greater egg-carrying capacity than those of the head louse. The eggs are slightly larger and the number laid was greater, while the habits associated with egg-laying differ, although by transposing the conditions suitable for other species a considerable degree of uniformity may be produced. It is probable that in nature their egg-laying habits are quite distinct.

Cross pairings between the insects are easily brought about and might, under exceptional circumstances, occur naturally. Hybrid strains resulting from pairings of *P. capitis* males with *P. humanus* females, and *vice versa*, were maintained without trouble until the F_3 generation, and there seemed no reason why such strains could not be continued indefinitely. Nevertheless, the marked disparity in the sexes of the F_1 generation of some crosses between *P. capitis* male and *P. humanus* female was suggestive of the specific rather than the racial rank of the two insects.

The mortality of females of *P. capitis* crossed with *P. humanus* males points in the same direction, but there was no such obvious disparity in the sexes of the first generation of hybrids from this cross, nor was there any marked disparity in the proportion of the sexes in the following hybrid generations.

In size the hybrid insects are approximately intermediate, but inclining in form, activity and habits towards *P. capitis*. Extreme disparity in the size of some individuals of either sex was noted in some of the broods of the F_3 generation; very large males and small females being observed.

Habits.

The body louse exhibits habits of gregariousness, especially during the moulting phases, and a preference for retiring to a particular spot to oviposit, which leads to the clustering of eggs; both of these habits are shown, though in a less marked degree, by *P. capitis*, and it is possible that they might be partly due to the conditions of captivity, though it seems more probable that the divergence in its habitat is accentuating both tendencies in *P. humanus*.

Pairing with both species took place at any hour, and was very frequently observed when the insects were examined after feeding; males with but little food in the alimentary tract were, however, often seen in coitus. The period during which the insects remained together was on several occasions noted to exceed an hour, but no limit of time was determined.

A male of *P. humanus* fertilized 18 out of 21 females placed with him in succession. Attempts with *P. capitis* were less successful; out of four trials one male fertilized 10 females, and might possibly have equalled the record of *P. humanus* but for the scarcity of virgin females while the experiment was in progress.

Eggs are laid by virgin females of both species on the second or third day following the final ecdysis, and continue to be freely laid so long as feeding continues and the body conditions of temperature prevail, but these unfertilized eggs do not hatch. The longest period for which a female *P. humanus* retained the power to lay fertilized eggs after the removal of the male was twenty days; more usually it would seem to be from sixteen to eighteen days. In the case of *P. capitis* the period was considerably shorter, twelve days being the longest ascertained period, while it was usually about seven to eleven days.

The greatest number of eggs laid by any one female of *P. humanus* was 295—an average of 6.4 per day; the daily average of a number of females being 5.1. Females of *P. capitis* showed a lower fecundity—the highest record being 141, with a daily average of 4 per day; the average of a number of females being 3.7 daily. These figures would probably be exceeded under natural conditions. An experiment in which some females of *P. humanus* were given an opportunity to feed for two hours by day in addition to seven hours each night, showed unmistakably the extent to which egg production was dependent upon food—the average of these females rising to eight per day. The fertility of the eggs laid was unaffected by the increased feeding. The greatest number of fertilized eggs laid by a female *P. humanus* after the removal of the male was 115; with a female of *P. capitis* the parallel figure was 70.

Length of Life.

The life of the male *P. humanus* which fertilized 18 females was 32 days after reaching maturity, while the longest female life after maturity was 46 days—the average of a number of females being 34 days. With *P. capitis* the figures were: Male life 30 days; female life 38 days—the average of a number of females being 27 days. The lives of the hybrid insects were not noticeably shorter than those of *P. humanus* and the hybrids seemed to breed more freely than *P. capitis*.

Tests made with unfed *P. humanus* showed that the longest lives were at a medium temperature of 60° to 65° F.; many of the insects living from 3 to 4 days, while two lived 5, and one 7 days. At 76° F. all died within 5 days, and at 98° F. all died within 3 days.

Newly-hatched larvae, unless fed, lived less than 24 hours at 98° F., and if kept in a box in the vest pocket they lived but little more than a day, unless fed; none survived a second day.

