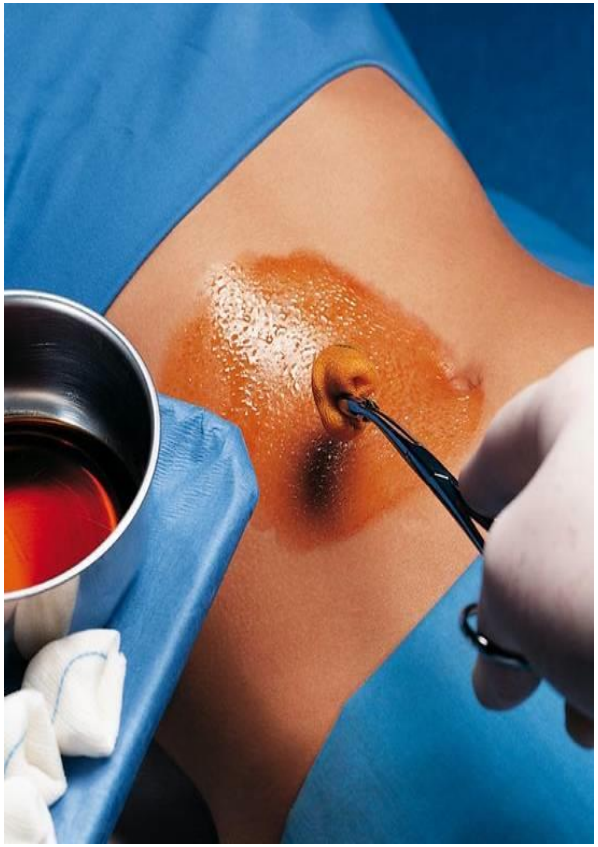
Hand hygiene

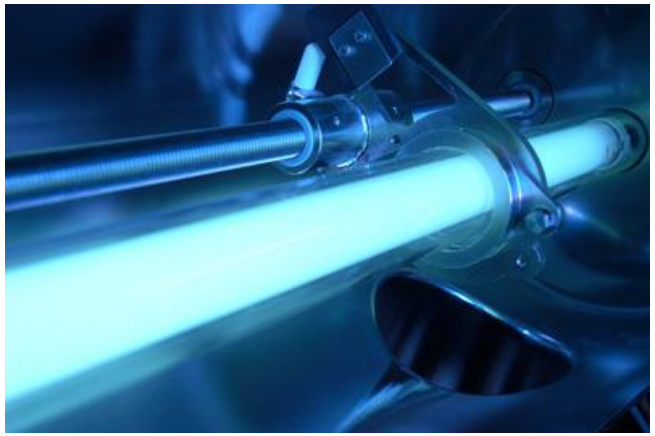
Antiseptics

- Antisepsis: Application of an agent to living tissue for the purpose of preventing infection.



Disinfectants

- Disinfection: Chemical or physical treatment that destroys most vegetative microbes or viruses, but not spores, in or on inanimate surfaces.



The Spaulding classification

- In 1968, Spaulding classified medi rgic ices as: critical, semi-critical an ential to spread i

- **Critical** ystem, or equip surgical inst sterilized, whic

- **Semi** embranes or nc nal probes, and respira se items require proper pre-c disinfection before use.

- **Non-critical items** h as blood pressure cuffs, stethoscopes) which only contact ct skin have a low risk for spreading infections. These devices should be cleaned by low-level disinfection.

High-level disinfection - destroys all microorganisms, with the exception of high numbers of bacterial spores.

Intermediate-level disinfection - inactivates Mycobacterium tubercuosis, vegetative bacteria, most viruses, and most fungi, but it does not necessarily kill bacterial spores.

Low-level disinfection - kills most bacteria, some viruses, and some fungi, but it cannot be relied on to kill resistant microorganisms such as tubercle bacilli or bacterial spores.

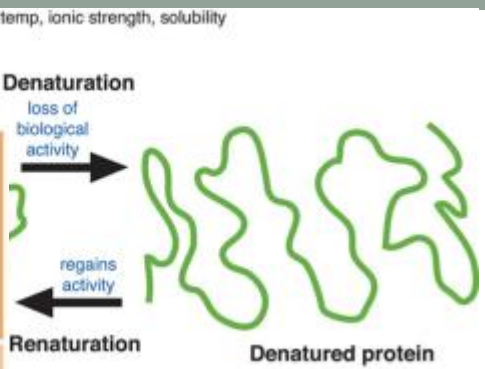
Sterilization

- Sterilization: A process intended to kill or remove all types of microorganisms, including spores, and usually including viruses, with an acceptably low probability of survival.

