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# 1915 THE TRAGEDY OF GAS WARFARE

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1915 heralded the use of a terrifying and potent weapon.  
Causing 1.2 million casualties with 5% of all deaths in WWI.  
Its use was outlawed by international convention in 1925 but has  
been used sporadically since.





John Singer Sargent's depiction of the effects of gas  
- blindness, vomiting, choking and death







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# Personalities involved

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## Fritz Haber

Brilliant German chemist dubbed “Father of chemical warfare” developed the Haber- Bosch process for synthesising ammonia.

In 1915 he personally supervised the deployment of chlorine gas at Ypres. Heading the Kaiser Wilhelm Institute, he supervised the team of Lommel and Steinkopf who synthesised mustard gas

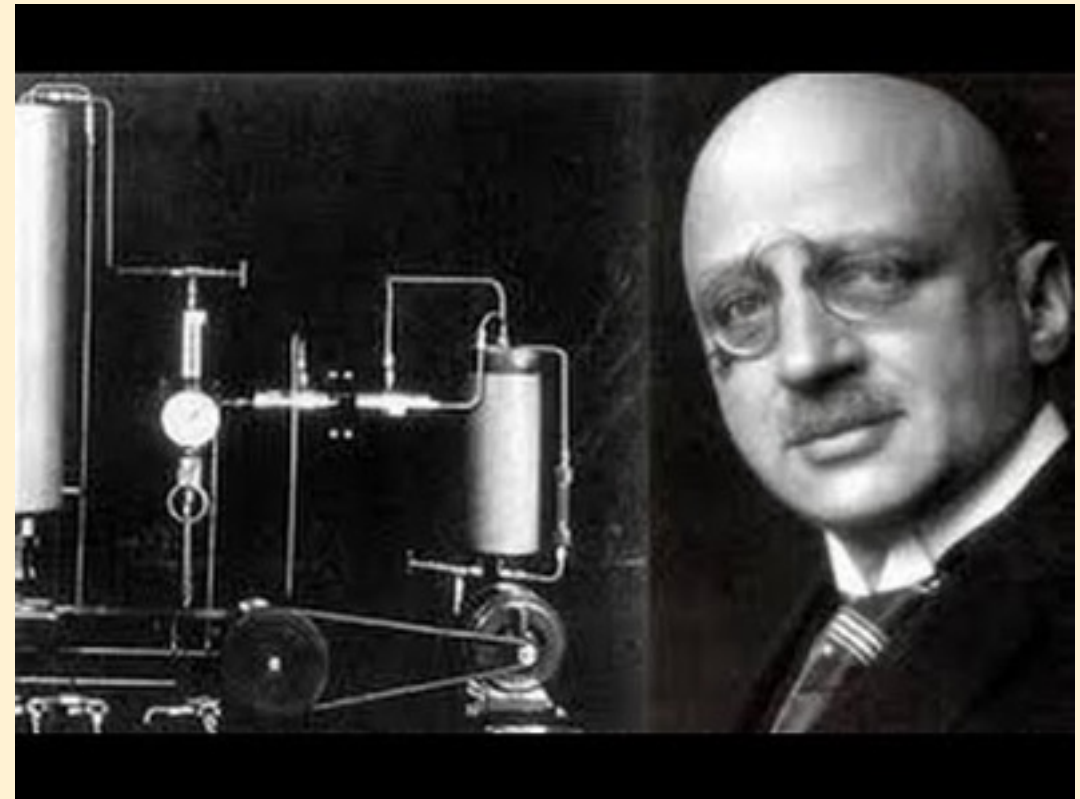
$\text{SCl}_2 + 2 \text{C}_2\text{H}_4 \rightarrow (\text{Cl-CH}_2\text{CH}_2)_2\text{S}$  assigned the acronym LoSt by the German Military



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# Fritz Haber

His wife, also a chemist distraught at his work on gas warfare committed suicide



Developed the Haber process for synthesising ammonia to make chemical fertiliser and explosives

Awarded the Nobel prize in chemistry 1918

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The Hague Conference of 1899 was quite unequivocal in outlawing the use of chemical warfare on the battlefield or the Home Front:

*Article 23: It is especially prohibited to employ poisons or poisonous gases.*

Or more specifically:

