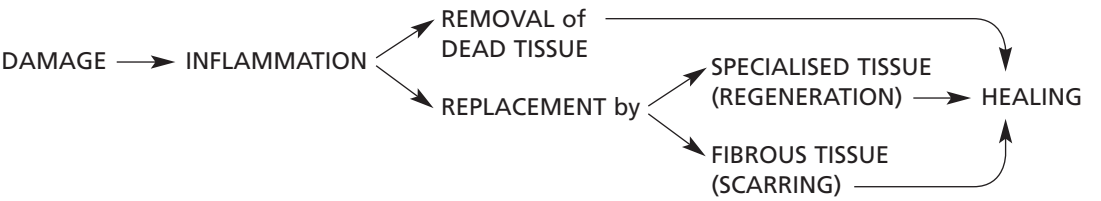
CHAPTER 3

HEALING

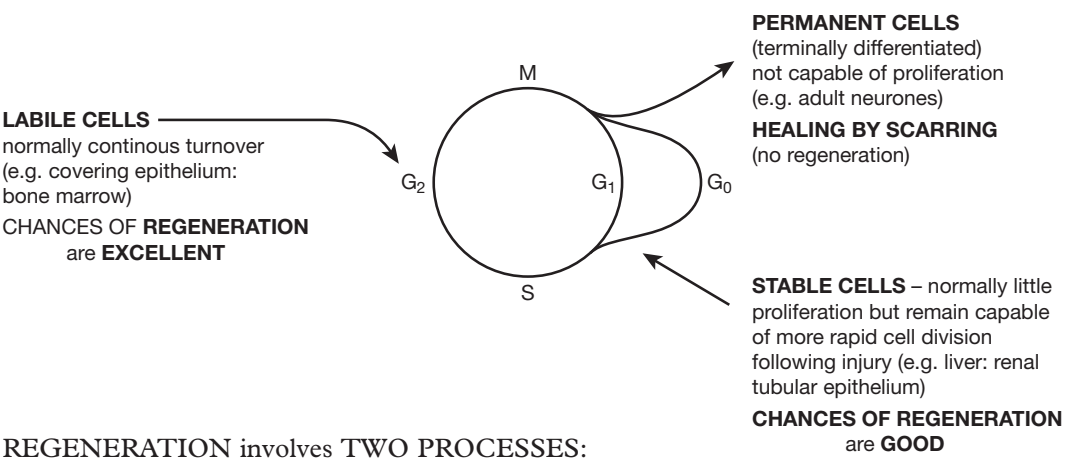
HEALING

Healing is the final stage of the response of tissue to injury.



The capacity of a tissue for REGENERATION depends on its PROLIFERATIVE ABILITY and on the type and severity of the damage. In particular, regeneration is not possible if the STEM CELLS are destroyed.

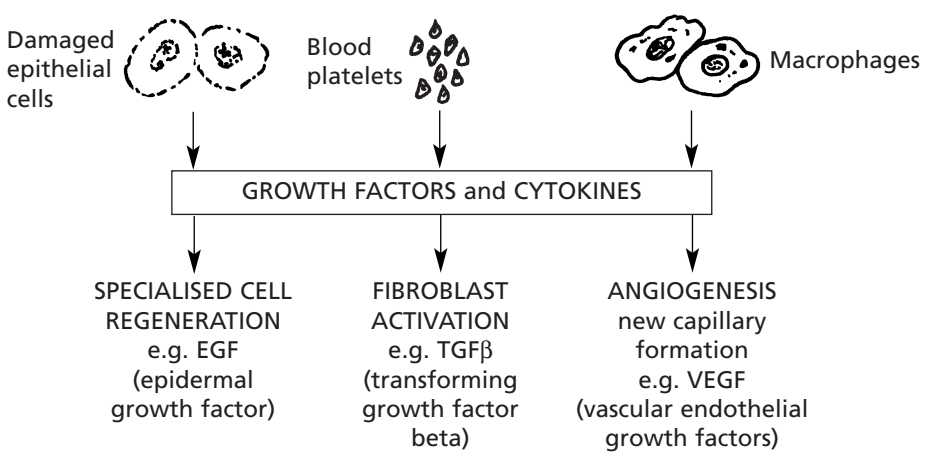
Three broad GROUPS of cells are considered in the context of the cell cycle (p.3).



REGENERATION involves TWO PROCESSES:

1. PROLIFERATION of SURVIVING CELLS to replace lost tissue.
2. MIGRATION of SURVIVING CELLS into the vacant space.

The FACTORS which CONTROL healing and repair are complex: they include the production of a large variety of **growth factors.**

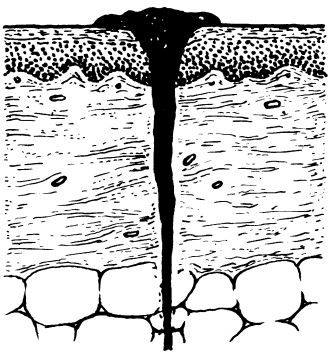


WOUND HEALING

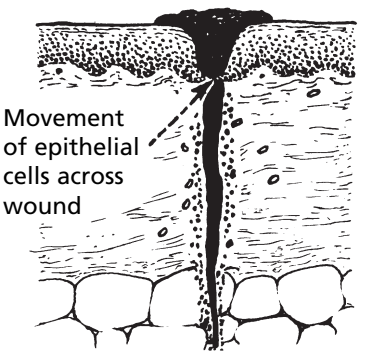
Healing of a wound shows both epithelial regeneration (healing of the epidermis) and repair by scarring (healing of the dermis).