Alcoh

Table 7.6	Biocidal Action of Various Concentrations of Ethanol in Aqueous Solution against *Streptococcus pyogenes*				
	Time of Exposure (sec)				
Concentration of Ethanol (%)	**10**	**20**	**30**	**40**	**50**
100	G	G	G	G	G
95	NG	NG	NG	NG	NG
90	NG	NG	NG	NG	NG
80	NG	NG	NG	NG	NG
70	NG	NG	NG	NG	NG
60	NG	NG	NG	NG	NG
50	G	G	NG	NG	NG
40	G	G	G	G	G

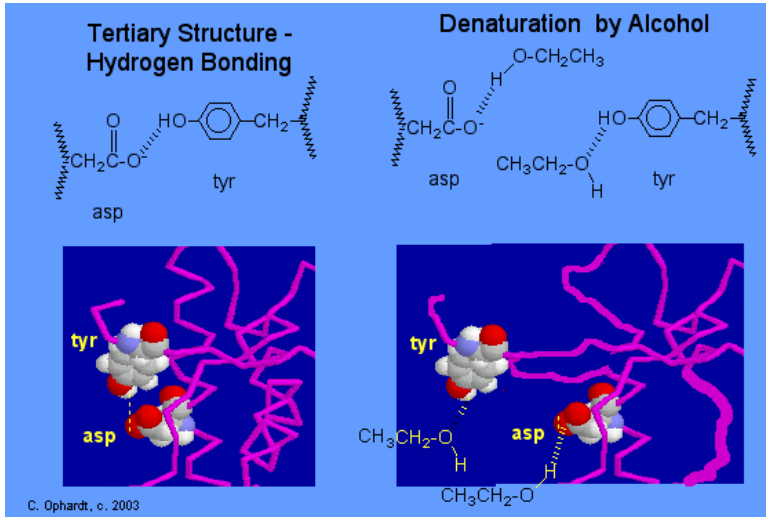
NOTE:
G = growth
NG = no growth



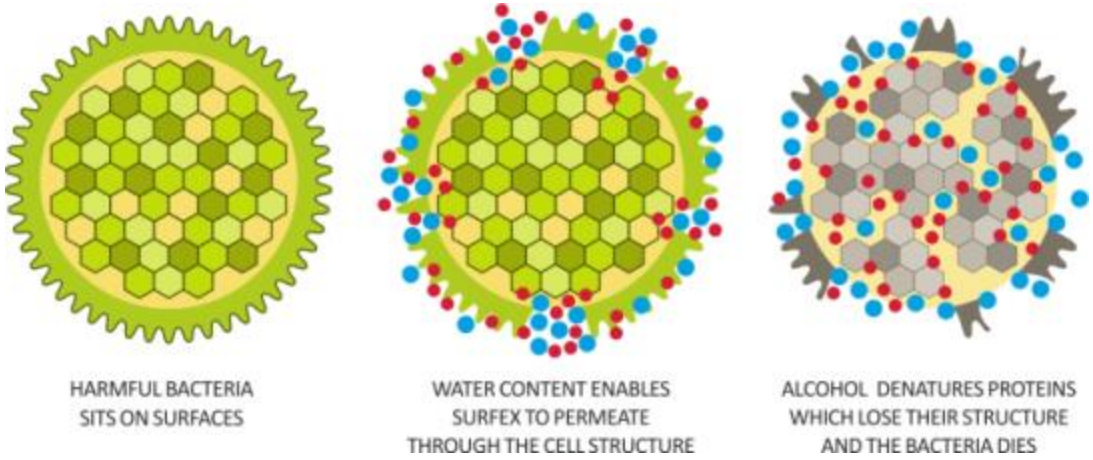
- Ethanol and is re rapidly active, killing vegetat *uberculosis*, and many fungi, a s. They are not used as sterila dal.
- They probably and the optimum bactericidal c olume in water. However, they they evaporate completely.
- Use of alcohc shown to reduce transmission of health care-associated bacterial pathogens and is recommended by CDC.

Alcohol Disrupts Hydrogen Bonding:

A 70% alcohol solution is used as a disinfectant on the skin, since this concentration of alcohol is able to penetrate the bacterial cell wall and denature the proteins and enzymes inside of the cell. A 95% alcohol solution merely coagulates the protein on the outside of the cell wall and prevents any alcohol from entering the cell. Alcohol denatures proteins by disrupting the side chain intramolecular hydrogen bonding. New hydrogen bonds are formed instead between the new alcohol molecule and the protein side chains.



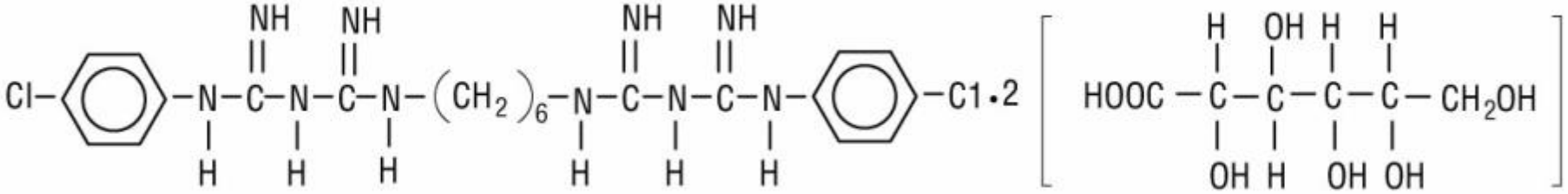
http://www.elmhurst.edu/~chm/vchembook/568denaturation.html



