9 The skin

The skin is one of the few organs to which drugs can be applied directly. This is the usual way of treating ear problems in small animals and foot problems in large animals. Many drugs whicha re applied to the skin have already been covered, the purpose of this chapter is to tidy up the loose ends.

Many drug formulations are available for topical use on the skin of animals. In general, surface active drugs can be classified as either mechanical or chemical in their mechanism of action. Thousands of drugs have been applied to the skin over the years; their use is largely empirical. The usual intention is for them to act locally, but to reach the deeper layers of the skin, they must penetrate the stratum corneum - many drugs carry on in and are aborbed systemically. Animals often lick drugs off the skin, again leading to systemic absorption. This can occasionally be useful - sometimes drugs are applied to the flanks of cows for them to lick off, but usually it is undesirable and can lead to toxic doses being absorbed.

To understand what happens when drugs are applied to the skin, you must know some histology and pathophysiology of the skin - absorption, and thus clinical effects, can vary enormously.

Remember that all drugs formulated to cross animal skin will affect human skin too - warn the owner to take care, or better still, give them some gloves. This is not absolute protection since drugs such as DMSO will happily diffuse through ordinary rubber gloves as well as skin, but is sufficient for most drugs.

Principles of Topical Therapy

The skin is the easiest organ to examine. It is also easy to biopsy. Treatment is most likely to succeed if targeted at a specific diagnosis.

When treating skin disease first consider whether systemic treatment is more appropriate than topical then select and implement any necessary ancillary therapy. Consider the actions of both the active ingredients and the vehicles of chosen topical formulations; then apply chosen topical drug formulations. Consider ramifications of systemic absorption of either the active drug or vehicle.

A rule of thumb for topical therapy is
if it is wet, dry it
if it is dry, wet it

Pharmacokinetics

Drug Penetration depends on:

- state of hydration of stratum corneum
- body condition
- surface area
- hair follicles
  number
  density
  type
- blood flow rate
  exercise
  inflammation
- skin thickness
- ambient temperature
- rainfall
- concentration of active drug molecule in the applied formulation
- solvent / carrier (vehicle)
- solubility (lipid/water partition coefficient)
- alteration to hydration state of keratinized layers

Topical formulations

A number of substances are used in topical preparations, both for their non-specific effects and as vehicles for active ingredients.

demulcents

These are water soluble ointments or creams which coat the surface, reduce dehydration, partially rehydrate and relieve irritation. They include gums, methylcellulose, hydroxymethylcellulose, etc.,glycerol (glycerin), propylene glycol, polyethylene glycol. These last two substances are very different, despite their similar names. Propylene glycol is similar to other alcohols, and can be irritant to exposed sensitive tissues, polyethylene glycol (PEG) is inert. PEG comes as a variety of different molecular weights, which range from an oily liquid (PEG200) to a waxy solid (PEG35k).

emollients

Inert oils which occlude the stratum corneum and reduce dehydration. They may be either oil in water suspensions or water in oil suspensions. They include: vegetable oils e.g. castor, animal fats e.g. lanolin, other oils e.g. liquid paraffin

protectives and adsorbents

These reduce contact exposure to irritants and allergens although they may have some direct actions to increase evaporation, block pruritus, adsorb toxins and reduce inflammation. They include: starch, especially oatmeal, talc (quite irritant to exposed tissue), zinc oxide, boric acid, gelatin, lanolin, olive and mineral oils, kaolin

astringents

Dry the skin or precipitate proteins if applied to wounds. They include: salts of Al, K, Zn, Ag, Fe, tannic acid, vegetable acids. Copper and zinc salts are sometimes used in

this way for foot rot.

COUNTERIRRITANTS

(= rubefacients, vessicants, blistering agents) These irritate the skin to induce hyperaemia and inflammation and "promote healing". They may cause blisters. They may produce a placebo effect in people ("I can feel it burning so it must be doing some good!") but their use in animals is obselete and unethical.

CAUSTICS

Historically used to "treat" lameness in horses and to seal open wounds (as was actual cautery, ie firing). They are likely to cause pain and suffering and should not be used. The more caustic astringents are sometimes used to stop bleeding after over enthusiastic nail clipping and to remove warts. Active ingredients silver nitrate, ferric chloride or salicylate.