*Declaration II: On the use of projectiles the objective of which is the diffusing of asphyxiating or deleterious gases.*

But hardly was the ink dry when the signatories began to question  
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Fritz Haber convinced Ludendorff, the German commander on the Western Front, of the value of chemical warfare





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# Ypres salient 1915

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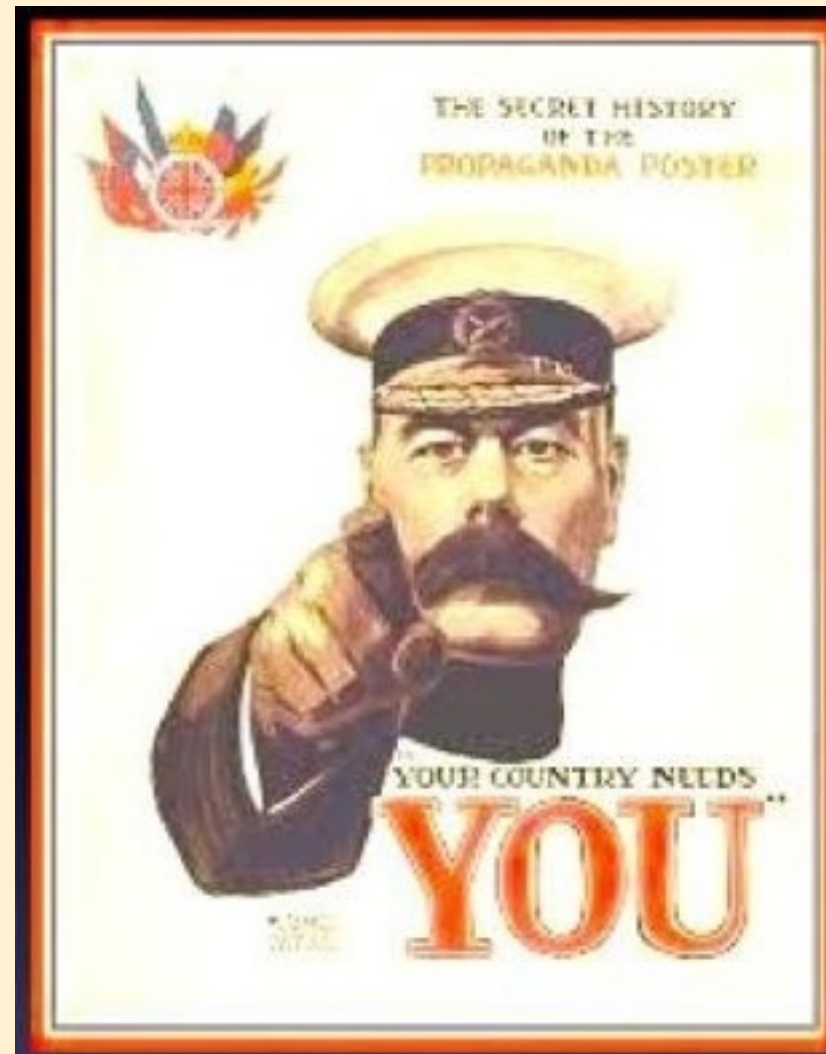
German troops released Chlorine gas from cylinders in the first major attack  
dispersion of the gas relied on wind direction and speed

Heavier than air, the gas settled in shell holes and trenches

Early realisation of poison gas as a disruptive and incapacitating weapon

Persistence of toxic chemical in soil established concept of area denial

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Kitchener describes the German use of chemical warfare as

*“An indication of the extent of the depravity that one could sink in an attempt to compensate for the lack of courage”*

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# Chemical agents employed

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At the outbreak of WWI German chemists identified 60 compounds and the Allies over 40 agents for use in warfare

Initially Chlorine and soon Mustard gas and Phosgene were deployed in great quantities killing and maiming

Lewisite developed and manufactured in huge quantities in USA was far more deadly than Mustard gas and had immediate effects. Fortunately it was not deployed before the armistice