http://www.a-ex.co.uk/surfex.html

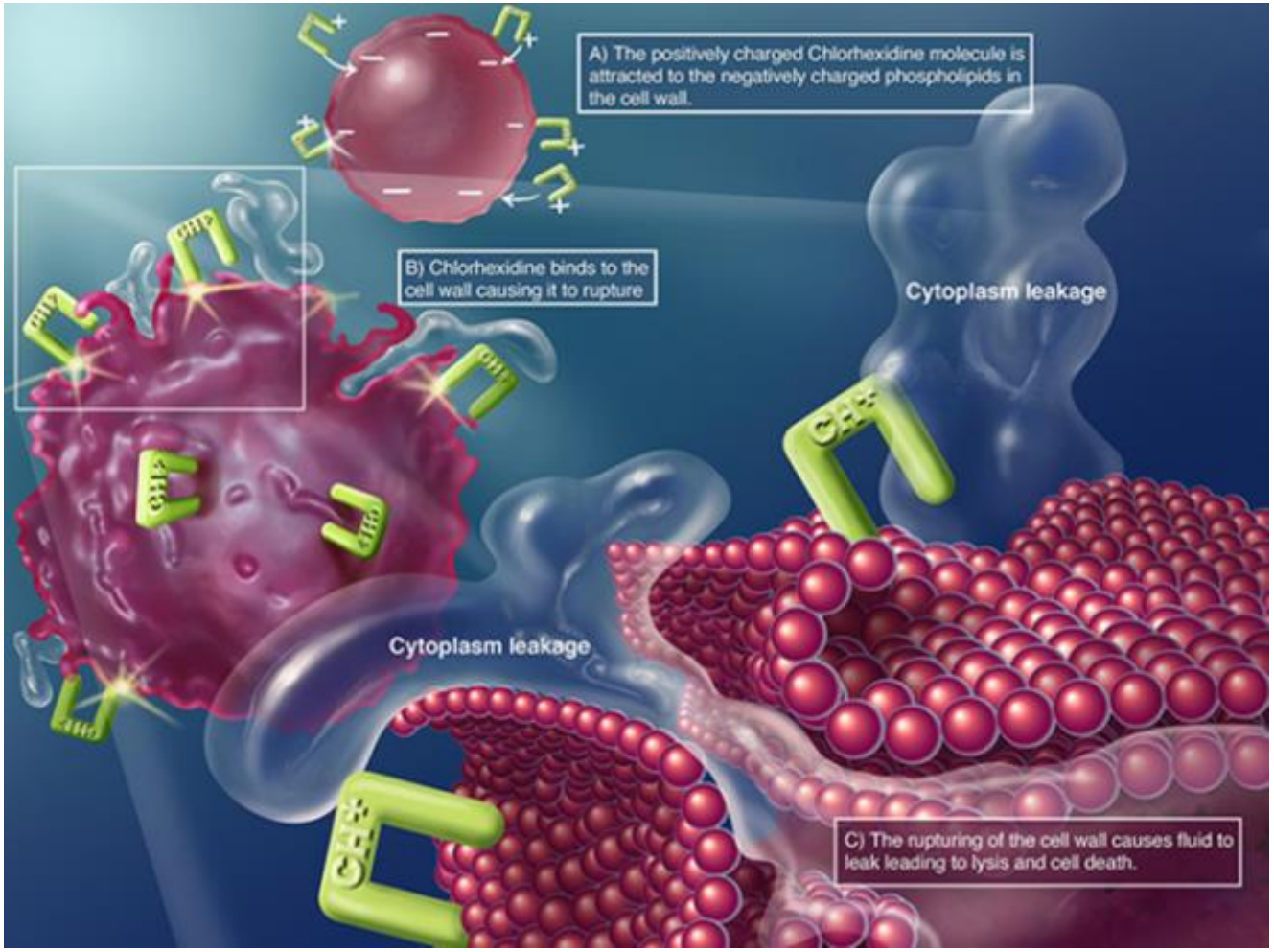
Chlorhexidine

- Chlorhexidine is a cationic biguanide with very low water solubility. Water-soluble chlorhexidine digluconate is used in water based formulation as an antiseptic, and active at pH 5.5-7.0.



- Chlorhexidine gluconate is slower in its action than alcohol, but, because of its persistence, it has residual activity when used repeatedly.

- Chlorhexidine gluconate strongly adsorbs to bacterial membranes, causing leakage of small molecules and precipitation of cytoplasmic proteins.



http://www.chlorhexidinefacts.com/mechanism-of-action.html

- It is active against vegetative bacteria and mycobacteria and has moderate activity against fungi and viruses. It is more effective against gram positive cocci and less active against gram-positive and gram-negative rods. Spore germination is inhibited by chlorhexidine.

- The combination of chlorhexidine gluconate in 70% alcohol is the preferred agent for skin antisepsis in many surgical and percutaneous procedures, but must not be used during surgery on the middle ear because it causes sensorineural deafness.

Halogens and Halogen-Containing Compounds

Iodine and **chlorine** are used as topical antimicrobial agents. They owe their activity to high affinity for protoplasm, where they are believed to oxidize proteins and interfere with vital metabolic reactions.

- Iodine in a 1:20,000 solution is bactericidal in 1 min and kills spores in 15 min. Tincture of iodine USP contains 2% iodine and 2.4% sodium iodide in alcohol.
- It is the most active antiseptic for intact skin, but not commonly used because of serious hypersensitivity reactions may occur.