KERATOLYTICS

Dissolve the intercellular cement and allow increased desquamation of keratocytes. They are used to treat hyperkeratosis. Active ingredients: benzoyl peroxide (also acts as antiseborrheic by opening the sebaceous gland pores), coal tar, zinc pyridinethione, salicylate, selenium sulphide, urea

ANTISEBORRHOEICS

Reduce excessive sebaceous gland secretions primarily by reducing inflammation. Active ingredients: selenium sulphide, coal tars (do not use on cats - they have problems metabolising phenolic compounds).

TOPICAL ANTI-INFLAMMATORIES

TOPICAL STEROIDS

fluocinolone, beclomethasone, hydrocortisone, triamcinolone, betamethasone. In people, these can sometimes cause an allergic reaction (to the vehicle?) so systemic steroids are usually used.

DIMETHYL SULPHOXIDE (DMSO)

DMSO is widely used in veterinary medicine. It is a solvent which rapidly penetrates the skin itself and is rapidly distributed throughout the body by the blood. It enhances penetration of solutes, drugs, toxins etc. Therefore, care must be exercised in its use, including wearing butyl rubber gloves during application. It also acts as a rubefacient (increasing blood flow) and stimulates mast cell degranulation at high doses.

It has potent anti-inflammatory activity, it is a free radical scavenger, it interferes with fibroblasts and collagen production, it may be antimicrobial, it may have some muscle relaxant properties and is analgesic, probably by direct interference with C fibre afferent neurones.

It is used clinically as a gel or solution applied topically to reduce acute swelling due to trauma, and as a vehicle for other drugs. It is used iv for treating acute cranial trauma in horses - great care in dilution and dose rate is necessary.

DMSO's side effects include local burning, itching, diuresis, blockade of collagen production, teratogenicity, lenticular cataracts, haemolysis (if too rapid or too concentrated iv), convulsions and pulmonary oedema. It may also be carcinogenic - it is rapidly going out of use from fears about clients absorbing it.

"INERT" VEHICLES

These are important since they are responsible for the absorption and many of the side effects of the active drugs. **These can cause enormous variations in clinical effect between different formulations containing the same active ingredient.** Commonly used vehicles include: aqueous creams, emulsifying ointments, hydrous ointments, white soft paraffin, starch powders, various lotions, gels and aqueous sprays. Nasty chemicals such as dimethyl formamide are sometimes used to get drugs across the skin in animals, safer products such as poloxamer lecithin organogels are starting to be used in people, and to a lesser extent, in animals. This is a big growth area for drug companies.

Since you are unlikely to be making up your own topical formulations, these will not be covered further.

Otitis externa

Despite the huge volumes of drugs poured down animals' ears annually, pharmacology is not always the answer. Otitis is very common - about 20% of dogs and 5% of cats - but it can be caused by many different things. First diagnose the cause - bacteria, yeasts, mites, ear conformation, or all of these! Otitis may also be the most obvious sign of generalised skin disease (55% of dogs with atopy also have otitis). Bear in mind that chronic inflammation will alter the conformation of the ear as well, which will predispose to bacterial infection. In acute otitis, remember foreign bodies, particularly grass seeds.

The goals of treatment are usually to remove muck and wax, establish drainage, reduce inflammation and get rid of whatever is causing the inflammation. Contact animals should also be checked and treated if necessary.

Treatment may involve:
flushing (under anaesthesia)
systemic steroids?
collars to stop scratching
surgery
as well as topical drugs

Drugs for infections

A large number of commercial preparations are sold for use in animals' ears. They are nearly all a mixture of different drugs to treat all the possible pathogens. Except in very severe otitis, drugs are always given topically.

Because the chances of recurrence are high, think carefully about resistance when giving antibiotics.

Mites

Otodectes cyanotis are involved in about 10% of otitis cases in dogs and 50% in cats (see parasitology note for further details). Commonly used drugs include pyrethroids and monosulphiram.

