AIMS
This module aims to enable students to gain the knowledge required to provide effective treatment to wounds. This module also aims to provide an overview of veterinary pharmacology.

OBJECTIVES
On completion of this module students will be able to:

- Describe the structure and function of the skin
- List and explain the stages of healing
- Identify potential problems with the healing process and know how to deal with them
- Describe different types of injury
- Demonstrate knowledge of good first aid
- Treat wounds and adjust treatment plans where necessary to compliment the healing process
- Demonstrate understanding of basic veterinary pharmacology and its relevance to physiotherapy.

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INTRODUCTION

As an animal physiotherapist you constantly work alongside the natural healing process of the body. Whether it is soft tissue or bone the fundamental series of events, which happen after injury, are the same. It is crucial to always be aware of which stage of the healing process you are working with, as it is this information which largely influences your choice of treatment.

The healing of open wounds is a process that can be significantly improved by physiotherapy treatment. Working alongside the Vet, a physiotherapist can help to maximise wound healing and minimise scar tissue.

Horses are very susceptible to injury. Their inquisitive nature can lead them into all sorts of trouble. Kicks are a common injury. In addition to the force a kick can assert, an unyielding metal shoe can cause horrific wounds. Horses also incur injury whilst being ridden and travelled. Falls commonly cause injuries to the knees, shoulders and flanks amongst other places.

Dogs and other small animals are generally less susceptible to open wounds due to the manner in which we keep them. However they too can be wounded just like a horse usually as a result of a fight or road traffic accident. Sporting or working dogs have the propensity for gaining open wounds while working over varied terrain. The use of physiotherapy to aid in the repair of operation sites and reduce suture breakdown is becoming more recognised as an efficient and non-traumatic way of delivering aftercare and the majority of work to wounds on small animals will be of this nature.

The intervention of physiotherapy to wounds both open and closed will be a very important part of your work and to understand the process of repair is the key to delivering accurate treatment.
SECTION 1
THE SKIN

Open wounds commonly occur alongside other injuries such as bruising. The skin is inevitably affected by kicks, bites and other trauma, therefore it is important to be familiar with its structure and function.

The common integument
The common integument is the term used to describe the protective covering of the body i.e.; the skin, hair and horn. The skin is the largest body organ and makes up the major part of the common integument. Other functions of the integument are:

- Storage
  - Energy
  - Nutrients
  - Water
- Immune defence
  - Antigens are trapped by Langerhans cells and initiate a direct immune inflammatory response
  - Immune mediators are secreted by Keratinocytes
  - Capillary network involved in immune response
- Thermoregulation
  - Air is trapped by surface hairs to insulate
  - Hypodermal adipose further insulates
  - Rich vascular supply acts as a radiator
  - Melanin acts as a heat sink
- Protective barrier
  - Pigment in the dermis protects against solar radiation
  - Melanin in cells protects DNA from U.V. rays, free radical oxidation and heat
- Sensory
  - Heat
  - Cold
- Pain
- Panniculus muscles – displace insects

Ensure you are familiar with the skin's structure and that you are aware of the functions of the:

- epidermis
- dermis
- hypodermis
SECTION 2
THE HEALING PROCESS

Blood composition
(all figures are approximate)
Plasma
Plasma makes up 55% of blood and is approximately 92% water. Plasma also contains:

- Proteins
- Glucose
- Fatty acids
- Amino acids
- Mineral salts
- Hormones
- Enzymes
- Antibodies
- Urea
- Co₂

Red cells
Red blood cells are responsible for carrying oxygen to all the cells in the body. In the lungs red blood cells combine with haemoglobin (red pigment) forming oxyhaemoglobin. At the body tissues oxyhaemoglobin gives up its oxygen providing nourishment. Red blood cells are disc-shaped and are unusual in that they do not have a nucleus; this allows more room to carry haemoglobin and oxygen.

How does this apply to what we know about injuries and lack of blood flow?