- Antimicrobial action of iodine is rapid, even at low concentrations. Iodine rapidly penetrates into microorganisms and attacks key groups of proteins (in particular the free sulfur amino acids cysteine and methionine), nucleotides, and fatty acids, which culminates in cell death. Similarly to bacteria, it is likely that iodine attacks the surface proteins of enveloped viruses, but they may also destabilize membrane fatty acids by reacting with unsaturated carbon bonds. ***Gerald McDonnell and A. Denver Russell Clin. Microbiol. Rev.***

Iodophors

- Iodophors are complexes of iodine with a surface-active agent such as polyvinyl pyrrolidone (PVP; povidone-iodine).
- Iodophors can be used as antiseptics or disinfectants, they kill vegetative bacteria, mycobacteria, and lipid-containing viruses, and may be sporicidal upon prolonged exposure.
- The amount of free iodine is low in iodophor solution, but it is released as the solution is diluted. Hence, it must be diluted according to the manufacturer's directions to obtain full activity.
- Iodophors require contact time on skin before becoming active, which can be a disadvantage.
- Although iodophors have a broader spectrum of activity than chlorhexidine, including sporicidal, they lack its persistent activity on skin.

Chlorhexidine gluconate in 70% alcohol *vs.* Povidone-iodine

The NEW ENGLAND JOURNAL of MEDICINE

ORIGINAL ARTICLE

Chlorhexidine–Alcohol versus Povidone–Iodine for Surgical-Site Antisepsis

CONCLUSIONS

Preoperative cleansing of the patient's skin with chlorhexidine–alcohol is superior to cleansing with povidone–iodine for preventing surgical-site infection after clean-contaminated surgery. (ClinicalTrials.gov number, NCT00290290.)

- The advantage of cholorhexdine gluconate/70% alcohol over povidone-iodine may derive from :
- 1) Its more rapid action after application
- 2) Its retained activity after exposure to body fluids
- 3) Its persistent activity on the skin

Chlorine

- Chlorine is a strong oxidizing agent and universal disinfectant that is commonly provided as a 5.25% sodium hypochlorite solution, a typical formulation for household bleach, a 1:10 dilution of bleach provides 5000 ppm of available chlorine.
- The CDC recommends 5000 ppm of available chlorine for disinfection of blood spills. Less than 5 ppm kills vegetative bacteria, whereas up to 5000 ppm is necessary to kill spores.
- Because chlorine is inactivated by blood, serum, feces, and protein containing materials, surfaces should be cleaned before chlorine disinfectant is applied. Undissociated hypochlorous acid (HOCl) is the active biocidal agent. When pH is increased, the less active hypochlorite ion, OCl^-, is formed.
- Alternative chlorine-releasing compounds include chlorine dioxide and chloramine T. These agents retain chloride longer and have a prolonged bactericidal action.

腸病毒消毒注意事項

一、消毒工作重點：

（一）應進行**全面環境清潔**及**重點消毒**工作，包括：電梯按鈕、手扶梯、門把、手推車及附設兒童遊戲設施等，均要以消毒劑進行清潔與消毒。

（二）清潔消毒時，工作人員應穿戴防水手套、口罩等防護衣物，工作完畢後手套應取下，避免碰觸其他物品而造成污染。

二、建議消毒方法：

（一）戶外紫外線、紫外線殺菌燈、氯及煮沸等方法均能有效殺滅腸病毒，衣物等物品可使用沸水浸泡或曝曬等消毒方式。

（二）**酒精**（為**乾式洗手液**常見的主要殺菌成分）、乙醚、氯仿、酚類（如：來舒）等常見消毒劑**對腸病毒殺滅效果不佳**，請避免使用。

（三）建議使用濃度為 **500ppm 漂白水**，配置方法如下：
市售家庭用漂白水濃度一般在 5 至 6%，以喝湯用的湯匙舀 5 湯匙共約 80-100cc，加入 10 公升的自來水中（大瓶寶特瓶每瓶 1,250cc，8 瓶等於 10 公升），攪拌均勻，且於 24 小時內使用。

（四）如遭病童口鼻分泌物或排泄物污染之物品或表面，建議使用 **1000ppm 漂白水**擦拭（取 20cc 市售家庭用漂白水加入 1 公升之自來水）。

（五）另可參考通過衛生福利部疾病管制署委託社團法人「國家生技醫療產業策進會」審查推薦之防疫產品，請至 http://www.ibmi.org.tw/anti/client/ProductList.php?REFDOCTYPID=0l4tha7ehh29uhj3 查詢，並選用適合腸病毒消毒之產品。

三、使用漂白水注意事項：

（一）使用口罩、橡膠手套和防水圍裙，最好也使用護目鏡保護眼鏡以避免被噴濺到。如果漂白水濺入眼睛，須立刻以清水沖洗至少 15 分鐘並即就醫診治。

（二）在通風良好處配製和使用漂白水。

（三）漂白水需使用冷水稀釋，因為熱水會分解次氯酸鈉，並降低其消毒效果。

（四）有機物質會降低漂白水效果，消毒擦拭之前應將表面的有機物清除乾淨，例如：分泌液、黏液、嘔吐物、排泄物、血液和其他體液，使漂白水可以充分作用。

（五）**擦拭消毒的接觸時間建議超過 10 分鐘，之後可再以清水擦拭，以降低異味。**浸泡消毒的接觸時間建議超過 30 分鐘。

（六）不要與其他家用清潔劑一併或混合使用，以防降低消毒功能及產生化學作用。當漂白水和酸性清潔劑（如一些潔廁劑、鹽酸）混合時，會產生有毒氣體（如氯氣），可能造成傷害或死亡。如有需要，應先使用清潔劑並用水充分清洗後，才用漂白水消毒。