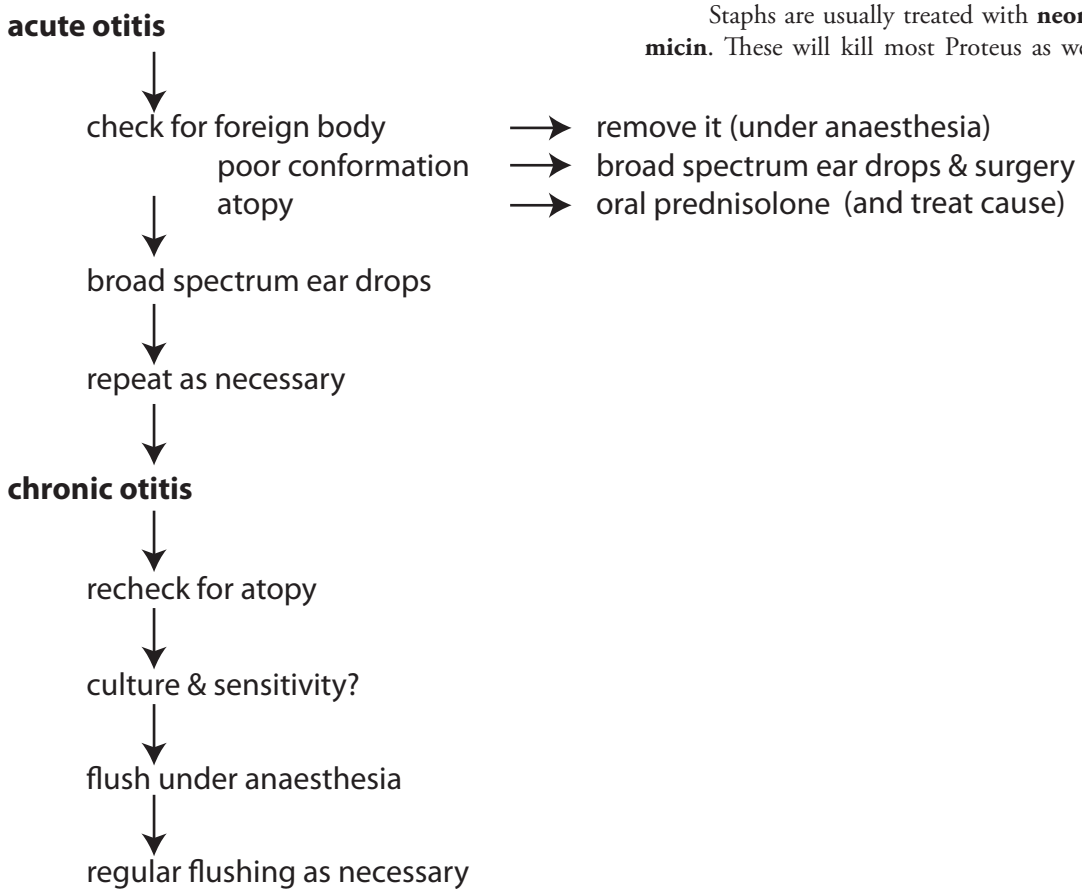
Yeasts

Malessezia pachydermatis (*Pityrosporon canis*) is a common inhabitant of dogs' earswhich is considered an opportunistic pathogen. Commonly used drugs include clotrimazole, miconazole, nystatin and natamycin.

Bacteria

Staphs can be cultured from 10 - 20% of normal ears in dogs and 20 - 40% of inflamed ears. Streps can be cultured from 16% of normal ears and only 10% of inflamed ears. *Proteus* spp are only cultred from inflamed ears - about 11%. *Pseudomonas* can be cultured at very low levels from normal ears and about 20% of inflamed ears.

Staphs are usually treated with **neomycin** or **gentamicin**. These will kill most Proteus as well. *Pseudomonas*



A common approach to treating otitis in dogs.

are more difficult. Although **gentamicin** or **polymixin** are the drugs of first choice, resistance usually develops quickly. Polymixin is inactivated by pus, so the ears must be clean before it is used. **Enrofloxacin** is sometimes used as a second line drug but resistance to it develops quickly as well.

Most chronically treated ears end up full of *Pseudomonas* resistant to most drugs. When this happens, the two approaches are to use specific antipseudomonal drugs such as **amikacin**, **ticarcillin** or **cephalosporins** (expensive and likely to induce resistance), or use non-antibiotic treatments (cheap and safe). **Silver sulphadiazine** 1% solution is effective (it is the silver which is thought to be active, not the sulphonamide). **2% acetic acid** (50% vinegar) reduces the skin to pH4 which stops the bacteria growing. There are a variety of commercial preparations containing other weak acids, usually including salicylic, which softens keratin and helps to clean the ear canal. A **Tris - EDTA solution** can also be effective (particularly with aminoglycosides) and relatively cheap, but has to be made up (see formulary).