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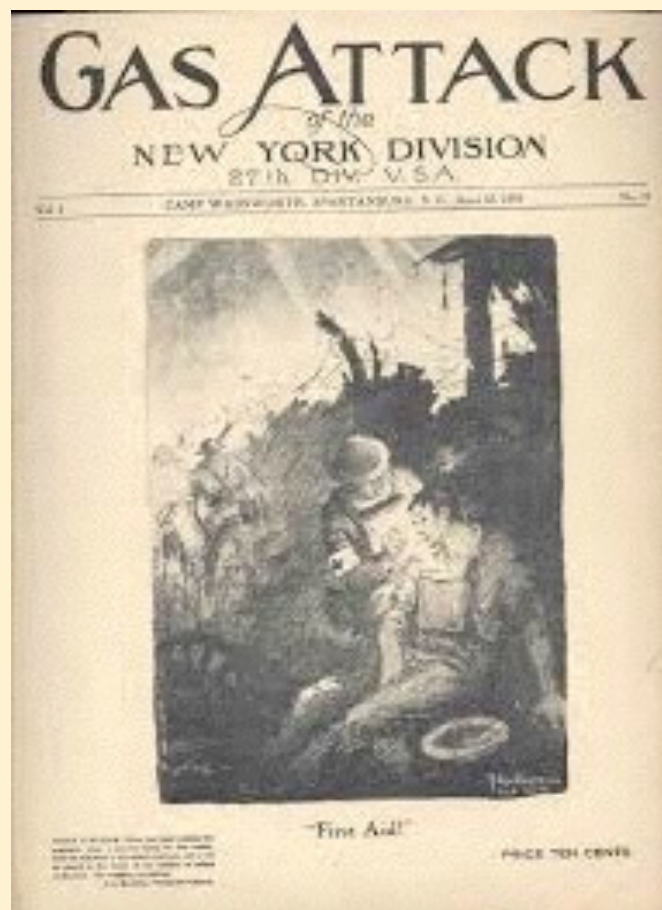
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The British used only captured German gas till 1917.  
At the onset, the British chemical industry was much inferior to that in Germany which was highly organised with militarised research.  
America rapidly stepped up production of gases. By 1917, 5000 scientists ensured the daily production of 200 tons of Mustard gas.



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The militarisation of poison gas production was highly developed in Germany and France with all the premier academic institutions taken over by the army.