（七）未稀釋的漂白水在陽光下會釋出有毒氣體，所以應放置於陰涼及兒童碰不到的地方。

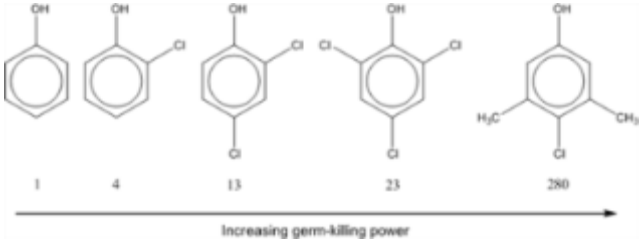
（八）請勿使用不透氣之玻璃瓶，長期盛裝 5-6%漂白水，以避免累積氣壓而爆炸，應使用塑膠瓶盛裝。

（九）由於次氯酸鈉會隨時間漸漸分解，因此宜選購生產日期較近的漂白水，並且不要過量儲存，以免影響殺菌功能。

（十）稀釋的漂白水，應當天配製並標示日期名稱，而未使用的部分在 24 小時之後應丟棄。

（十一）稀釋的漂白水必須加蓋及避免陽光照射，最好存放在避光的容器並避免兒童碰觸。

Phenolics

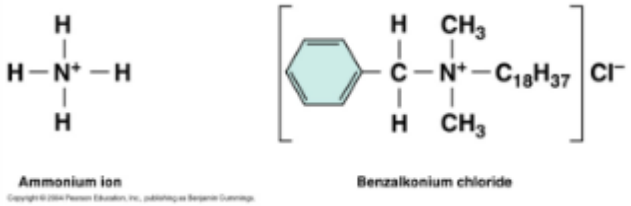


Phenol itself is no longer used even as a disinfectant because of its corrosive effect on tissues, its toxicity when absorbed, and its carcinogenic effect. These adverse actions are diminished by forming derivatives in which a functional group replaces a hydrogen atom in the aromatic ring.

- In high concentrations, phenol acts as a gross protoplasmic poison, penetrating and disrupting the cell wall and precipitating the cell proteins. Low concentrations of phenol and higher molecular-weight phenol derivatives cause bacterial death by inactivation of essential enzyme systems and leakage of essential metabolites from the cell wall. They are bactericidal and fungicidal and are capable of inactivating lipophilic viruses, but are not sporicidal.

- The phenolic agents most commonly used are *o*-phenylphenol, *o*-benzyl-*p*-chlorophenol, and *p*-tertiary amylphenol. Mixtures of phenolic derivatives are often used.
- Phenolic disinfectants are used for hard surface decontamination in hospitals and labs, but are not recommended for use in nurseries and especially in bassinets, where their use has been associated with hyperbilirubinemia.
- Use of hexachlorophene as a skin disinfectant has caused cerebral edema and convulsions in premature infants and, occasionally, in adults.

Quaternary ammonium compounds



- The bactericidal action of quaternary compounds has been attributed to inactivation of energy-producing enzymes, denaturation of proteins, and disruption of the cell membrane.
- These agents are fungistatic and sporistatic and also inhibit algae. They are bactericidal for gram-positive bacteria and moderately active against gram-negative bacteria, but are not tuberculocidal or sporicidal and do not inactivate hydrophilic viruses.
- Quaternary compounds are used for sanitation of noncritical surfaces. Their low toxicity has led to their use as sanitizer in food production facilities.
- CDC recommends quaternary ammonium compounds such as **benzalkonium chloride** not be used as antiseptics because several outbreaks of infections have occurred that were due to growth of Pseudomonas and other gram-negative bacteria in quaternary ammonium antiseptic solutions.

Aldehydes

- Aldehydes (formaldehyde, glutaraldehyde) are highly toxic agents (carcinogen, irritation) which can be used as sterilants, high-level disinfectants of instruments that cannot withstand exposure to the high temperatures of steam sterilization or tissue preservatives.
- They act by alkylation of chemical groups in proteins and nucleic acids, and have a broad spectrum of activity against microorganisms and viruses.
- An 8% formaldehyde solution in water has a broad spectrum of activity against bacteria, fungi, and viruses. Sporicidal activity may take as long as 18 hours, and its rapidity of action is increased by solution in 70% isopropanol.
- Solutions of 2% weight per volume glutaraldehyde are most commonly used, and must by alkalinized to pH 7.4-8.5 for activation. Glutaraldehyde has greater sporicidal activity than formaldehyde, but its tuberculocidal activity may be less.