Anti-inflammatory drugs

Steroids (usually **betamethasone**) are often used to try to reduce inlammation and pruritus. They also reduce bacterial populations by making growing conditions less favourable. Local anaesthetics such as amethocaine are also used for pruritus.

Flushing solutions

Cleaning the muck out of the ear is very important to allow examination, allow the drugs to get to the tissues, stop inactivation of drugs, remove bacteria and bacterial breakdown products which may cause inflammation. The ears can be thoroughly cleaned under anaesthesia, followed by regular flushing by the owner.

If the ear drum is intact, solutions containing mild detergents designed for this purpose can be used. If the eardrum is ruptured or cannot be seen, use saline. If there is just an accumulation of wax, oils are sometimes used to soften it. Bactericidal flushing solutions (Tris EDTA) may be desirable.

Drug administration

The pinna is held up and drugs dropped into the vertical canal. The ear is massaged for about 30 seconds. It is then a good idea to stand back, as the animal's response is usually to shake its head vigorously, when the drug plus any muck is distributed around the room.

Beware

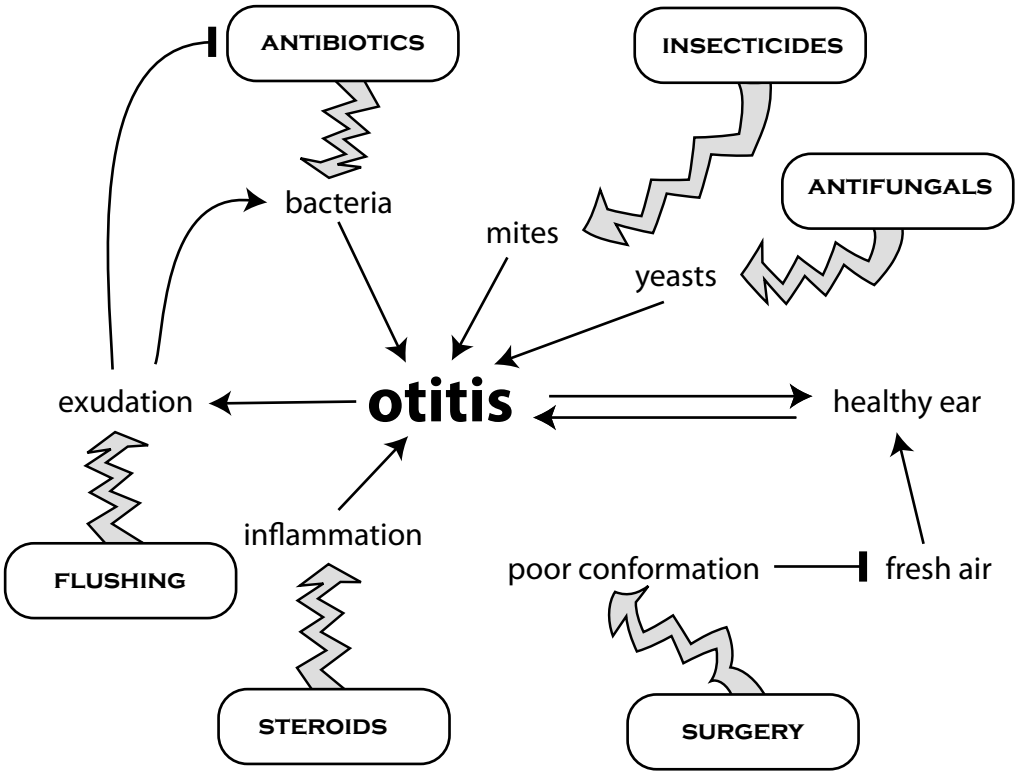
Many drugs are toxic to the inner ear - be extremely careful if the eardrum is not intact. Drugs to avoid include: aminoglycosides, chloramphenicol, polymixin, anything containing polypropylene glycol (polyethylene glycol is OK) or a detergent and most antiseptics (especially chlorhexidine).