Adults kept in a box in an outer pocket of a walking coat during March lived five days without food.

Of forty young lice which emerged from the egg on the same day the following record of the moulting periods was made:

First Moulting.			Second Moulting.		
3 per cent. on the 3rd day			15 per cent. on the 7th day		
42 " " 4th "			72 " " 8th "		
55 " " 5th "			13 " " 9th "		
Third Moulting.					
5 per cent. on the 10th day			... ..	... ..	mature
3 " " 11th "			...	...	"
55 " " 12th "			...	...	"
32 " " 13th "			...	...	"
5 " " 14th "			...	...	"

Cold.

Active specimens of *P. humanus* survived two days at a temperature of 28° F. to 30° F., but none after exposure to these conditions for a week.

Hatching of Eggs.

Under humid conditions in an incubator kept at 87° F.—

3 per cent. of the 1,300 eggs tested hatched on the 7th day					
56 " " "					8th "
33 " " "					9th "
8 " " "					10th "
0.2 " " "					11th "

A test carried out with eggs taken from a stock box—date of laying uncertain, some having been laid possibly as many as three days previously—showed that none hatched at 60° to 65° F., while at 76° F. there was considerable mortality in the egg stage. The hatching period of those that survived was spread over a longer period than usual. At 98° F. the period of hatching only covered five days, while the mortality was not excessive.

To give some idea of the possible rate of multiplication of *P. humanus*, we may estimate the egg period as twelve days and a further twelve days to the maturity of the females. Allowing an average of eight eggs per day, spread over a fertility period of forty days, we find that during her life a single female may have 4,160 offspring.

AN INVESTIGATION OF THE BEST METHODS OF DESTROYING LICE AND OTHER BODY VERMIN.

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II.

In a preliminary communication¹ to the BRITISH MEDICAL JOURNAL I described some early experiments in breeding lice, which showed that the humidity of the atmosphere was of importance—a fact which I have since ascertained to have been previously discovered by Mr. Bacot, of the Lister Institute, with regard to the breeding of fleas.²

Up to the present I have been unable to determine the constant conditions that would enable lice to breed and live in the incubator, the lice being removed from the incubator only while feeding on the human body. On one occasion, out of some forty experiments with different samples of lice, it was found possible to keep the lice alive and to hatch out their eggs when they were suspended over water by means of a cotton-wool plug

inserted midway in a glass tube kept at body temperature in the incubator, but failure to repeat this result suggests that perhaps some other factor at present unknown is essential to secure the requisite constant conditions.

It has therefore been necessary for the purpose of insecticidal experiments with lice to take them from verminous clothing and expose them directly to the insecticidal agents. To this end a supply of verminous clothing was obtained about twice weekly from military barracks, and from lodging-houses, and the Poor Law institution.

The variation in resistance of lice as found in nature is very great, and it therefore seemed well in all the insecticidal experiments already reported to pass over experiments where death to the louse resulted, if in a similar experiment with another strain of lice an occasional louse appeared to survive. In some recent experiments undertaken for the purpose of testing earlier results I have not found any of the lice to show unquestionable evidence of life after exposure to boiling water even for five seconds. It would therefore appear that in my earlier series of experiments I had been misled in interpreting certain movements as a sign of life, the more that so competent an authority as Mr. Bacot³ has in a recent contribution on the subject stated that he invariably obtained a lethal result. Mr. Bacot, in his interesting and valuable paper, has described a method for breeding and rearing lice in contact with the human body. He found that lice thus reared never survived thirty seconds' immersion in boiling water, and that a temperature of 55° C. (131° F.) maintained for half an hour killed both active lice and their eggs.

Volatile Oils and Phenol Bodies.

I have made some additional tests with oil of cloves and oil of turpentine. I have also experimented with oil of bergamot. I have found that when immersed in oil of cloves for two minutes and then placed on a piece of blotting paper, the lice move freely over the paper. After similar immersion in oil of bergamot only an occasional louse moves, and the movements are feeble. After immersion for the same time in oil of turpentine all the lice are dead. But how far the movements noted are compatible with the ultimate survival of any of the lice has not been determined.