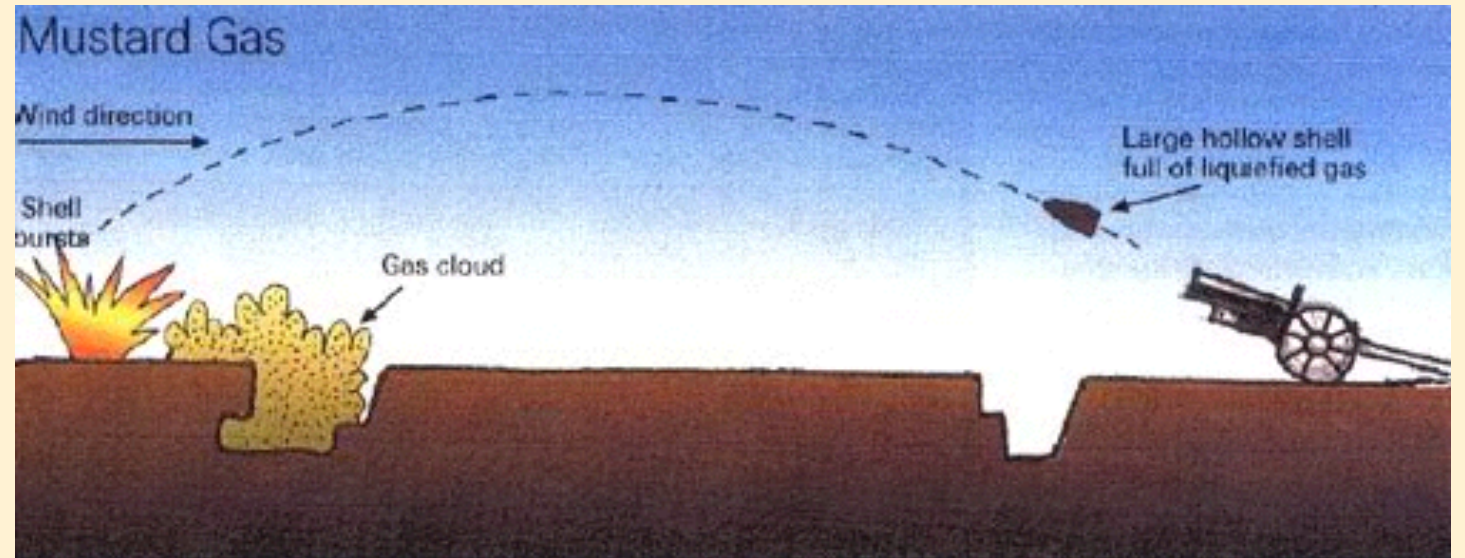


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Delivery of gas from cylinders was haphazard and soon replaced by artillery shells and mortars.

The British Livens gas projector mortar was cheap and simple to operate. Thousands were produced and rushed to the front.





Tricks and ruses were employed by both sides in the deployment of gas

Gas shells landed with a plop on the earth, warning of their arrival. Mixing the barrage with high explosives masked the arrival of gas

By 1917 one quarter of the millions of shells fired were gas filled



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# Early protective measures were primitive

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Pad soaked in Sodium bicarbonate or urine placed over mouth and helped protect against

Desperate troops buried their faces the earth



British Daily Mail newspaper campaign for home made masks produced 30,000 defective masks stuffed with cotton wool supplied to the front line. Tragically dry masks were ineffective , wet masks suffocated.

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Gas density allowed greater safety on parapet

Mustard gas persisted on foliage and clothing. The need to remove contaminated clothing as soon as possible after exposure in a safe place reduced ongoing contamination.

Most vulnerable were those wounded lying at the base of shell hole

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*Gas! GAS! Quick, boys! — An ecstasy of fumbling,  
Fitting the clumsy helmets just in time;  
But someone still was yelling out and stumbling,  
And flound'ring like a man in fire or lime ...  
Dim, through the misty panes and thick green light,  
As under a green sea, I saw him drowning.  
In all my dreams, before my helpless sight,  
He plunges at me, guttering, choking, drowning.*

—[Wilfred Owen](#), "[Dulce et Decorum est](#)", 1917

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Accidents and disasters in the manufacture and deployment of poison gases were common

The first British deployment of chlorine was marred by the wrong spanner size supplied to open the cylinders. Further problems arose when the wind direction changed gassing their own troops

Leakage in a gas factory in Lille France affected 1200 workers

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# Examples of early protection

Protection was partial with little time to don masks. The masks were cumbersome, difficult to fight wearing a mask with visibility and limited absorptive capacity.

Trainers in gas warfare referred to "quick and the dead"



Early Hypo helmet or British smoke hood developed by physiologist John Haldane

Cotton impregnated with Sodium Phenate effective for phosgene

Later model "small box respirator" A rubber hose connected to a small box of absorbent neutralizer

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# Design of an early protective mask

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Masson, Osborne and Laby  
1915

University of Melbourne ,  
Department of Chemistry collection





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Melbourne University prototype  
respirator designed by Laby,  
Masson and Osborne 1916

Air was filtered through soda lime  
absorbent and expired through a  
one way valve. Worn with a nose  
clip and motoring goggles it  
offered partial protection against  
Chlorine and Bromine.

It never saw service as an  
improved British version was soon  
introduced



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# Early warning of attack

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Powered by compressed air, the Strombus horn placed every 200m along the trenches, gave a deafening hoot to warn of a gas attack

The hoot supported by drums and beating on shell cases, caused a huge din further raising anxiety



Australian War Memorial Canberra

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Mustard gas produces delayed painful blistering on skin and airways



A British victim of the first mustard gas attack, recorded five days after exposure, this man was suffering from slight laryngitis and bronchitis but his eyes and skin were affected, the latter in areas of perspiration.