Having said that, a middle ear full of *Pseudomonas* is not good news either - you will have to weigh up the benefits and side effects.

If chronic otitis is not treated, the ear canal lining becomes so thickened that the only likely effective treatment is surgical ablation.

Further reading

Rosychuk, R.A.W., 1994, Management of otitis externa. Veterinary Clinics of North America, **24**, 921



The scabby dog

Scabby dogs and cats which spend most of their time scratching are the predominant feature of small animal practice, particularly if they have diarrhoea as well. In many cases, the original cause is flea infestation (or rarely mites) which should be treated aggressively, including contact animals and the environment. However, there is a wide variety of diseases which can cause skin problems and which should be diagnosed and treated. Once all of these have been ruled out, there is a large number of dogs and a smaller number of cats which probably have atopic dermatitis. This is the development of an allergy to environmental allergens. If it is possible to avoid these allergens, the problem can also be avoided, but it is usually necessary to give anti-inflammatory / immunosuppressant drugs of some sort. The dog is likely to need treatment for life, so side effects (and cost) of drugs becomes important.

Skin reactions are a common side effect of drugs in people, but are not recognised in animals.

Monotherapy

Traditionally, corticosteroids have been the main treatment and many dogs have developed Cushing's syndrome as a result. Oral prednisolone is still the main treatment, but the dose should be reduced as much as possible, often by using adjuvant drugs.

Cyclosporin can be used as a monotherapy with fewer side effects, but is expensive. A veterinary product has recently become available in NZ. Similar drugs, topical tacrolimus and pimecrolimus, are used in people. Oral formulations work better in dogs.

Remember that dogs have an immune system for a good reason - long-term, high-dose immunosuppressants increase the risk of strange infections or tumours.

Adjuvant drugs

Antihistamines

Histamine H1 blockers are useful in about 20% of dogs. A wide variety of drugs with antihistamine effects is available. Hydroxyzine, diphenhydramine, amitriptyline and several of the older phenothiazines such as promethazine and trimeprazine are used. It is difficult to predict which will work, so a two week treatment trial is often used.

Essential fatty acids

Omega 3 fatty acids, either as dietary supplements (pills or just vegetable oil) or prescription diets can reduce pruritus in about 40% of dogs. They take at least three months to work (see anti-arthritis drugs).

Oxpentifylline

Oxpentifylline (pentoxifylline USAN) may have some anti-inflammatory effect on its own, but also seems to potentiate corticosteroids and antihistamines. It has partial efficacy at best, but is reasonably safe (most likely side effect is vomiting).

Washing

Washing at least weekly helps to keep allergen concentration on the skin down. Shampoos containing emollients may help to prolong the effect (emollients are the main treatment in people). They may also contain things such as oatmeal which are supposed to adsorb irritant bacterial toxins. Remember that washing will remove any residual flea treatments.

Hyposensitisation

If the allergen has been specifically identified, hyposensitisation using the allergen as a “vaccine” may work. It can take up to six months to have an effect.

Disinfectants

Although most vets would prefer to leave disinfectants and antiseptics to their nurses, these things can have nasty effects on people (and animals) so you have to know about them.

Disinfectants are chemicals which are lethal to bacteria, bacterial spores, fungi, yeast, protozoa or viruses. Just as is the case with antibiotics, some disinfectants are broad in spectrum, whereas others are relatively confined in their spectrum to one or other of these groups of target organisms. Properties of an ideal disinfectant include:

- rapidly lethal activity against the broad spectrum of target species
- a low surface tension for ease of spread
- activity in the presence of organic matter
- low toxicity
- not corrosive
- low cost.

An antiseptic is essentially a disinfectant which can be applied to skin or mucus membranes of mammals without causing toxicity. Therefore, the properties of the ideal antiseptic are essentially similar to those of the ideal disinfectant. In addition, an antiseptic ought not be:

- irritant to the host's tissues
- allergenic
- absorbed to any significant extent across the skin
- lacking in pleasant aesthetic properties!

Frequently the only difference between a disinfectant and an antiseptic is dilution.

Both disinfectants and antiseptics can be generally classified into broad groupings based on their mechanism of action or chemical structure.