I have also made further tests with the phenol bodies, and in consonance with my former experiments I have repeatedly found a varying proportion of the lice survive half an hour's immersion in a 5 per cent. emulsion of cyllin in water at ordinary room temperature.

Insecticidal Powders.

During the past year I have received several letters from officers of the R.A.M.C., who have indicated that in endeavouring to keep soldiers free from vermin infection much trouble has been occasioned by the rapidity with which a unit once cleansed has been reinfected. It appears that a lice-free unit is generally infected from barns and trenches previously occupied by lice-infected units. In order, therefore, to secure immunity from lice infection, means are required for keeping the clothes and body constantly obnoxious to lice.

I have investigated several insecticidal powders in the hope that one might be found which, when applied to the clothing, would secure the desired result. I first tested the antiparasitic powder described by Mr. Langford Moore⁴; it has been largely used, and has gained a considerable reputation as an insecticide. It consists of

Ammoniated mercury	...	...	1 oz.
Zinc oxide...	...	...	$\frac{1}{2}$ oz.
Magnesium silicate...	...	...	$\frac{1}{2}$ oz.

Mr. Moore believes that the zinc oxide, by its astringent and dehydrating effect, inhibits absorption of the slowly ionized mercurial salt, and thus prevents toxic action. The magnesium silicate (or French chalk) is added to increase the diffusibility of the powder on application. I have repeatedly found that lice in contact with this powder at body temperature and humidity remain alive and apparently unaffected after twelve hours—the period of the experiments—and that if suspended over the powder they remain altogether unaffected. It may be that the powder is obnoxious to lice in an indirect manner or when ionization of the mercurial salt has proceeded

further, but I have failed to secure the suitable experimental conditions.

In a similar manner I have tested several powders of unknown composition sold as insecticidal powders for soldiers, and have failed to observe any marked insecticidal effect.

I have made some experiments with freshly ground Dalmatian insect powder (*Pyrethrum cinerariaefolium*). When used at once in the fresh condition it has a definite insecticidal action, commonly killing all lice immersed in it in a period of two hours. The insecticidal value of the powder becomes gradually diminished when it is exposed to the air; after two days' exposure it failed to kill lice even when left in contact with it for several hours.

Naphthalene.

The powder known as N.C.I. powder is being largely used in the army. I have learnt since my experiments with it were completed that it was originally prepared under the direction of a member of the staff of the Royal Army Medical College, Millbank, but I have ascertained from the college that no experiments have so far been published. This powder is being supplied by the South Metropolitan Gas Company, and the chemist of the company has informed me that the N.C.I. powder consists of

Naphthalene...	...	...	95 per cent.
Creosote	...	...	2 "
Iodoform	...	...	2 "

I conducted test tube experiments with the powder in two series. In one lice were immersed in the powder, and all were killed within five minutes; usually two minutes were sufficient. In the second series the lice were separated from the powder by cotton-wool, and were exposed only to the vapour from the powder. Here the extreme length of time required for the killing of the lice was about thirty minutes, but in some of the tests the lice were killed in about fifteen minutes. To ascertain the effect of the powder when applied to the human body, pieces of cloth, such as is employed for underwear, were dusted with it and were used for loosely covering lice applied to a portion of the skin for varying periods of time. It was found that the lice were killed within one hour, but that many died within a quarter of an hour. The powder showed no irritant effect, even after application for a period of eight hours. Three series of experiments were made to test the values of naphthalene, creosote, and iodoform separately as insecticides, with the following result:

1. *Naphthalene*.—Specimens of pure naphthalene and of commercial naphthalene were used, and it was found that while lice in contact with freshly powdered pure naphthalene commonly died in one hour, lice in contact with freshly powdered commercial naphthalene usually died in half an hour. These experiments appear to show that the lethal power of naphthalene for lice is dependent in great part on the presence of hydrocarbons and coal-tar derivatives other than pure naphthalene.

2. *Creosote*.—It was found that immersion in fluid creosote for one minute commonly killed lice, but on a rare occasion a louse could be revived. So far it has not been possible to revive any louse after immersion for two minutes. Lice exposed to the vapour of creosote were usually killed in twenty minutes, and no louse was found to survive at body temperature for more than thirty minutes.