Two patterns are described depending on the amount of tissue damage. These are the same process varying only in amount.

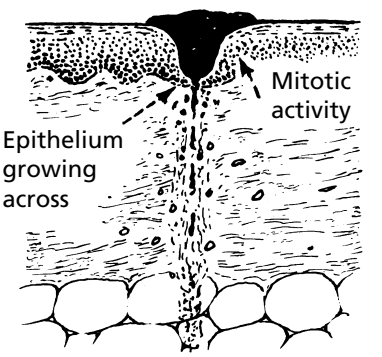
1. Healing by first intention (primary union)
This occurs in clean, incised wounds with good apposition of the edges – particularly planned surgical incisions.



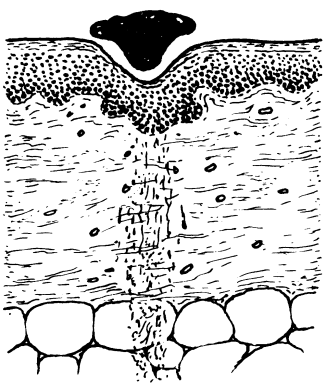
Immediately: Blood clot and debris fill the small cleft.



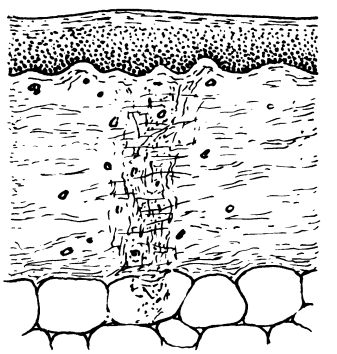
2–3 hours: Early inflammation close to edges. Mild hyperaemia and a few polymorphs.



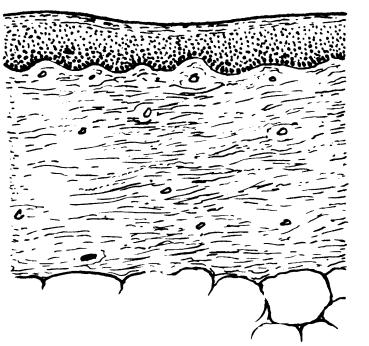
2–3 days: Macrophage activity removing clot. Proliferation of blood vessels.
Fibroblastic activity.



10–14 days: Scab loose and epithelial covering complete. Fibrous union of edges, but wound is still weak.



Weeks: Scar tissue still slightly hyperaemic.
Good fibrous union, but not full strength.



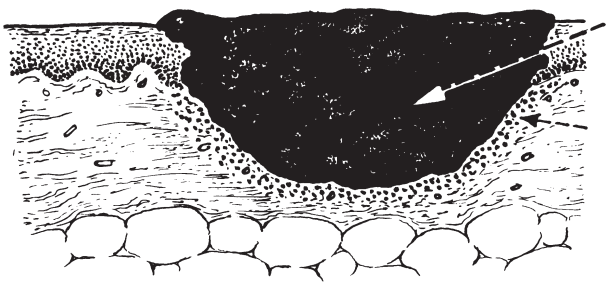
Months – years:
Devascularisation. Remodelling of collagen by enzyme action. Scar is now minimal and merges with surrounding tissues.

WOUND HEALING

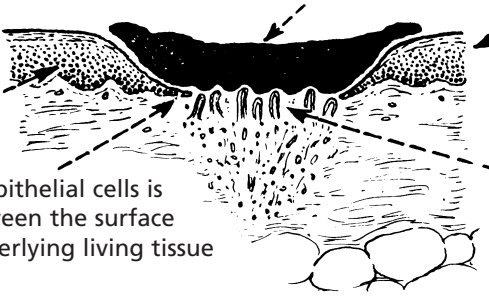
2. Healing by second intention (secondary union)

This occurs in open wounds, particularly when there has been significant loss of tissue, necrosis or infection.

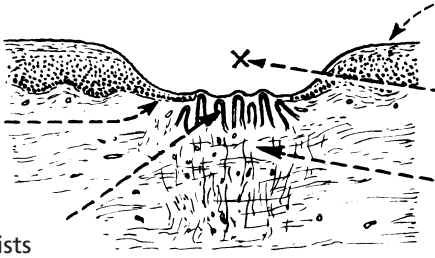
Early



A few days

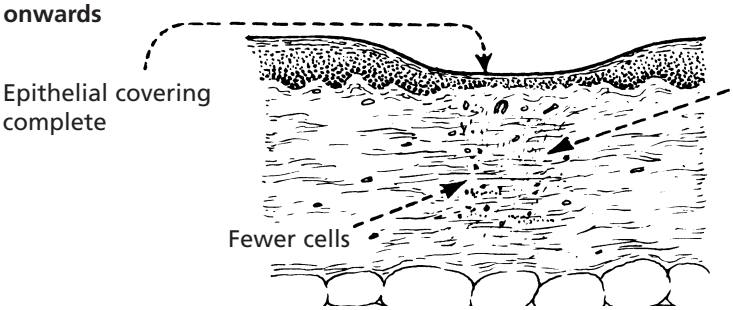


1 week approximately



Granulation tissue is seen in the base of the wound. This tissue consists of newly formed capillaries with fibroblasts and macrophages and occurs in many circumstances in addition to wounds.