White cells
White blood cells are responsible for defence against disease. There are two main types of white blood cells;

- Granulocytes – these make up 75% of all white blood cells and are responsible for defending the body against micro-organisms.
• Agranulocytes
  o Phagocytes (monocytes) – engulf and destroy foreign substances
  o Lymphocytes – make antibodies

White blood cells are bigger than red blood cells, have a nucleus and are irregular in shape.

Platelets
Platelets are involved in the blood clotting process. These cells are small and fragile and do not have a nucleus.

What happens at the time of injury?
The time between the initial injury and the initiation of the inflammatory response is approximately 10 minutes. A series of both chemical and mechanical effects occur within this time forming a blood clot and containing the damaged area so that the inflammatory process can begin.

Damage to local blood vessels will cause
- oxygen decrease or cessation
- bleeding

Oxygen decrease or cessation leads to cell death and disintegration and a release of histamine, kinins and enzymes.

Enzymes;
- continue the break down of dead cells
- increase the rate of chemical reaction

Histamine;
- Increases dilation in nearby capillaries
- Makes capillaries more permeable
Kinins;
- Increase dilation in nearby capillaries
- Can increase blood pressure

Capillary dilation and increased permeability last for approximately 10-15 minutes after which time vasodilation is maintained by prostaglandins.

Prostaglandins are;
- formed by cell membrane (lipids) when cell damage occurs.
- Released when the kinin system is activated
- Responsible for pain production and lymph flow

Bleeding initiates the following series of changes that lead to the formation of a blood clot:
- Red blood cells break down producing free haemoglobin and cellular debris
- Blood platelets release the enzyme thrombin
- Thrombin changes fibrinogen into fibrin
- A meshwork of fibrin is laid down around the injury site – this is known as walling off.
- The meshwork and the dead cells intertwine and form a
- BLOOD CLOT
- The healing process can now begin

The Healing Process
Stage 1 – Inflammation (acute stage)
The inflammatory response is the same within all tissue. The length of the inflammatory stage depends on the amount of tissue damage. It can be as short as a few minutes or as long as several days. An injury such as a kick or an operation site is usually in the acute stage for approximately 48 hours.

The signs of inflammation are;
• heat
• redness (can be difficult to see on animals)
• swelling
• pain

These four signs can together cause an inability to use the affected area.

This can manifest itself in;
• lameness/altered gait
• stiffness
• restriction

**What causes heat and redness?**
The heat and redness are caused by the increase in local blood flow. Capillaries near the injury site dilate and become more permeable. Heat and redness can take several hours to develop.

**Do new capillaries grow?**
Yes, approximately 12 hours post injury cells surrounding the injured capillaries divide and solid capillary buds grow. Over the next 3-4 days cell division continues and the capillary buds grow towards the area of low oxygen concentration. These capillaries supply the fresh blood needed for healing. The gradually increased oxygen to the area allows for phagocytosis to begin (engulfing of bacteria).

**What causes swelling?**
Leukocytes (white blood cells) are what give blood its sticky consistency. Normally these cells flow through the centre of blood vessels. The blood that flows in contact with the vessel walls is of a thinner less sticky consistency. Under normal circumstances the level of protein in blood plasma is higher than that of tissue fluid. Therefore an osmotic pressure is created drawing fluid back into the capillaries (out of the tissue).
In damaged capillaries the flow slows down due to the loss of fluid. The leukocytes drift towards the vessel walls, where they stick and further reduce blood flow. The vessel walls become covered in a jelly-like substance and the cells of the epithelial lining begin to contract. As these cells contract they pull away from each other and gaps form between them. This occurs approximately four hours after injury and allows fluid and leukocytes to escape into the damaged tissue and surrounding area.

At an injury site the fluid that leaks into the damaged tissue is high in protein (from the blood plasma). As the fluid in the tissue reaches a higher protein level than that of the fluid in the capillaries there is a change in osmotic pressure. The extra blood volume in the area due to capillary dilation and increased permeability leads to an increase in local blood pressure. The change in osmotic pressure together with the increased local blood pressure results in fluid being forced out of the capillaries into the surrounding tissues causing swelling.