- Aldeh agents (carci h-level disinf to the high t s.
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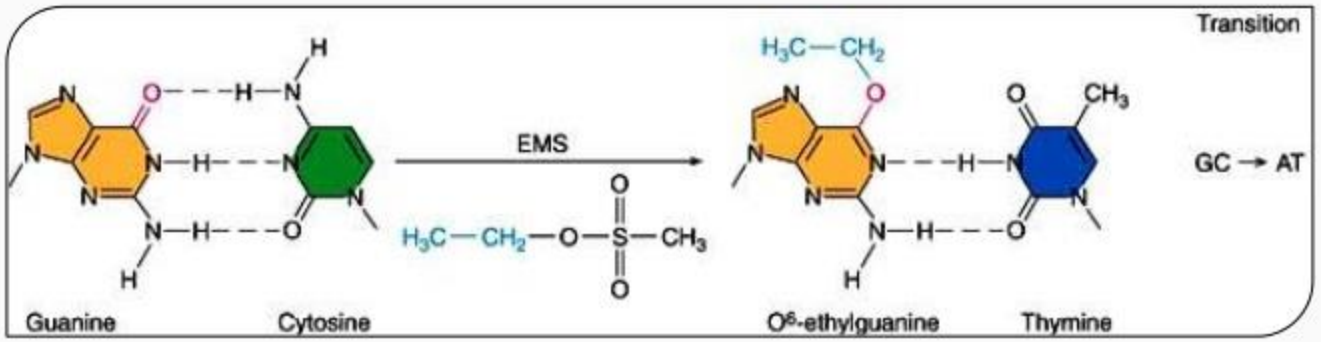
- Soluti most comm vation. Glutaraldehyde has greater sporicidal activity than formaldehyde, but its tuberculocidal activity may be less.



Alkylation is the addition of methyl or ethyl groups to various positions on the DNA bases. Example: alkylation of guanine by ethylmethane sulfonate (EMS). At the left is a normal G-C base pair. Note the free O_6 oxygen (red) on the guanine. EMS donates an ethyl group (blue) to the O_6 oxygen, creating O_6-ethylguanine (right), which base-pairs with thymine instead of cytosine. Mustard gas (sulfur mustard) is the most well-known example because of its use and consequences observed during World War I. It has two reactive groups that form intra-chain and inter-chain cross-links on DNA directly.

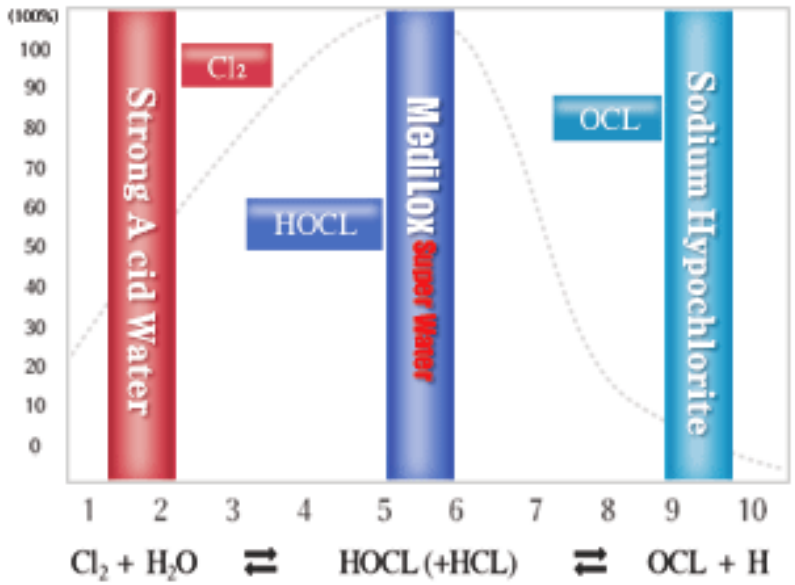
Ortho-phthalaldehyde (OPA)

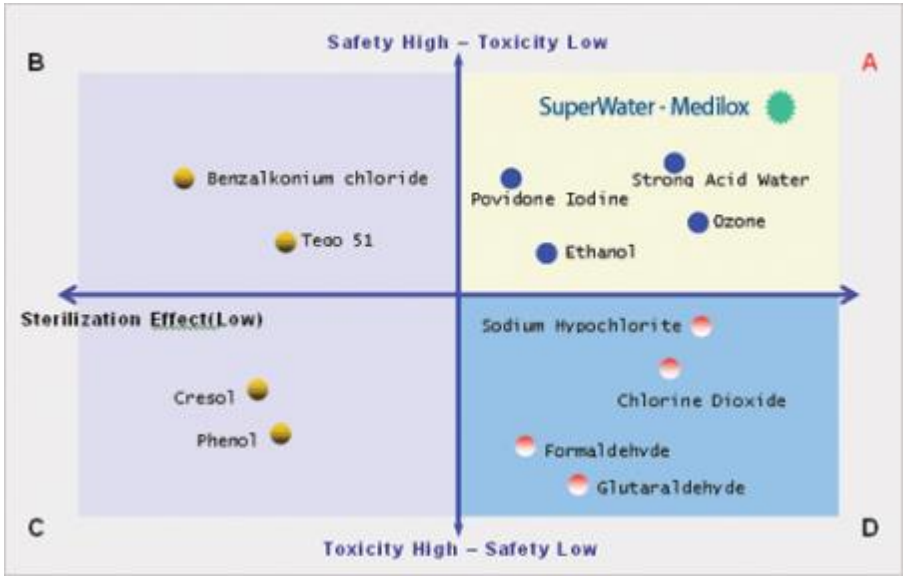
- OPA solution typically contains 0.55% OPA, and its label claim is that high level disinfection can be achieved in 12 min at room temperature compared with 45 min for 2.4% glutaraldehyde.