2 weeks onwards

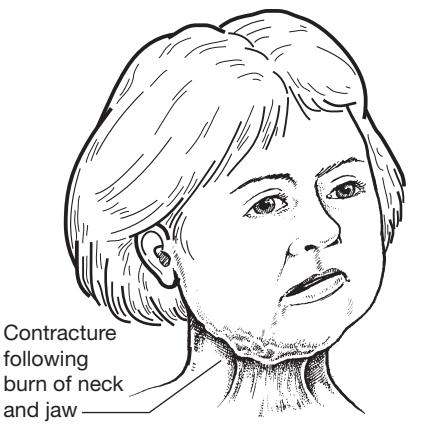


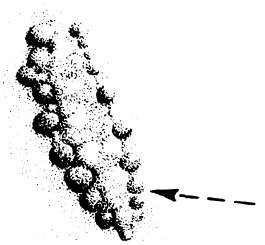
WOUND HEALING

Wound contraction
Wound contraction, which is beneficial and begins early, is due mainly to the young, specialised 'myofibroblasts' in the granulation tissue exerting a traction effect at the wound edges. The exposed surface is reduced by gradual regeneration of the surface epithelium. The remodelling of the collagen continues for many months.

COMPLICATIONS

1. Contracture
Later, CONTRACTURE may cause serious cosmetic and functional disability, particularly in deep and extensive skin burns and around joints if muscles are badly damaged.



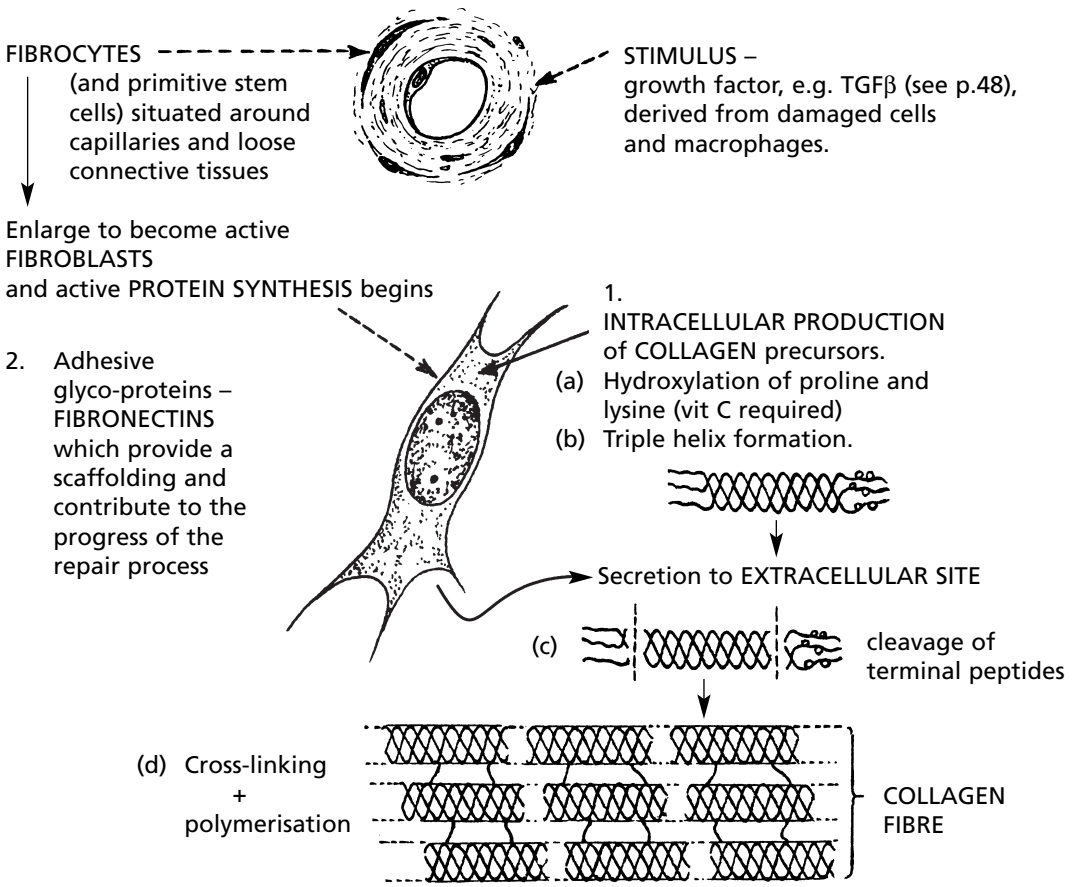


2. Keloid
The formation of excess collagen in the form of thick interlacing bundles which causes marked swelling at the site of the wound is known as a KELOID. The essential cause is unknown. It is particularly common in black people.

HEALING – FIBROSIS

FIBROSIS is the end result of WOUND HEALING, CHRONIC INFLAMMATION and ORGANISATION.