Alcohols

Ethanol and **isopropyl alcohol** at dilutions of 70% by weight in water are rapidly bactericidal and virucidal for some virus families. They do not kill spores. Isopropyl alcohol has a more rapid killing action against vegetative bacteria than does ethyl alcohol. Methanol is not a good disinfectant nor antiseptic and is also toxic, therefore is not a good substitute for ethyl or isopropyl alcohols.

The alcohols act by disrupting cytoplasmic membranes causing disruption of the semi-permeable membrane barrier and resulting in bacterial death through the leakage of cytoplasmic constituents. The genera of large viruses, especially those with lipid membrane coats are also susceptible. The alcohols have no residual effect, being active only whilst in direct contact with the bacteria or virus. A contact time of between 1 and 30 minutes to aqueous dilutions of ethyl alcohol is required for the killing of most organisms. Dilutions of less than 30% of ethanol are not effective.

Topical application of the alcohols as antiseptics is unlikely to result in a serious toxicity. However, as is well known, oral toxicity of ethyl alcohol involves central nervous system depression which can be life-threatening. Isopropyl alcohol is similar but more potent. It can also cause ketosis. Ethanol and isopropyl alcohol in effective concentrations are inflammable and volatile. They should be used in well ventilated areas and kept in sealed containers somewhere safe. Remember the HSNO Act and OSH.

Aldehydes

Glutaraldehyde and **formaldehyde** are both potent and broad spectrum disinfectants and fumigants: they must not be used as antiseptics. They are active against most vegetative bacteria, fungi, yeast, many viruses and some bacterial spores. Glutaraldehyde is usually supplied as a 2% alkaline solution known as activated glutaraldehyde. Glutaraldehyde can also be purchased at higher concentrations or in dry form ready for dilution in water.

Both formaldehyde and glutaraldehyde react with amide groups of cellular proteins, thereby disrupting cellular protein activity. In addition, glutaraldehyde causes much general coagulation and binds to thiol groups resulting in the production of highly reactive compounds. Some vegetative bacteria are killed within minutes of exposure to glutaraldehyde, but 10-20 minutes of contact with new 2 % glutaraldehyde is necessary for broad spectrum action. As glutaraldehyde ages the contact time required for killing increases. By 28 days in use bactericidal contact times are greater than 1 to 2 hours are often necessary. Because of its pungent odour solutions of formaldehyde are rarely used as disinfectants in veterinary practice.

It is now well established that glutaraldehyde is dangerous to people inhaling it. In human hospitals exposure of patients to glutaraldehyde has been shown to slow healing. This is a possible concern for veterinary practices. Because of the volatile nature of alkaline activated glutaraldehyde, it must only be used in well ventilated areas. Care must be taken while mixing and while discarding glutaraldehyde preparations to avoid aerosol production. Contact by users to aerosols of glutaraldehyde results in upper respiratory and ocular irritation. Persistent exposure to glutaraldehyde over prolonged periods or single acute large exposures to glutaraldehyde, can cause malaise, anorexia, weakness, rashes or alterations in measurable parameters of the immune system. These parameters include the development of antinuclear antibodies, the development of antibodies to single stranded DNA and disorders of compliment and compliment components.

Glutaraldehyde should not be used unless there is no alternative. If it is deemed necessary then personal protective equipment and carefully constructed, written guidelines for it use should be available for all workers. The number of people exposed to glutaraldehyde should be minimized. The HSNO

Act is likely to severely limit the use of aldehydes.

Halogens

Free **chlorine** in solution is an effective disinfectant, rapidly killing bacteria, many spores, fungi, algae and viruses. Chlorine acts by: direct disruption of the cytoplasmic membrane, reaction with thiol groups on enzymes disrupting their function, reaction with amine groups on cellular proteins and production of highly reactive compounds.

Chlorine is normally made available in solution by the addition to water of salts of hypochlorites. Sodium **hypochlorite** is the most commonly used salt, which is stable at an alkaline pH, but which at an acid pH releases chlorine. The concentration of chlorine resulting in solution is a function of the concentration of sodium hypochlorite and the pH. Label recommendations should be followed closely to produce a final solution which is an effective disinfectant.