W. G. MacPherson (ed.), History of the Great War Medical Services Diseases of the War, Vol. II, plate VI.



Lung of a gassed soldier  
death from bronchopneumonia 12 days  
after exposure to gas

WW1 collection , Bayerisches Armeemuseum , Munich

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# Injuries in gas warfare

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Canadian soldier with  
severe respiratory and  
skin burns



Burns were delayed after  
exposure and were  
extremely painful

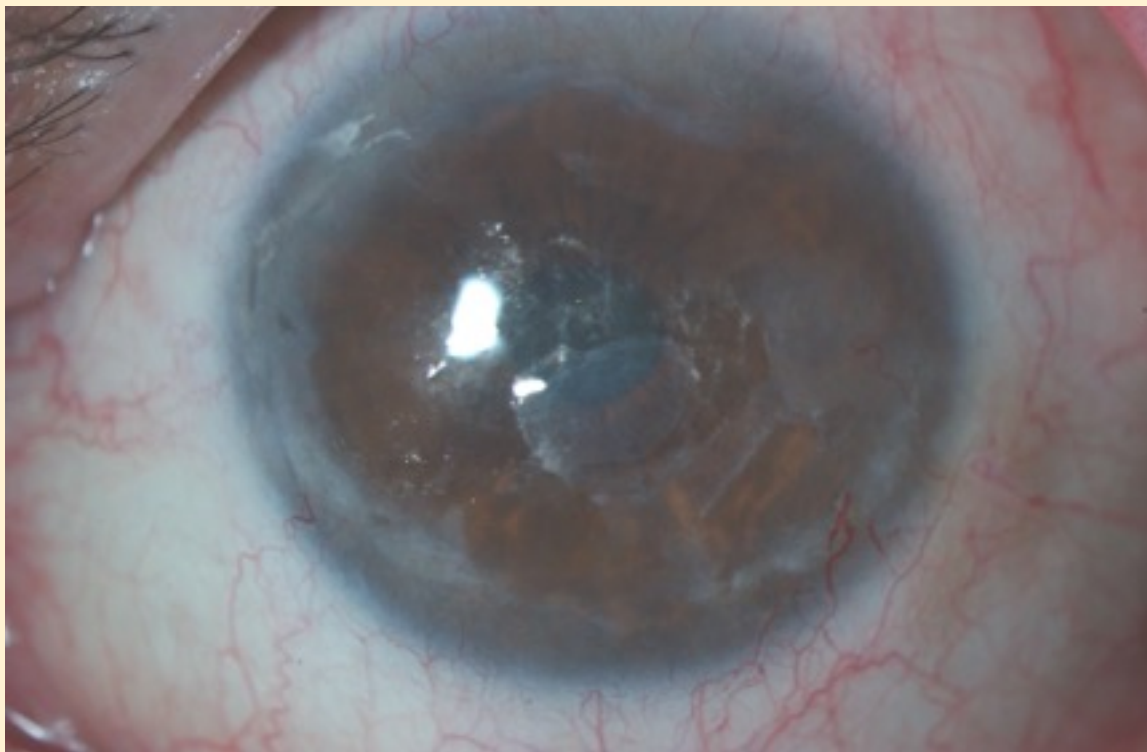
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Eye burns were the most common injury from Mustard gas

Tissue binding occurs within 15 minutes

Damages adhesion molecules between epithelium and basement membrane causing early epithelial breakdown and ulceration





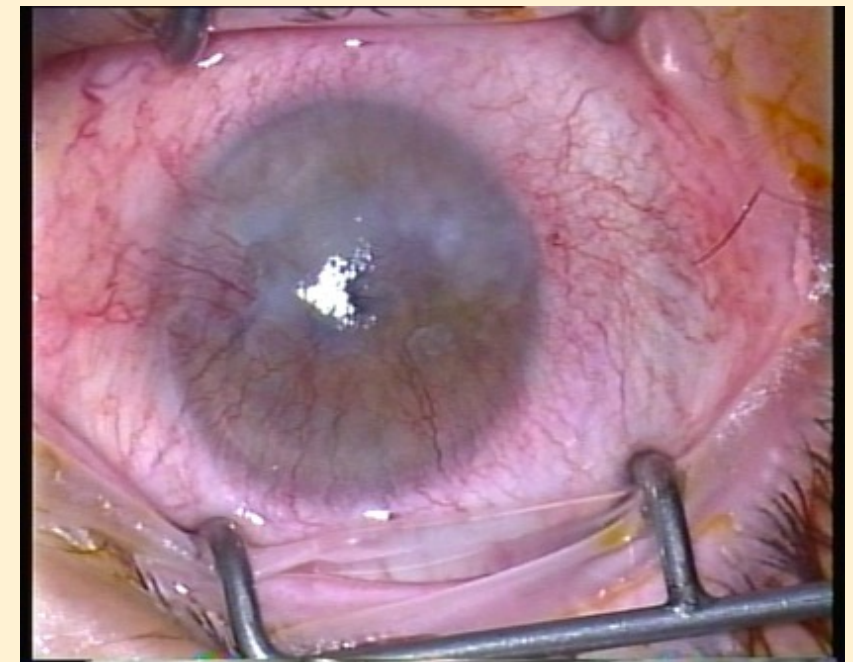
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Immediately after exposure to Mustard gas there may be few initial symptoms;