Formation of fibrous tissue



REMODELLING follows: Action of COLLAGENASE ⟶ SCAR TISSUE
+ secretion of COLLAGEN

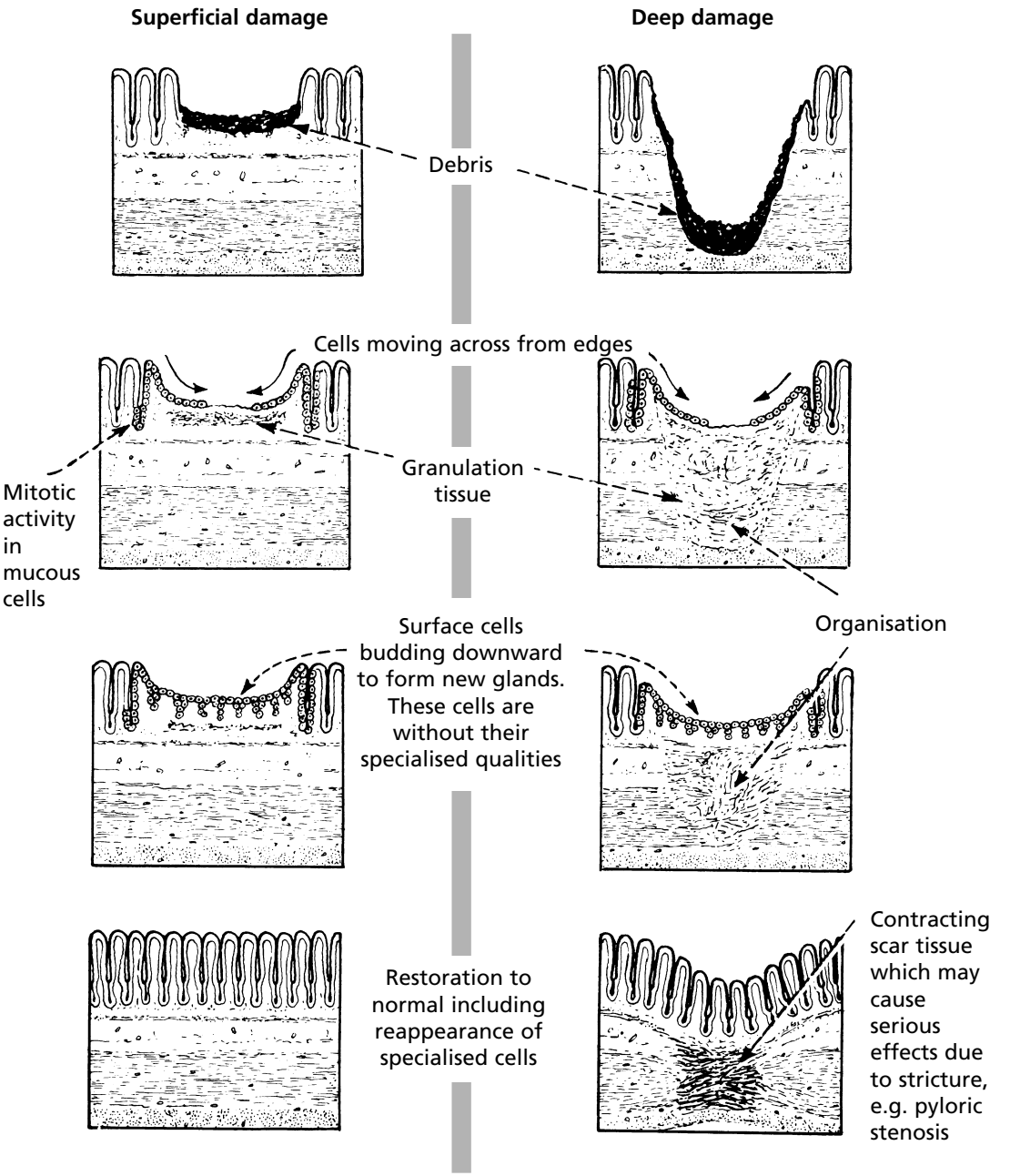
Factors delaying healing

1. Local
   INFECTION, a POOR BLOOD SUPPLY, excessive movement and presence of foreign material DELAY HEALING.
2. General
   DEFICIENCY of VITAMIN C
   DEFICIENCY of AMINO ACIDS (in malnutrition)
   DEFICIENCY of ZINC
   EXCESS of ADRENAL GLUCOCORTICOIDS
   DEBILITATING CHRONIC DISEASE
   } Failure of proper collagen synthesis with delayed healing and weak scars.

HEALING – SPECIAL SITUATIONS

INTERNAL SURFACES

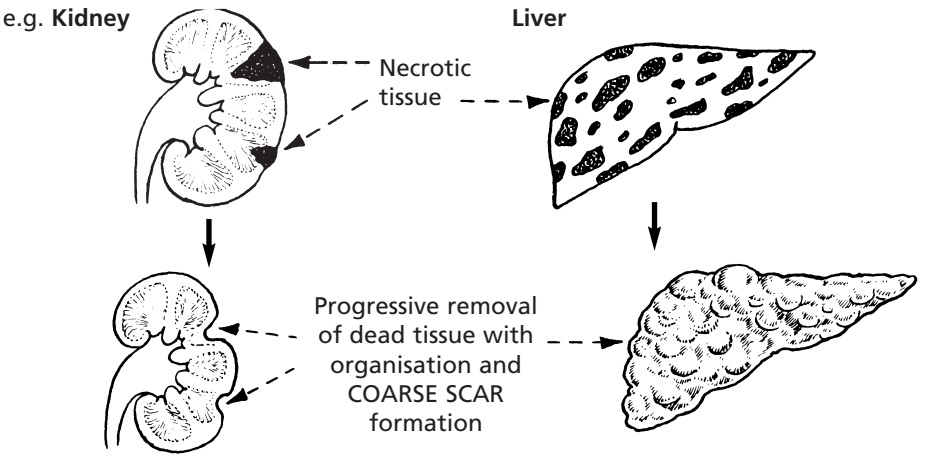
The epithelial lining of the gastrointestinal tract regenerates in a similar way to the skin.