3. *Iodoform*.—It was found repeatedly that lice in contact with iodoform, even when buried in it, remained alive for eight hours, but were usually killed after twelve hours. Over the vapour of iodoform lice lived practically unaffected for several days.

It would appear, then, that of the three constituents of N.C.I. powder, naphthalene and creosote have each a strong and iodoform only a very feeble insecticidal action. But before iodoform could be regarded as a somewhat useless constituent of N.C.I. powder it was necessary to be certain that its presence did not markedly modify the action of the powder. To determine this, two powders were prepared, one being the ordinary N.C.I. powder, the other differing only in that it contained no iodoform. In a series of test tube experiments in which lice were suspended over the powders or placed in contact with them it was found that the lethal period was the same for both powders.

Experiments were now made with these powders on the human body, pieces of clothing being dusted with the powder and used for covering lice previously placed on the forearm. It was found that the N.C.I. powder adhered much better to the clothing than did the powder without

the iodoform, and that while the N.C.I. powder commonly killed the lice in half an hour, the N.C. powder required an hour.

In order to determine whether the superiority of the N.C.I. powder depended mainly on its greater adhesiveness for cloth and not on the presence of iodoform, a powder was prepared that differed from N.C.I. powder only in that insecticidally inert magnesium silicate was substituted for iodoform. A comparison of this powder with the N.C.I. powder showed that for practical purposes the action of the two powders was identical.

In a fairly large series of these experiments I have been left with the impression that the N.C.I. powder is very slightly more effective than the naphthalene, creosote, and magnesium silicate powder, and this was to be expected, since iodoform has a slight insecticidal action, while magnesium silicate has no such action. Both powders contain naphthalene and creosote, and, since the price of iodoform at the present time is 25s. 6d. per pound, and the price of magnesium silicate is 4s. 6d., it would appear that the efficiency of the N.C.I. powder would not suffer in any material degree if magnesium silicate were substituted for iodoform.

A solid substance capable of being powdered and of being applied without harm to the human body must be an essential basis of an insecticidal powder. Of all the solid substances I have examined naphthalene is the most actively insecticidal. It would have been of interest to have investigated the toxic effects on man and lice of the solid perchlorethane on account of the high insecticidal value of the chlorine derivatives of ethane. Perchlorethane is a crystalline body with a camphor-like odour, but, so far, I have been unable to obtain a supply of this substance. Theoretically, it is not essential that the solid basis of the powder should be actively insecticidal, provided that it is possible to incorporate actively insecticidal agents with it. In a series of experiments powders were prepared, with magnesium silicate as a basis, and containing various actively insecticidal liquids, such as trichlorethylene and creosote, and were compared with powders containing similar liquids, but with naphthalene as the basis. In every case the greater efficiency of naphthalene as a basis for the powders was substantiated.

Experiments were made for the purpose of ascertaining whether the creosote in the N.C.I. powder could be advantageously replaced by another insecticide. In my early experiments I had found that the liquid preparations most lethal to lice are certain chlorine derivatives of ethylene and ethane. Recently also I have investigated the insecticidal value of anisol (methyl phenyl ether), which appears to enjoy some reputation for this purpose. In a series of comparative experiments with these insecticides and with creosote I have ascertained that trichlorethylene commonly kills lice by immersion in a few seconds, and invariably kills them within thirty seconds. Immersion experiments with tetrachlorethane, pentachlorethane, anisol, and creosote showed that they usually kill lice in one minute, and that no louse survives immersion for two minutes. It is difficult to place these four substances in order of insecticidal activity, so nearly do they agree and so variable is the resistance of the occasional louse, but the experiments showed that tetrachlorethane was slightly more active than creosote, and there can be no doubt as to trichlorethylene being much more active.

The different insecticides were each separately incorporated with commercial naphthalene in the two proportions of 2 per cent. and of 5 per cent., which was found to be the limit within which naphthalene could conveniently hold the liquids without ceasing to be pulverulent. In a series of experiments with freshly-prepared powders the trichlorethylene powder easily maintained its advantage, commonly killing by contact all lice within a few seconds, while the tetrachlorethane, pentachlorethane, anisol, and creosote powders usually required two to three minutes. But when the powders had been exposed in the open air for some time the results were different. The trichlorethylene powder, when thus exposed for even a few minutes, rapidly deteriorated, and after fifteen minutes' exposure its action on lice corresponded to that of naphthalene alone. On the other hand, the other preparations, initially inferior to the trichlorethylene powder were found, even after exposure to air for a period of one to

three days, to have an insecticidal activity superior to that of naphthalene alone.