Lymph vessels become more permeable and attempt to ‘mop up’ excess fluid and protein. This helps to a degree but swelling still occurs.

Why do we need to control inflammation?
Exudate – because of its high protein content – will lead to the formation of adhesions. If inflammation is not controlled, this inflammatory fluid can spread a great distance from the original injury site. The presence of exuded matter will lead to;

- pain – caused by the chemical effects on nerve endings and stretched tissues
- restricted movement
- lack of fresh blood and nutrition reaching muscles leading to muscle atrophy
- Tough adhesions
The above sequence of events can lead to chronic inflammation.

- What effect would the promotion of vasodilation have during acute inflammation?
- Why is inflammation necessary?

Stage 2 – Repair (sub-acute)

This stage will only begin once the inflammatory stage is over. Regeneration usually begins approximately five days post injury and lasts about three weeks. It is during this time that collagen synthesis occurs. Fibroblasts multiply and move toward the injured tissue where they begin to ‘lay down’ fibrils of collagen. Collagen will lay down in a haphazard way if the tissue is not subject to controlled tensile stresses. This will lead to weak scar tissue and re-injury is likely to occur. Controlled movement will cause the individual fibrils to form into parallel collagen bundles. Collagen orientation will be along the lines of stress leading to a much stronger scar and earlier return to function.

Rest is advisable during the first 48 hrs post injury to soft tissues – to avoid further injury, but after this stage it is essential that controlled movement is applied to the affected area to ensure the correct alignment of collagen fibres and tensile tissue strength. In the first five days these movements should not stress the wound, however after five days gentle pain free wound tensioning can begin.
The granulation tissue is the new capillary rich material resulting from the new capillary growth. This forms a ring around the periphery of the wound.

This fistula wither has ‘gone proud’. Note the oozing. This needs to be carefully managed otherwise it may cause burns to the skin. The area should be thoroughly cleaned and allowed to dry. This should be followed with the application of some waterproof barrier such as petroleum jelly. Great care must be taken as the waterproof substance will collect dirt and this could get into the wound. Be advised by the vet!

The following picture is the same wound after the application of a topical treatment that has successfully taken back the proud flesh.
The following picture is some days later after the application of red phototherapy. The new healthy granulation tissue can be clearly seen around the periphery of the wound. This wound is in the early stages of repair.
By the end of three weeks the quality of collagen has stabilised and the wound will have received its allocated amount of collagen. Remodelling can now begin.

**Stage 3 – Remodelling (chronic)**
The third stage of healing begins at about 3 weeks post injury. The time span for remodelling depends on many factors such as the type, site and degree of injury and the age and condition of the animal – it can be as little as three weeks but if inflammation and repair were not assisted remodelling can continue indefinitely (chronic injury). In an injury such as this there will usually be;

- random collagen orientation
- wound contracture
- adhesions

Which can lead to;

- restricted movement/lameness/altered gait
- lack of muscle nutrition resulting in atrophy
- prominent scarring

The aims in the treatment of chronic wounds such as this are;

- to promote collagen orientation and reduce scarring
- to restore range of motion to the restricted area
- to restore muscular strength
- to restore proprioception and co-ordination (these can sometimes be disturbed)

However if the first two stages of healing were managed correctly the main aim at this stage are to reduce scar contracture. During this stage collagen is modified and strengthened. However, new scar tissue will contract unless it is repeatedly stretched and contracture could lead to the above problems. It is essential that scars are periodically stretched both dynamically and passively to ensure the animal can maintain normal function. The use of ultrasound
over scar tissue followed by gentle stretching and/or exercise will help reduce contracture.

A common injury in horses is a scar around the back of the pastern or through the bulbs of the heel, usually caused by wire or similar. If the scar is not regularly stretched and preferably treated with ultrasound (longwave only as near bone) the wound will contract and this can lead to a contracted hoof, restricted blood flow and potentially more serious problems within the hoof.
SECTION 3
SOFT TISSUE INJURIES

Closed wounds
A closed wound is an injury in which the epidermis is not broken. A direct blow can cause a bruise (contusion) as bleeding occurs from torn blood vessels under the skin. There are varying degrees of closed wounds, which can affect the skin alone, or the skin and the underlying tissue.