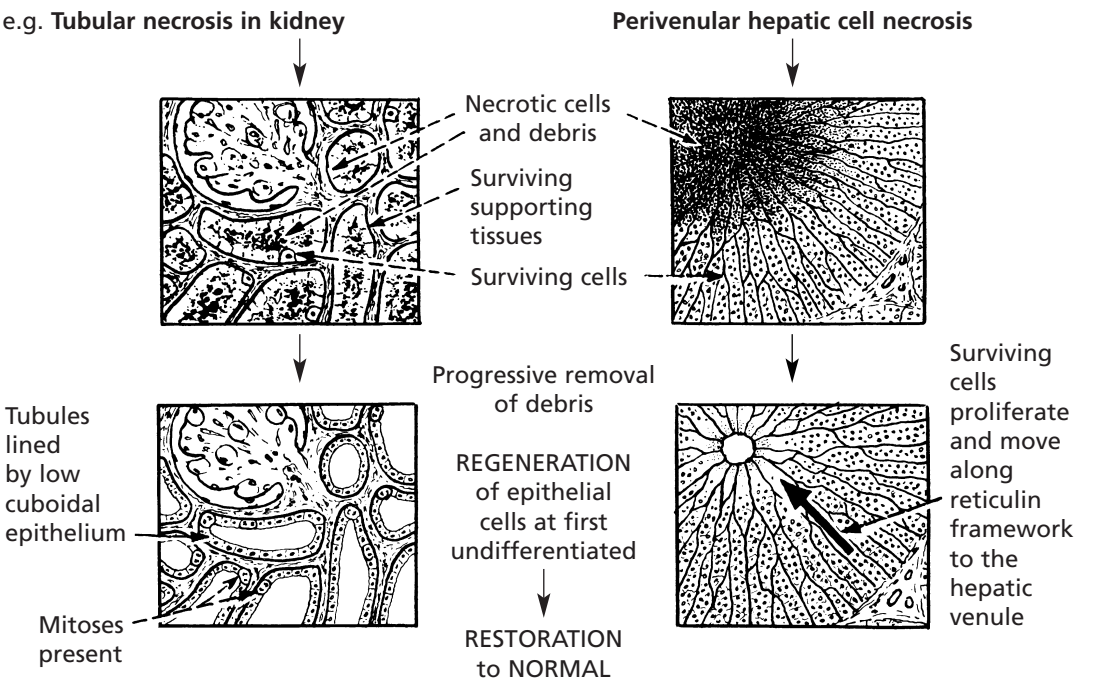
HEALING – SPECIAL SITUATIONS

SOLID EPITHELIAL ORGANS

1. **Following gross tissue damage – including supporting tissue** (post-necrotic scarring)



2. **Following cell damage with survival of the supporting (reticular) tissues**



HEALING – SPECIAL SITUATIONS

MUSCLE

Muscle fibres of all 3 types – skeletal, cardiac and smooth – have only limited capacity to regenerate.

When a MASS of muscle tissue is damaged, repair by SCARRING occurs. This is particularly important in the HEART after infarction.

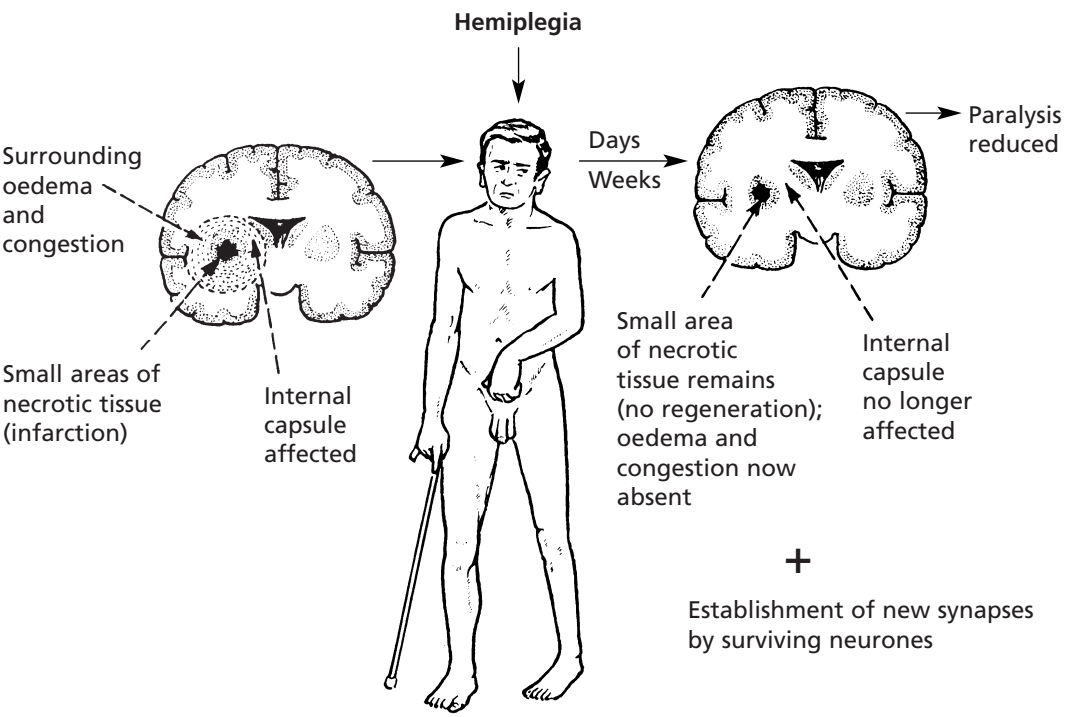
If the damage affects individual muscle fibres diffusely and with varying severity, then regeneration of the specialised fibres is possible (e.g. the myocardium may recover completely from the effects of diphtheria toxin and virus infection).