Early: (1 to 8 hours) Lid swelling and eye closure, grittiness, lacrimation, photophobia, blepharospasm and impaired vision.

Intermediate: (1 to 10 days) Corneal epithelial loss, stromal opacification and thinning, secondary infection and uveitis.

Late: (Months-Years) Abnormalities of limbal vascular bed with ischaemia and ulceration.



Instruction  
manual  
showing  
effects of  
Mustard gas



Acute  
Stage.

B



Later  
Stage.

Severly Burned Eye. Mustard Vapour.



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# Treatment

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After admission to the hospital, the gassed patients were stripped of all clothing and showered. Those with serious symptoms were bathed while still lying on stretchers.

After leaving the showers, medics sprayed their eyes, noses and throats with bicarbonate of soda to mitigate corrosion of the mucous membranes.

To counteract the effects of inhaled gas, oxygen was administered through a funnel. Bleeding by venesection although outdated, was advocated by some medical advisors.



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# Treatment

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Those who had ingested gas contaminated food or water were prescribed olive or castor oil to coat irritated stomach linings.

Physical strain or effort within the first month after being seriously or severely gassed could lead to cardiac arrhythmias known as “Irritable soldier’s heart.”

“Gas fright” was the description given to the severe psychological terrors suffered by victims.





Horses were used in vast numbers and these too were subject to the horrors of gas warfare suffering burns and slowly succumbing

Mask protection was supplied to some animals but failed to protect the exposed areas

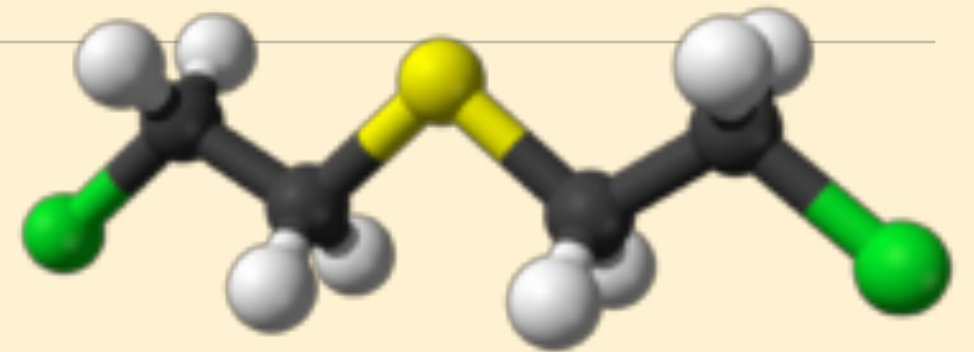




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# Mechanism of Mustard gas

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The compound is lipophilic, readily absorbed through skin and mucous membranes