A mild muscle strain:

- A small number of muscle fibres are torn
- Muscle fascia will be intact
- Minimal bleeding
- Localised pain and spasm

A more severe muscle strain:

- A larger number of muscle fibres are torn
- Muscle fascia will still be intact and bleeding will be contained within the muscle
- An intramuscular haematoma will develop
- Increased pressure will prevent further bleeding
- There will be visible swelling
- Pain, spasm and swelling will be evident on palpation
- There will be considerable pain
- Loss of muscle function will occur

Complete muscle rupture:

- A much larger area will be involved
- The muscle fascia will be torn
- A group of muscles could be involved
• Bleeding will spread over a much larger area
• As the muscle ends contract, dents and gaps can be seen and felt
• There will be a large amount of pain and swelling
• The muscle or muscles will be unable to contract resulting in loss of function and atrophy

This horse has suffered a severe blow to the shoulder and complete muscle rupture. The result was this haematoma. With physiotherapy the haematoma reabsorbed, muscle atrophy was limited and the horse was rehabilitated back to full work with no further complications.
Grazes or abrasions are also considered a closed wound as the skin is broken but the tear is not full thickness.

**Open wounds**
An open wound is where the epidermis is pierced such as puncture wounds and lacerations.

**Healing by first intention**
Healing by first intention occurs when the margins of the wound are close together. A blood clot quickly forms and within a few days the clot becomes organised and the epithelial cells from each side of the wound will join together.

A clean-cut laceration will usually heal by first intention. Wounds of this type are usually stitched and providing the stitches are not rejected and the wound does not become infected this type of wound will heal well.

**Healing by second intention**
Healing by second intention occurs when the margins of the wounds are further apart, stitches have broken down or infection has set in. Jagged lacerations or lacerations where flaps of skin have been lost or have died back will heal by second intention. This process takes much longer to heal and is prone to more problems such as proud flesh and large amounts of scar tissue.

In some cases it is possible to save flaps of skin, if you get to an injury early enough. By using red light phototherapy over the flap of skin it is possible to stop the skin from dying back for long enough so that it can be stitched into place.

**Problems with the repair process**
Injuries do not always follow the pattern of the healing process. The physiotherapist must be able to change their treatment if required to follow the changes of the wound they are treating. It is essential that the physiotherapist
can recognise if the wound is taking a turn for the worse and therefore can refer the case back to the vet. Some problems with the repair process are:

- Stitches break down – usually about five to nine days after injury
- Proud flesh – this is very common in horses especially on their limbs. Proud flesh is an excessive mass of granulation tissue that grows outward and usually beyond the skin surface. Proud flesh is susceptible to;
  - Infestation of parasites
  - Alteration into a tumour
The vet will prescribe a topical application to reduce back the proud flesh or in more severe circumstances the vet may need to surgically remove the mass. Note that once a bed of granulation tissue is present, the strong blood supply to the area means that infection is extremely unlikely.
- wounds on old animals or animals in a poor condition can take longer to heal
- Infection
- Wounds on horses with Cushings disease can take longer to heal and can break down. Animals suffering with this disease can have thinner skin, which has reduced elasticity. Bruising is increased and puncture wounds will bleed for longer than usual.
# SECTION 4
## PHYSIOTHERAPY OPTIONS