NERVOUS TISSUE

Central nervous system

Regeneration does not occur when a neurone is lost.

In cases of acute damage, the initial functional loss often exceeds the loss of actual nerve tissue because of the reactive changes in the surrounding tissue. As these changes diminish, some function may be restored.



Scarring within the CNS is by proliferation of ASTROCYTES and the production of fibrillary glial acidic protein – a process known as GLIOSIS.

HEALING – SPECIAL SITUATIONS

NERVOUS TISSUE *(continued)*

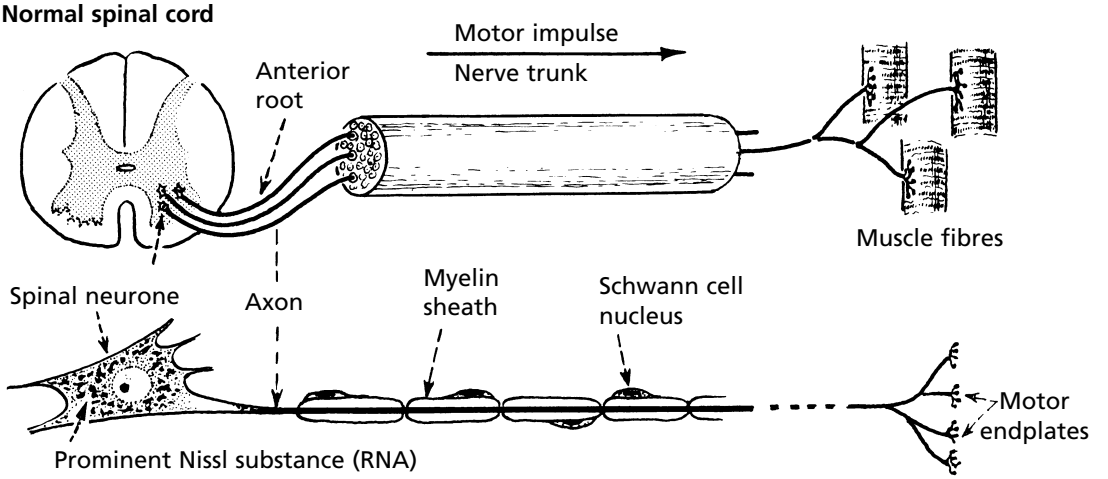
Peripheral Nerves

When a peripheral nerve is damaged, the axon and its myelin sheath rapidly degenerate distally. The supporting tissues of the nerve (Schwann cells) degenerate slowly.

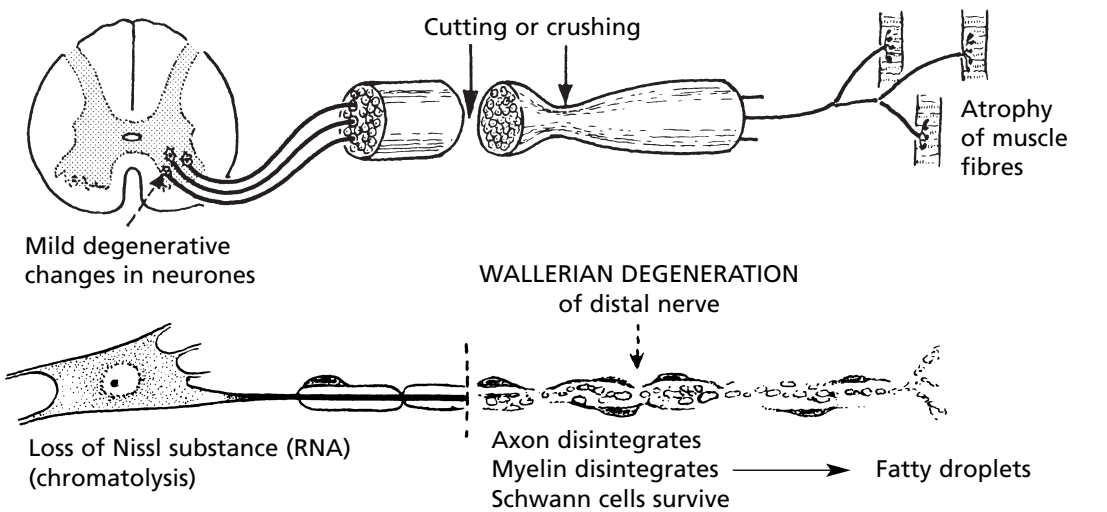
Regeneration can occur because the central neurone of which the axon is a peripheral extension is remote from the site of damage.