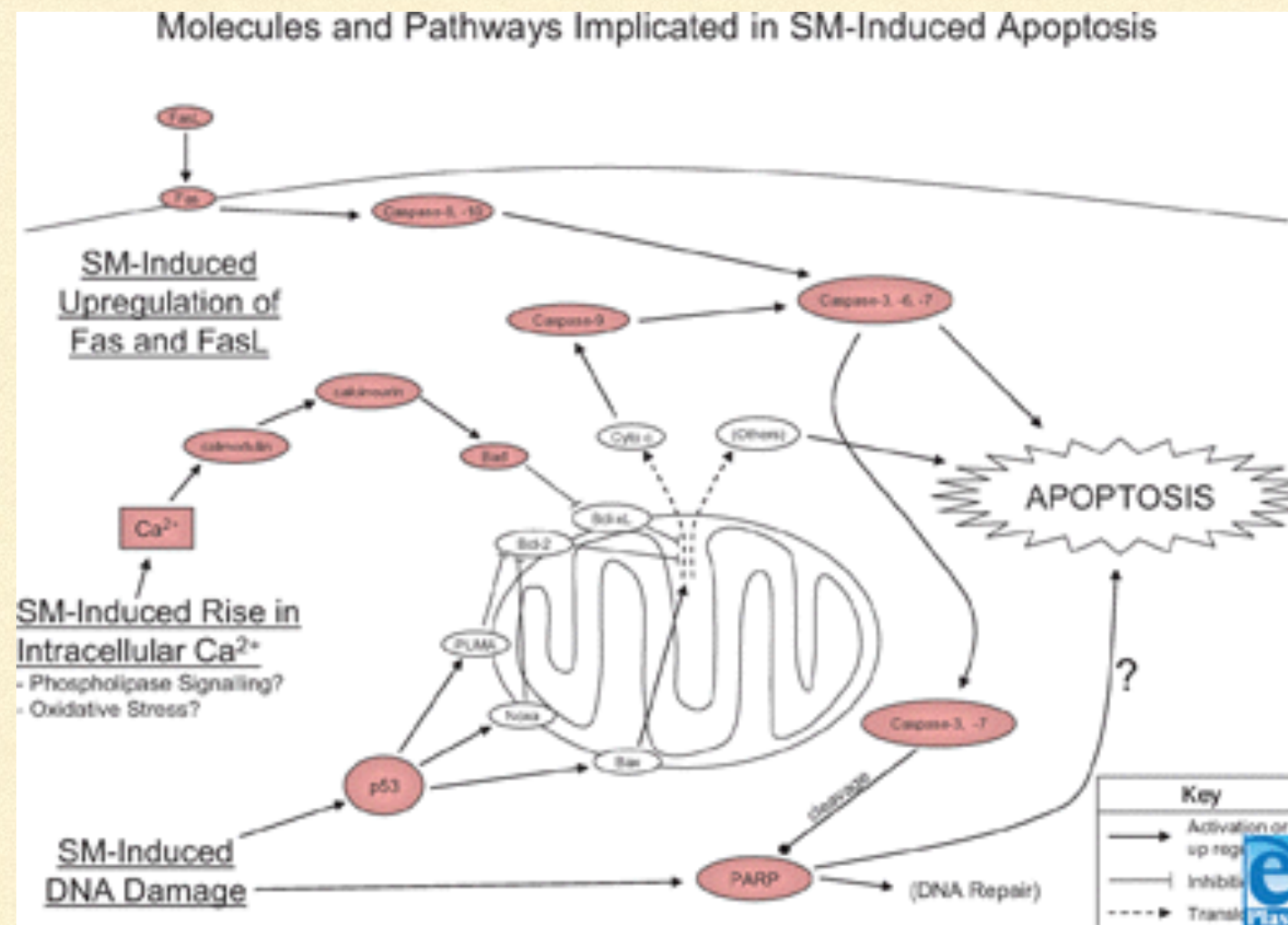
Nucleophilic substitution forms a cyclic sulfonium ion which is a highly reactive alkylating agent

Alkylation of the guanine nucleotide in DNA strands prevents cellular division and generally leads directly to apoptosis

Damaged DNA may lead to the development of cancer

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Many of the molecules and mechanisms implicated in Sulphur Mustard injury are now being experimentally validated. Critical questions are proposed that remain to be answered to increase our understanding of SM toxicity and accelerate the development of vesicant therapeutics.





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# How effective was the use of poison gas?

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The initial attack with chlorine killed over 5000 and incapacitated many more.

With protective measures, the fatalities accounted for 5% of all deaths in WWI

As a disruptive and as a agent of area denial, gas was highly effective

The psychological effects were devastating





.....an oily liquid, dropping like fine rain and covering a huge area with thousands of droplets, each of which, when it touched the tissues, made a small burn, turning a few hours later into a blister... Thousands of soldiers were affected by severe lesions...”.

*Report by Dr. Marcel Junod 1935 Abyssinia*