Chlorine disinfectants are irritant to tissues and should not be used as antiseptics. Care should be taken in their preparation, use and disposal to avoid endangering the health of the people handling the disinfectant. Sodium hypochlorite loses activity on exposure to air and light. New solutions should be prepared frequently. Chlorine adheres to organic matter and becomes unavailable. Chlorine is also corrosive and bleaches textiles.

If hypochlorite solutions are mixed with acids or ammonia solutions, free chlorine or chloramine gas is produced, which is very irritant.

Municipal water supplies sometimes have chlorine added in the form of **chloramine**, but this seldom causes problems.

Free **iodine** in aqueous solution (Lugol's solution) is effective against bacteria, bacterial spores, yeast, fungi and most viruses. Iodine is also active in alcoholic solution (known as tincture of iodine). Iodine has a bactericidal action through interference with the electron transport chain and with the function of thiol groups on bacterial enzymes.

Alcoholic solutions of iodine lose their potency rapidly on exposure to air, both through evaporation of the solvent and through loss of the iodine (which is a volatile molecule). Alcoholic preparations of iodine are also drying to skin and irritant. Exposure of animals to Lugol's solution or tincture of iodine has resulted in central nervous system depression and in suppression of thyroid hormone production.

These disadvantages of iodine have been largely overcome by formulation with active carrier agents such as polyvinylpyrrolidine (povidone). Formulations of iodine with povidone and other similar polymers are collectively known as the **iodophors**. Povidone in aqueous solution above a critical concentration forms aggregations known as micelles. Iodine dissolves into the micelles from which it is slowly released as free iodine into the aqueous solution for activity against bacteria etc. Therefore, if povidone iodine preparations are diluted below the critical micellar concentration, the reservoir for iodine is lost and the volatile free iodine is therefore depleted. This results in rapid loss of activity.

Iodophors are popular as surgical scrub solutions and as antiseptics. They have an extremely broad spectrum of activity, low toxicity, low propensities for sensitization, stability and low likelihood of bacteria developing resistance. However, they can be absorbed in some situations, such as burn treatment. They are corrosive to metal instruments.

In comparison to chlorhexidine the iodophors have a slower bactericidal action. Therefore, the use of iodophors as surgical scrub solutions requires more care. Strict adherence to recommended duration of pre-surgical scrub procedure is necessary. An inadequate period of contact between the iodophor and the skin will result in fewer bacteria being killed. Nevertheless, the iodophors are very useful in surgical scrub solutions.

Phenols and Cresols

Phenols are rapidly bactericidal and virucidal for some germs. Their activity depends upon:

direct action on the cell wall
interference with action potentials
alterations to cell membrane permeability
general coagulation of cell constituents.

Phenols are all irritant, unless very dilute. They can also cause allergic dermatitis in people.

These disinfectants have fallen into disuse since the development of more effective and safer agents. Nevertheless many phenol-containing disinfectants are still used principally as toilet cleaners and as floor detergents. These products often have a pleasant smell and lack of contact irritation.

For most species, **diluted** phenols are minimally toxic. **Cats are an exception.** Cats are extremely sensitive to phenol induced toxicity, showing CNS signs of seizure and coma. Phenols should be used with care in areas to which cats have access - remember that cats lick their feet.

Hexachlorophene is a chlorinated phenol which is distinguished from most disinfectants by its ability to work in the presence of anionic soaps. Therefore hexachlorophene is formulated as both hard and liquid soaps. When used repeatedly over prolonged periods, hexachlorophene results in a decrease in the density of skin commensals and is sometimes used as a routine soap by surgeons. However, hexachlorophene is not recommended as a pre-surgical scrub solution. Triclosan is similar.

Pine oil is similar to the phenols in smell, uses and toxicology. It is fine for cleaning toilets, but keep it away from animals.

Quaternary Ammonium Compounds

The quaternary ammonium compounds are highly surface active agents. Their activity depends upon general coagulation of cell components. The commonly known quaternary ammonium compounds include **benzalkonium** chloride, **cetrimide** (cetavlon) and **cetyl pyridium** chloride.

The quaternary ammonium compounds are rapidly bactericidal against Gram positive bacteria and have some Gram negative activity. Their major drawback is that some Gram negative organisms including *Pseudomonas* spp., may thrive in these solutions. Quaternary ammoniums possess some fungicidal activity, but are not active against bacterial spores or viruses. The activity of this group of disinfectants is markedly inhibited by the presence of organic matter. Therefore thorough cleaning is required before their use.