A spinal motor nerve is taken as an example.

Normal spinal cord



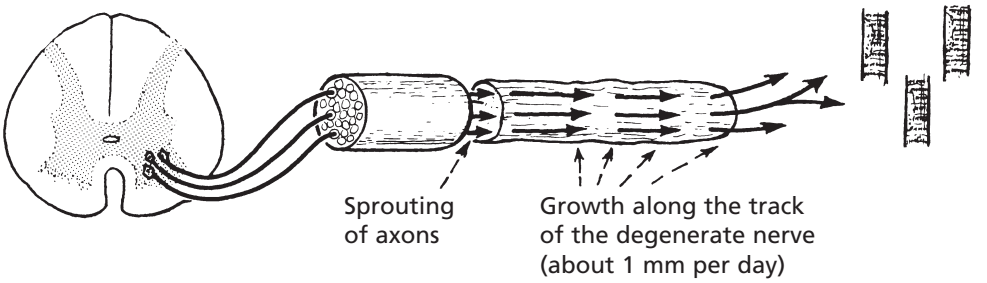
Results of damage



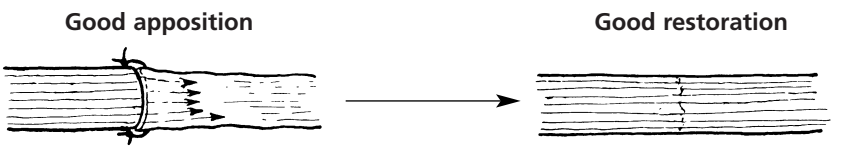
HEALING – SPECIAL SITUATIONS

Peripheral Nerves *(continued)*

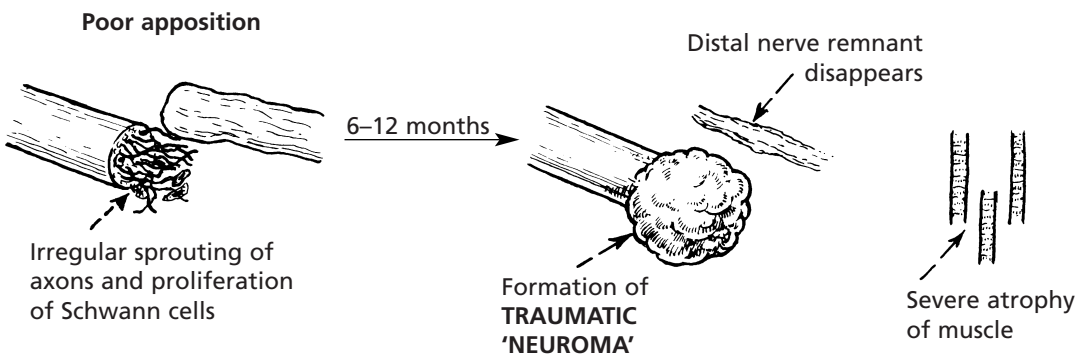
Regeneration takes the form of a sprouting of the cut ends of the axons.



The results depend on the apposition of the distal remnant with the sprouting axons.



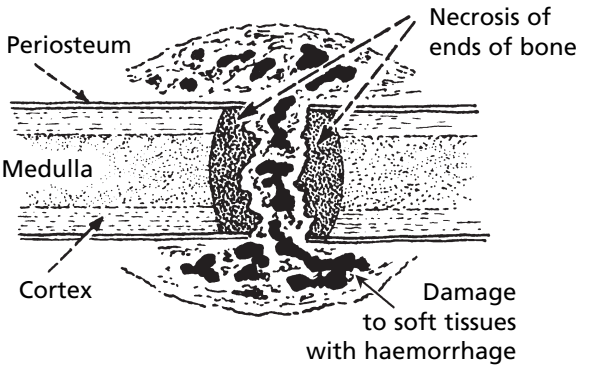
The best results are seen in crushing injuries where the sheaths remain in continuity.



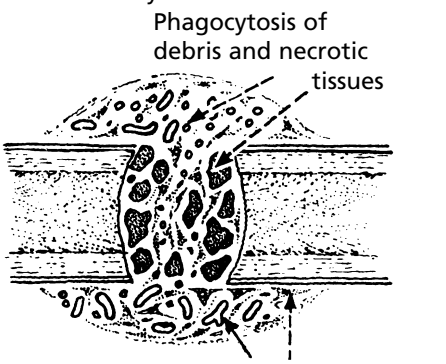
FRACTURE HEALING

BONE – Fracture Healing

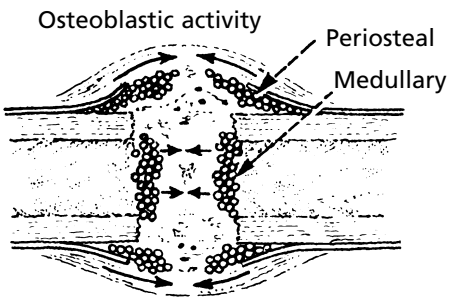
1. ***Immediate effects***



2. ***Early reaction-inflammatory***
First 4–5 days

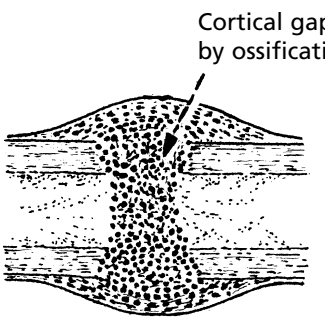


3. ***Formation of callus***
(early bone regeneration) – after 1 week.