- Unlike glutaraldehyde, OPA requires no activation, is less irritating to mucous membranes, and has good material compatibility and an acceptable environmental safety profile.

Superoxidized water

- Electrolysis of saline yields a mixture of oxidants, primarily hypochlorous acid and chlorine, with potent disinfectant and sterilant properties.
- High-level disinfection is achieved with a contact time for 10 minutes.
- The solution is nontoxic and nonirritating and requires no special disposal precautions.





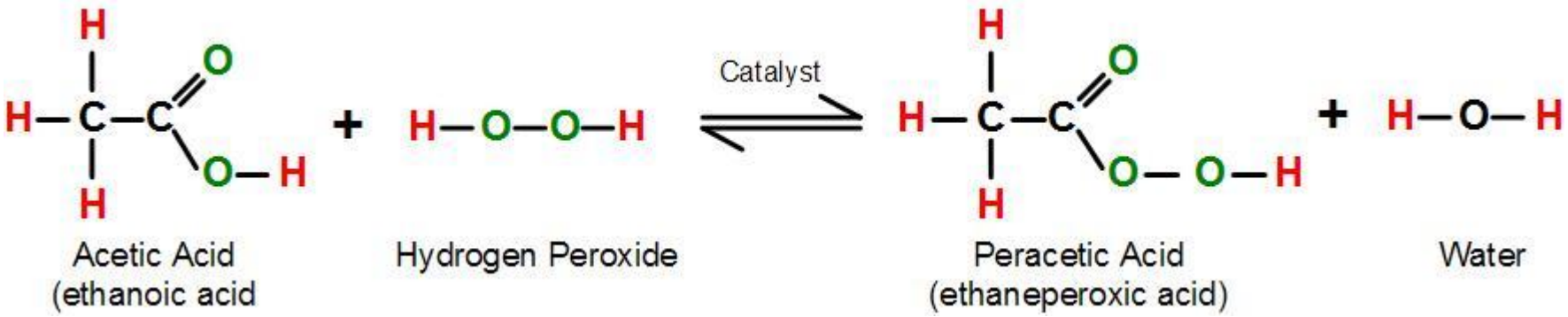
Peroxygen compounds

- The peroxygen compounds, hydrogen peroxide and peracetic acid, have high killing activity and a broad spectrum against bacteria, spores, viruses, and fungi when used in appropriate concentration.
- They are powerful oxidizers that are used primarily as disinfectants and sterilants, and their decomposition products are no toxic and do not injure the environment.

Hydrogen peroxide

- Hydrogen peroxide acts as an oxidant by producing hydroxyl free radicals (•OH) which attack essential cell components, including lipids, proteins, and DNA.
- Concentration of 10-25% hydrogen peroxide are sporicidal.
- Vapor phase hydrogen peroxide (VPHP) is a cold gaseous sterilant that has the potential to replace the toxic or carcinogenic gases ethylene oxide or formaldehyde.

Peracetic acid



- Peracetic acid is more active than hydrogen peroxide as a bactericidal and sporicidal agent.
- Concentration of 250-500 ppm are effective against a broad range of bacteria in 5 min at pH7.0. Bacterial spores are inactivated by 500-30,000 ppm peracetic acid. Viruses require variable exposures, enteroviruses require 2,000 ppm for 15-30 min for inactivation.
- Peracetic acid is a potent tumor promoter but a weak carcinogen.

Heavy metals

- Heavy metals, principally mercury and silver, are now rarely used as disinfectants.

- Nevertheless, thimerosal 0.001-0.004% is still used safely as a preservative of vaccines, antitoxins, and immune sera.

- Inorganic silver salts are strongly bactericidal. Silver nitrate has been commonly used particularly as a preventive for gonococcal ophthalmitis in newborns. Silver sulfadiazine slowly releases silver and is used to suppress bacterial growth in burn wounds.

Sterilants

- When autoclaving is not possible, ethylene oxide is used at 440-1200 mg/L at 45-60℃ with 30-60% relative humidity. However, ethylene oxide is classified as a mutagen and carcinogen.

- Alternative sterilants now being used increasing include vapor phase hydrogen peroxide, peracetic acid, ozone, gas plasma, chlorine dioxide, formaldehyde, and propylene oxide.

- Automatic peracetic acid systems are being used increasing because of their effectiveness, automated features, and the low toxicity of the residual products.