Paraffin Bodies.

In experiments with the volatile paraffin bodies, such as petrol and royal daylight oil, it was found that petrol ordinarily killed lice by immersion in one minute and invariably in two minutes, while the ordinary illuminant oils commonly killed in two minutes and invariably in five minutes. When these substances were severally incorporated with naphthalene in 2 and 5 per cent. proportions, as in the other experiments, it was found that even with the freshly prepared petrol powder no insecticidal action greater than that of naphthalene could be definitely determined, and that with the illuminant oil powders the insecticidal action of naphthalene was only slightly increased.

The explanation of these results appears to depend on the rate at which the incorporated liquid is volatilized. The enormous surface provided by the powdered naphthalene must greatly accelerate the evaporation of the added volatile fluid. The rate of evaporation of the several liquids was roughly tested.

Equal weights of each of the liquids were exposed to the air in wide-mouthed bottles of equal calibre for a period of sixteen hours at the body temperature, and the loss of weight noted. Petrol and trichlorethylene were found to evaporate much more rapidly than any of the other substances, and petrol more rapidly than trichlorethylene. Then next in order came tetrachlorethane, royal daylight oil, pentachlorethane, anisol, and, finally, creosote with the lowest vapour pressure of the series.

Creosote would therefore appear, when all conditions are taken into account, to be the most valuable of the actively insecticidal liquids for admixture with naphthalene in an insecticidal powder. When mixed with naphthalene the immediate lethal effect of creosote is less than that of the trichlorethylene powder, but the much longer period during which creosote continues to exert its action more than compensates for this initial disadvantage.

N.C.I. powder has been objected to on account of its moist condition. The chemist of the company supplying the powder has informed me that the use of liquid creosote renders the powder apt to clog in the perforated tins in which it is supplied, and that it has been suggested that the creosote might be replaced by pure phenol. I have not been able to satisfy myself that the substitution of phenol for creosote makes any practical difference to the dryness of the powder, and tests made with the phenol powder on various individuals show that the skin in not a few instances is distinctly irritated by the phenol.

I have made some experiments to determine if the N.C.I. powder could be made drier, and therefore more easily dusted, by some variation in its composition and yet retain its efficiency. In some experiments such efflorescent salts as disodium hydrogen phosphate, sodium sulphate and sodium carbonate were added in turn to the extent of 5 per cent. to N.C.I. powder; when these preparations were kept in sealed bottles the various efflorescent salts exerted no drying effect of practical importance, every preparation tending to cake and adhere to the bottle. In this condition the powders were found to retain their insecticidal activity unimpaired. When, however, the powders in these experiments were exposed to the open air drying occurred in from one to two days, and the powders became very suitable for application through perforated tins. But on testing the insecticidal properties of the dried powders, it was found that their values had greatly deteriorated, and that in a well-dried powder lice could live for hours apparently unaffected. It would appear that the coal-tar products on which the insecticidal effect mainly depends are volatilized. So far it seems impossible to dry a naphthalene-creosote powder and at the same time retain the efficient moist and volatile hydrocarbons and other coal-tar derivatives.

In perforated tins any naphthalene-creosote powder must gradually lose its insecticidal properties, and the moist nature of the powder precludes it being used successfully in these tins. It would therefore appear to be desirable that naphthalene-creosote powders, such as N.C.I. powder and naphthalene, creosote and magnesium silicate powder should be supplied in sealed tins of small size. I believe that the application of such powders twice weekly

to clothing would destroy any lice that might be present, and would practically keep the persons lice-free.

Gases.