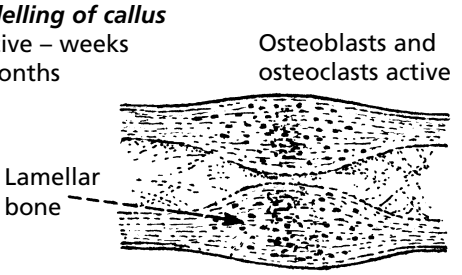


Provisional callus bridges the gap – first, osteoid tissue (may include cartilage) then woven bone

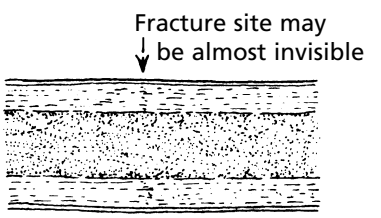
4. ***Mature callus***
– from 3 weeks onwards



5. ***Remodelling of callus***
Definitive – weeks into months



6. ***Final reconstruction***
Months later

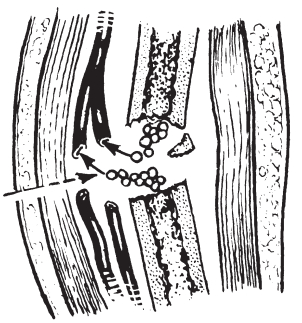


FRACTURE HEALING

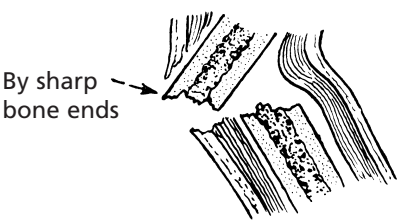
Events following a fracture *(continued)*

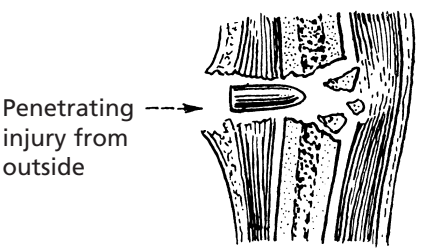
Complications

1. *Fat embolism* may occur in fracture of long bones due to entry of fat from the marrow cavity into the torn ends of veins.



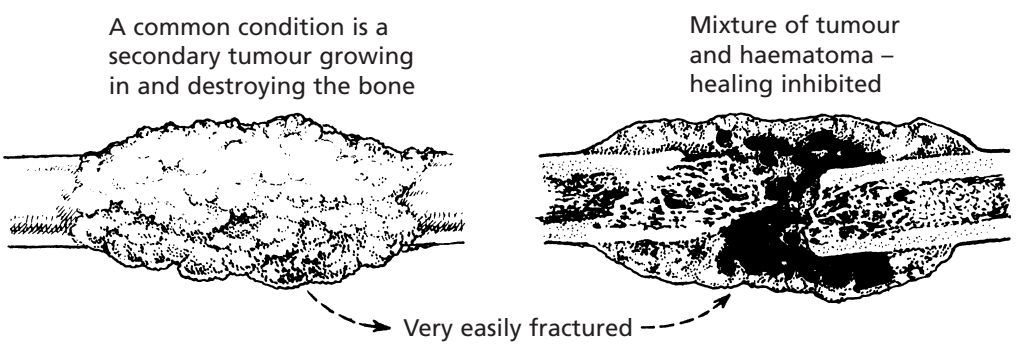
2. *Infection*
   If the overlying skin is breached in any way, i.e. the fracture is 'compound', the risk of infection is greatly increased; this is an important adverse factor in the healing process.





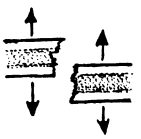
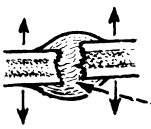
PATHOLOGICAL FRACTURE

When the break occurs at the site of pre-existing disease of the bone, the term 'pathological fracture' is applied.



FRACTURE HEALING

FACTORS INFLUENCING HEALING OF FRACTURES

	ADVERSE	FAVOURABLE
1. Local factors		
(a) *Infection* } See previous (b) *Pathological fracture* } page		
(c) *Poor apposition and alignment*	 There may be interposition of soft tissue, e.g. muscle Large irregular callus: slow repair, permanent deformity of bone	*Good apposition*  Small callus, quick repair
(d) *Continuing movement of bone ends*	  Callus formation inhibited Fibrous union In extreme cases, a rudimentary joint (pseudoarthrosis) may form 	*Good immobilisation*  Small callus, good bone formation
(e) *Poor blood supply*	This is largely influenced by the anatomical site of the fracture, for example: (a) Nutrient artery entering remote from the fracture or damaged by fracture (e.g. scaphoid, femoral head) (b) Fracture through area devoid of periosteum (e.g. neck of femur) (c) Minimal adjacent soft tissue (e.g. tibia).	*Good blood supply* In favourable conditions blood supply is derived from: (a) periosteal arteries (b) nutrient artery (c) adjacent soft tissues.
2. General factors		
(a) *Old age*		*Youth*
(b) *Poor nutrition* – e.g. famine, malabsorption leading to lack of protein, calcium, vit D and vit C.		*Good nutrition* – especially protein, calcium, vit D and vit C.