These compounds have little place in modern disinfection despite their continued wide availability.

Cetrimide is frequently included at approximately 3% in formulations intended for use as antiseptics. Cetrimide in these products is included primarily for its detergent properties rather than its properties as a disinfectant. Cetrimide improves the general cleansing action. Unfortunately, cetrimide frequently causes contact sensitivities. Veterinarians with contact sensitivity to antiseptics in use in their practice should check if cetrimide and other quaternary ammoniums are part of the formulation.

High concentrations are very caustic.

Miscellaneous Disinfectants

Thiram is a powder which has action as a disinfectant when in suspension in water (it is virtually insoluble). It is fungicidal and bacteriostatic and is included in some bacteriostatic soaps. Thiram has little application in companion animal or equine practice.

"**Virkon**" is a mixture of oxidising agents (notably potassium monopersulphate), a surfactant (a rapidly-degraded alkyl benzene sulphonate), organic acids and an inorganic buffer system. It also contains various aldehydes. It is effective against most species of bacteria, fungi, yeast, bacterial spores and viruses including *Parvovirus*. It also has some effect against *Cryptosporidium* cysts. It is available as a powder which when mixed according to label directions provides a strong oxidising solution. Virkon has little, if any, oral or contact toxicity. It is as yet unknown whether infectious organisms are able to develop resistance to this disinfectant.

Chlorhexidine is a biguanide antiseptic with a wide spectrum of activity against both Gram positive and Gram negative vegetative bacteria. Chlorhexidine is not sporicidal, fungicidal or virucidal. The mechanisms of action of chlorhexidine are general coagulation of cell components, alteration of cell membrane permeability and inhibition of the enzyme adenosine triphosphatase.

Chlorhexidine has a rapid action. It use during surgical site preparation and hand scrubbing results in significant decrease in bacterial numbers within one or two minutes of contact time. Chlorhexidine also has residual action which results in a decreased rate of recontamination of surgical sights or hands when compared to other surgical scrub solutions.

Chlorhexidine is rarely toxic to mammals unless it gets into eyes or ears. It has been used to promote scar formation in people. Chronic or repeated exposures to chlorhexidine containing surgical scrub solutions can cause skin sensitization in people. It is probable that this is usually caused by surface active agents such as cetrimide in the scrub.

Hydrogen peroxide is occasionally used as an antiseptic. It releases oxygen on contact with tissue which kills many bacteria; the frothing action also removes muck.

Steam (usually produced by a hot water blaster) kills most things and is a good way of disinfecting premises. It must be kept well away from animals and people.

Ultraviolet and γ radiation kill many bacteria. γ rays penetrate packing and are used for some surgical instruments and consumables.

group	spectrum	use	drugs
alkylating agents	G+, G-, weak spores, fungi, viruses, Mycobacteria?	disinfectant - surgical equipment, feed, housing	formaldehyde, glutaraldehyde, ethylene oxide
biguanides	G+, G-, a few fungi & viruses	antiseptic & disinfectant	chlorhexidine
cationic detergents, quaternary ammonium compounds	G+, G-	antiseptic & disinfectant	cetrimide, benzalkonium chloride
halogens	G+, G-, viruses, fungi including yeasts	antiseptic & disinfectant	chlorine, sodium hypochlorite, povidone iodine
alcohols	G+, G-, most viruses, some fungi	antiseptic & disinfectant	ethyl alcohol, isopropyl alcohol
acids	bacteria (Pseudomonas), yeasts	antiseptic & disinfectant	boric acid, acetic acid, benzoic acid
oxidising agents	bacteria, especially anaerobes	antiseptic	hydrogen peroxide, benzoyl peroxide
cresols	G+, Mycobacteria, fungi (not G-)	antiseptic & disinfectant	Lysol, hexachlorophene
phenols	bacteria, fungi	disinfectant	phenol, coal tar and pine derivatives
anionic detergents	weak antibacterial activity, some fungi	antiseptic	soaps, sodium lauryl sulphate
acridines	gut and skin bacteria, protozoa, fungi	antiseptic	hydroxyquinoline, clioquinol, iodoquinol