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<th>Stage of healing</th>
<th>Aims</th>
<th>Treatment options</th>
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<tbody>
<tr>
<td><strong>Inflammatory stage</strong></td>
<td>• limit swelling&lt;br&gt;• prevent further injury&lt;br&gt;• control pain&lt;br&gt;• prevent tension to wound&lt;br&gt;• control bacteria</td>
<td>• cryotherapy&lt;br&gt;• PMEF b50Hz p5Hz&lt;br&gt;• Restrict movement&lt;br&gt;• PMEF b200Hz pC&lt;br&gt;• Blue light phototherapy&lt;br&gt;• Compression</td>
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<tr>
<td>Up to 48 hrs post injury</td>
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<tr>
<td>48 hrs to 5 days</td>
<td>• Reduce initial haemorrhage&lt;br&gt;• Reduce swelling&lt;br&gt;• Prevent tension to wound&lt;br&gt;• Control bacteria&lt;br&gt;• Aid granulation tissue&lt;br&gt;• Control pain&lt;br&gt;• Limit atrophy&lt;br&gt;• Limit adhesions</td>
<td>• PMEF b50Hz p17.5Hz&lt;br&gt;• Ultrasound&lt;br&gt;• Controlled movement&lt;br&gt;• Blue light phototherapy&lt;br&gt;• Red/infrared phototherapy&lt;br&gt;• heat&lt;br&gt;• PMEF b200Hz pC</td>
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<td>5 days to three weeks</td>
<td>• promote collagen synthesis&lt;br&gt;• promote epithelial growth&lt;br&gt;• promote collagen orientation&lt;br&gt;• restore range of motion&lt;br&gt;• restore muscular strength&lt;br&gt;• limit proud flesh</td>
<td>• red/infrared phototherapy&lt;br&gt;• wound tensioning&lt;br&gt;• stretching and passive ROM&lt;br&gt;• gentle exercise&lt;br&gt;• Electrostimulation&lt;br&gt;• massage&lt;br&gt;• PMEF b50Hz p17.5Hz&lt;br&gt;• Ultrasound&lt;br&gt;• Heat</td>
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<tr>
<td>Three weeks plus</td>
<td>• promote epithelial growth&lt;br&gt;• limit wound contracture&lt;br&gt;• promote collagen orientation&lt;br&gt;• restore range of motion&lt;br&gt;• restore muscular strength</td>
<td>• red/infrared phototherapy&lt;br&gt;• stretching and passive ROM&lt;br&gt;• ultrasound&lt;br&gt;• PMEF b50Hz p17.5Hz&lt;br&gt;• Massage&lt;br&gt;• Electrostimulation&lt;br&gt;• Exercise&lt;br&gt;• Heat</td>
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Blue phototherapy – used promptly – can reduce the proliferation of bacteria and help to limit suture breakdown.

Red/infrared phototherapy acts on the skins surface and promotes superficial vasodilation, which in turn will enhance epithelial growth, collagen synthesis and capillary growth.

Once a stage is reached when maximum collagen is laid down the use of the red light should be directed at the periphery of the wound instead of directly over the wound.

Why is this?

Ultrasound used around the wound will increase membrane permeability, which will in turn aid fluid re-absorption and will have the following effects;

- Removal of haematoma and oedema
- Increase in blood flow bringing fresh oxygen and nutrients to muscles
- Break down any adhesions that have already formed
- Reduce discomfort

The low frequency sound waves produce a minute to and fro movement of particles that causes compression within the muscles. When used over scar tissue ultrasound will;

- soften the scar tissue
- prepare the scar tissue and the surrounding area for stretching
- aid collagen organisation
- break down adhesions and loosen scar tissue from underlying structures
Pulsed electromagnetic fields will increase collagen synthesis and wound repair.

? Make sure you can identify, describe and list;
- The benefits of magnetic field to the injured area
- The different settings which could be used and what each combination of settings could achieve
- When the use of magnetic fields would not be appropriate

Use your physiotherapy equipment module to help you.

Electrostimulation can considerably enhance the ‘current of injury’. When injury occurs, fibroblast cells travel to the site of injury in response to signals from the nervous system. These immature cells can change into cartilage, bone, collagen and can combine with muscle fibre to make myofibroblasts. A mass of cells is formed at the injury site. Other mature cells revert back to primitive cells and add to this mass of cells. An electrical charge is needed to convert these cells into the type of cell needed for repair. This charge is the ‘current of injury’. Electrostimulation can also be used to;
- relieve pain
- reduce oedema and haematoma
- maintain/increase muscle strength

Manual therapy can be used in the form of massage and passive range of movement and stretching. These can be used to;
- maintain/improve range of movement
- treat the effects of rest on the other muscles and joints of the body
- break down adhesions and fibrous tissue
- remove swelling
- tension the wound
- stretch scar tissue
- improve wellbeing
Direct pressure or transverse friction over contracted structures will put them under longitudinal tension and help collagen orientation.