Agents	Spectrum	Uses	Advantages	Disadvantages
Alcohols (60-90%) including ethanol and isopropanol	Low- to intermediate-level disinfectant.	Used for decontaminating the outside of some semi-critical and noncritical items, e.g., oral and rectal thermometers and stethoscopes. Also to disinfect small surfaces such as rubber stoppers of multi-dose vials. Alcohols with detergent are safe and effective for spot disinfection of countertops, floors, and other surfaces. Also common in handrubs.	Fast acting. No residue. Non-staining. Low cost. Widely available in many countries for medicinal and research purposes.	Volatile, flammable, and an irritant to mucous membranes. Inactivated by organic matter. May harden rubber, cause glue to deteriorate, or crack acrylate plastic.
Chlorine and chlorine compounds: the most widely used is an aqueous solution of sodium hypochlorite 5.25-6.15% (domestic bleach) at a concentration of 100-5000 ppm free chlorine	Low- to high-level disinfectant.	Used for disinfecting tonometers and for spot disinfection of countertops and floors. Can be used for decontaminating blood spills. Concentrated hypochlorite or chlorine gas is used for disinfection of large and small water distribution systems, such as dental appliances, hydrotherapy tanks, and water distribution systems in haemodialysis centres.	Low cost, fast acting. Readily available in most settings. Available as liquid, tablets or powders.	Corrosive to metals in high concentration (>500 ppm). Inactivated by organic material. Decolourises or bleaches fabrics. Releases toxic chlorine gas when mixed with ammonia. Irritant to skin and mucous membranes. Unstable if left uncovered, exposed to light, or diluted; store in opaque container.

Agents	Spectrum	Uses	Advantages	Disadvantages
Aldehydes Glutaraldehyde: ≥2% alkaline or acidic solutions. Also formulated with phenol-sodium-phenate and alcohol.	High-level disinfectant.	Widely used as high-level disinfectant for heat-sensitive semi-critical items such as endoscopes.	Good material compatibility.	Allergenic and irritating to skin and respiratory tract. Must be monitored for continuing efficacy levels when reused.
Ortho-phthalaldehyde (OPA) 0.55%	High-level disinfectant.	High-level disinfectant for endoscopes.	Excellent stability over wide pH range. Superior mycobactericidal activity compared to glutaraldehyde. Does not require activation.	Expensive. Stains skin and mucous membranes; may stain items not thoroughly cleaned. Eye irritation. Poor sporicide. Must be monitored for efficacy during reuse. Contraindicated for reprocessing certain urological instruments.
Peracetic acid 0.2-0.35% and other stabilised organic acids.	High-level disinfectant/ sterilant.	Used in automated endoscope reprocessors. Can be used for cold sterilisation of heat-sensitive critical items, e.g., haemodialysers. Also suitable for manual instrument processing when properly formulated.	Rapid sterilisation cycle time at low temperature (30-45 min. at 50-55°C). Active in presence of organic matter. Environmentally-friendly by-products (oxygen, water, acetic acid).	Corrosive to some metals. Unstable when activated. May be irritating to skin, conjunctivae and mucous membranes.

Agents	Spectrum	Uses	Advantages	Disadvantages
Hydrogen peroxide 7.5%.	High-level disinfectant/ sterilant.	Can be used for cold sterilisation of heat-sensitive critical items. Requires 30 minutes at 20°C.	No activation. No odour. Environmentally-friendly by-products (oxygen, water).	Not compatible with brass, copper, zinc, nickel/silver plating.
Hydrogen peroxide 7.5% and peracetic acid 0.23%	High-level disinfectant/ sterilant.	For disinfecting haemodialysers.	Fast-acting (high-level disinfection in 15 min.). No activation required. No odour.	Not compatible with brass, copper, zinc, and lead. Potential for eye and skin damage.
Phenolics	Low- to intermediate-level disinfectant.	Has been used for decontaminating environmental surfaces and non-critical items. Concerns with toxicity and narrow spectrum of microbicidal activity.	Not inactivated by organic matter.	Leaves residual film on surfaces. Harmful to the environment. No activity against viruses. Not recommended for use in nurseries and food contact surfaces.
Iodophores (30-50 ppm free iodine)	Low-level disinfectant.	Used on some non-critical items, e.g., hydrotherapy tanks; however, main use is as an antiseptic.	Relatively free of toxicity or irritancy.	Inactivated by organic matter. Adversely affects silicone tubing. May stain some fabrics.
Quaternary ammonium compounds	Low-level disinfectant unless combined with other agents.	Used mainly on environmental surfaces. Can be used on skin.	Stable with good detergent properties (cationic detergent). Usually non-irritating.	Relatively narrow microbicidal spectrum, but range of activity can be expanded when combined with other agents, e.g., alcohols.

ppm = parts per million

Activities of disinfectants

	Bacteria			Viruses			Other		
	Gram-Positive	*Gram-Negative*	*Acid-Fast*	*Spores*	*Lipophilic*	*Hydrophilic*	*Fungi*	*Amebic Cysts*	*Prions*
Alcohols (isopropanol, ethanol)	HS	HS	S	R	S	V	. . .	. . .	R
Aldehydes (glutaraldehyde, formaldehyde)	HS	HS	MS	S (slow)	S	MS	S	. . .	R
Chlorhexidine gluconate	HS	MS	R	R	V	R	. . .	. . .	R
Sodium hypochlorite, chlorine dioxide	HS	HS	MS	S (pH 7.6)	S	S (at high conc)	MS	S	MS (at high conc)
Hexachlorophene	S (slow)	R	R	R	R	R	R	R	R
Povidone, iodine	HS	HS	S	S (at high conc)	S	R	S	S	R
Phenols, quaternary ammonium compounds	HS	HS	MS	R	S	R	S	. . .	R

HS, highly susceptible; S, susceptible; MS, moderately susceptible; resistant; V, variable; …, no data.

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Chemical agents of control have **4 primary sites of action**: **cell wall** (if present), **cellular membranes, proteins** and **nucleic acids (DNA or RNA).**