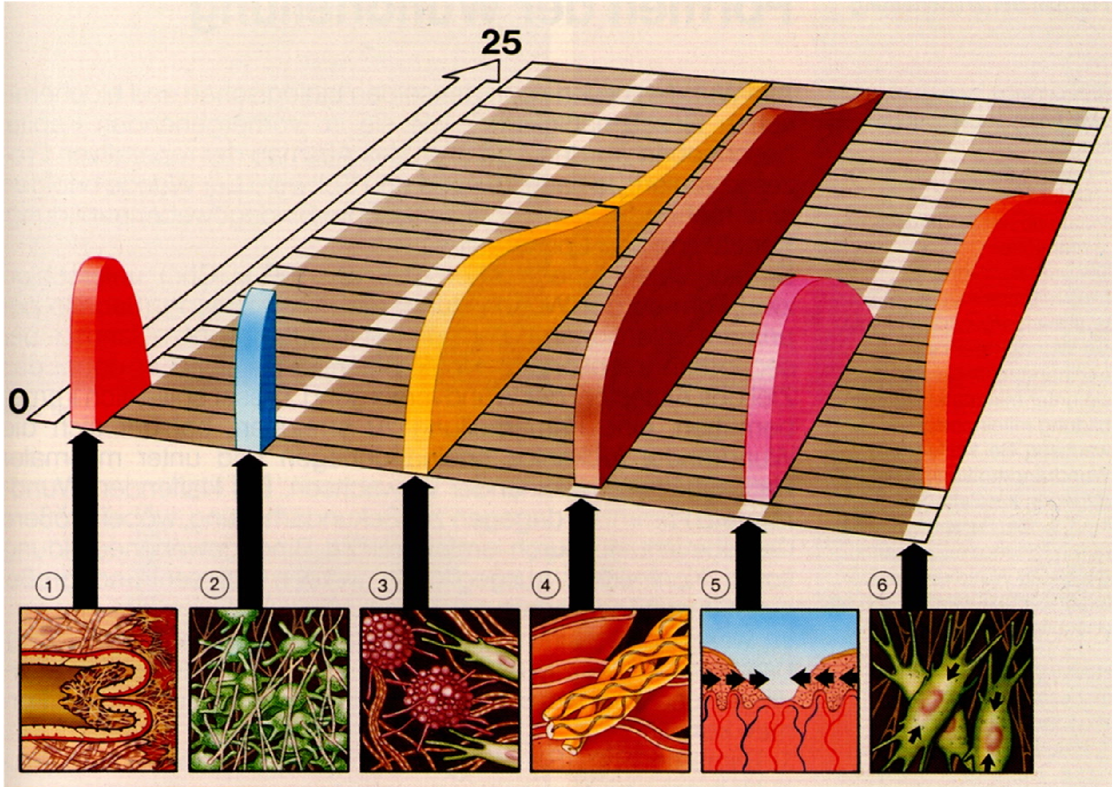
} open wound (is torn, is cut, is punctured)

} closed wound (has a contusion)

Wound Healing Process

- **Exudation phase:** Exudation of fibrin, generation of a primitive wound matrix (hyaluronic acid, fibronectin), migration of leukozytes and makrophages, thrombocytes release growth factors
- **Granulation phase:** Granulation, generation of new capillaries and settlement of the wound matrix with cells (fibroblasts)
- **Epithelialisation phase:** generation of epithel
- ***Maturation phase*** *of the scar*

Physiology of the wound healing process



1. Reaction of the blood vessel
2. Blood coagulation
3. Inflammation
4. Tissue generation
5. Epithelialisation
6. Contraction

Wound Classification

Dry „black“ wounds	„sloughy“ wounds	secreting „yellow“ wounds	clean „red“ wounds	healing „pink“ wounds

Comberg, Klimm, Allgemeinmedizin (ISBN 313126814X), © 2004 Georg Thieme Verlag

Requirements on effective wound dressings

- Moist wound milieu has to be kept
- Gas exchange between wound and environment has to be guaranteed
- Wound exudate has to be absorbed by the dressing
- Thermal insulation of the wound
- Dressing replacement must be possible without destroying the new formed epithelial tissue
- Protection of the wound against secondary infections

Advantages of an Occlusive Treatment

- Induction of the autolytic debridement (removal of dead, damaged, or infected tissue)
- Stimulation of the „repairing“
- Propagation of the epithelialisation
- Wound protection against external infections
- Maintenance of a ideal temperature for wound healing
- Atraumatic dressing replacement