Great care should be taken when tensioning an area not to over do it. Too much tension can irritate muscles are cause inflammation. Between 5 days and 2 weeks post injury wound tensioning should be pain free. After this time it can be to the point of resistance. When treating chronic injuries that have been badly managed, tensioning is likely to be uncomfortable for the animal as the tough adhesions are broken down.
SECTION 5
FIRST AID

It is essential to be aware of general first aid and bandaging techniques. If you do not have a veterinary nursing background, it is advisable to attend the practical day on first aid.

Make sure you have a good understanding of first aid and understand the rationale behind the different applications.
Only a veterinarian can prescribe drugs. An animal physiotherapist must never prescribe drugs or medication or make suggestions which could be misunderstood by the owner as a prescription. However it is important that you are familiar with medications and their effects.

Classes of commonly used drugs

Anti-inflammatory drugs

- steroids
  - used to control severe inflammation rather than pain
  - can be known as glucocorticoids
- non-steroids
  - Non steroidal anti-inflammatory drugs (NSAID’s)
  - Commonly used for pain relief
  - Block the production of prostaglandin
  - Examples of commonly used NSAID’s are Phenylbutazone (bute) in horses and Metacam and Rimadyl in dogs.

Antibiotics

These include;

- Tetracyclines
- Penicillins
- Cephalosporins

CNS Drugs

- Diazepam – used to control seizures, anxiety and for sedation.
- Potassium bromide – used to control seizures and epilepsy in dogs
Contraindications for therapy

PEMF – pulsed magnetic therapy has been shown to increase the uptake of particular cancer treatment in humans therefore there is a possibility it may influence the uptake of other drugs and enhance their effect. Quite often this may be a good thing however, if the animal is on medication, it is essential that the animal physiotherapist checks with the vet before using PMEF.

Phototherapy – Some drugs such as antibiotics can make the skin light sensitive. Phototherapy should not be used on animals that are on such medication. Always check with the vet.

Ultrasound – applications of low frequency ultrasound have been shown to significantly increase the skins permeability. This allows for effective transmission of drugs through the skin and can be used to administer medication in this way. However this method should only be used to deliver topical medications that have been prescribed by the vet for this purpose and should never be used to deliver any other medication.

Adverse reactions

Adverse reactions to medications can occur and these can often present signs which can be mistaken as neurological and orthopaedic problems. Always ask the owner if the animal is on medication and bear this in mind when assessing the animal. If the animal is presenting new signs that could possibly be due to an adverse reaction always contact the vet. Some adverse reactions are;

- muscle loss and weakness
- laminitis
- seizures
- infections around injection site
- sickness or colic and diarrhoea
- distress
- lethargy
- haemorrhage
- clinical deterioration
- tissue damage
GLOSSARY

Adipose tissue – a specialised connective tissue. Major storage site for fat

Agranulocytes - A type of white blood cell

Contusion – bruise

Exudates – Inflammatory fluid

Fibroblasts – immature cells that can change into collagen and bone

Granulation tissue – capillary rich tissue essential for wound repair

Granulocytes – a type of white blood cell

Haematoma – a collection of blood in any part of the body

Leucocytes – white blood cells

Lymphocytes – a type of agranulocyte

Myofibroblasts – a combination of muscle fires and fibroblasts

NSAID’s – non steroidal anti-inflammatories

Osmosis – the movement of water molecules through a partially permeable membrane from a region of higher concentration to one of lower concentration

Phagocytes – a type of cell – engulf and destroy foreign substances

Phagocytosis – engulfing of bacteria

Plasma – the fluid that bathes the cells of the body

Proud flesh – excessive granulation tissue

Walling off – a process by which a meshwork of fibrin is formed around the injury site