Experiments have been made in which verminous clothing was exposed to chlorine, formaldehyde, and sulphur dioxide. In one series articles of clothing infested with lice were placed for one hour in air heavily charged with each of the gases. It was found that chlorine had least effect. Some of the lice on the surface of the clothing were killed, many of them were stupefied, but many remained active. Formaldehyde stupefied all the lice on the surface of the clothing, but many afterwards revived; lice protected by folds of clothing remained active. Sulphur dioxide killed all lice on the surface of the clothing, but only stupefied lice protected from the gas by folds of clothing. Many of such lice afterwards revived. In some experiments where articles of clothing infested with lice were placed in rooms and exposed for twelve hours to these gases as ordinarily employed for disinfecting purposes a somewhat similar result was obtained.

A few experiments similar to those described by Blacklock² when investigating the resistance of the bed-bug to gases were made to determine directly the insecticidal action of sulphur dioxide. When lice were placed in a two-way glass tube through which sulphur dioxide was passed from a pressure bottle, they were killed in a few seconds, and no louse survived five seconds. In another experiment the gas was poured into a deep vessel and the lice dropped into it. Here also the lice were all dead within five seconds. Lice wrapped in cotton-wool and dropped into the jar were all dead after one minute, but when wrapped in pieces of clothing and dropped into the gas an occasional louse was found living after one minute, but none survived after two minutes.

Sulphur dioxide has, therefore, in these experiments maintained its reputation as the most efficient gaseous insecticide, but as ordinarily used for disinfecting purposes it cannot, owing to lack of power of penetration, be depended on to kill all lice in verminous clothing.

Emergency Cleansing of Clothing by means of Petrol.

In a letter to the *BRITISH MEDICAL JOURNAL* of June 26th, 1915, Dr. Davison, Monkseaton, Northumberland, indicated that in some cases it would be of value to medical officers responsible for the cleansing of soldiers if a safe and economical method for cleansing an occasional verminous kit by means of petrol might be devised without having recourse to the installation of an elaborate dry cleaning apparatus. It is obvious that any such method to be practical must be free from the general danger of fire and from possible damage to clothing as a result of excessive heat. It was necessary, then, to devise a method of vaporizing petrol without danger from fire so that it could be applied in emergency on active service or for the occasional verminous kit at home. In experimenting with various substances, such as boiling water and red-hot iron, as sources of heat, I found that a stone heated in the fire to a dull red heat and then transferred directly into a basin of petrol is the best means of securing the evaporation of petrol with safety. I arranged a box roughly divided into a lower and upper compartment by means of a wire screen. The verminous garments were placed in the upper compartment and the box closed. A door at the side gave access to the lower compartment, containing a basin of petrol into which a hot stone was introduced. The evaporation of the petrol proceeded rapidly, but it was found that the petrol immediately condensed on the nearest cold surfaces. Thus the lower layer of clothing was moistened with petrol, and the lice there were killed, but no penetration occurred and many lice survived. To secure the insecticidal action of the vapour of petrol a regulated oven would have to be employed, and this is costly and not available for emergency purposes.

It would appear, then, that for the purposes indicated immersion of verminous clothing in petrol remains the most suitable method. Danger from fire would be diminished by using a petrol soak tank with a well-fitting lid, but the danger in wringing and removing the garments would remain. Such a tank could be placed in an open shed, apart from any building, and the petrol-treated clothing exposed to the outside air would dry within an

hour. Similarly, an enclosed rotary hand washing machine, costing about £4 4s., might be employed for the purpose, and this would also permit of the clothing being dry-cleaned.

Recently a further problem in the control of lice has arisen in towns where rest houses have been provided for soldiers delayed by train connexions or otherwise while travelling home on leave from France. In many cases the soldier remains in the town for too short a time to permit of efficient cleansing of himself and his kit, and until it is found convenient to cleanse all soldiers granted leave the use of an actively insecticidal powder in these houses is the best method.

Cleansing of Verminous Heads.

The superior value of the chlorine derivatives of ethylene and ethane as destroyers of lice, and their non-inflammable properties, as previously recorded, led me to suggest that these bodies might be employed with advantage in the cleansing of verminous heads, and I suggested that they might be employed as soap preparations and in vaseline pomades. Recent experience in hospital has indicated that nurses were averse to shampooing verminous heads, and has led to tests being made with these chlorine derivatives undiluted. The effect of trichlorethylene when applied freely to the scalp is variable. Little discomfort seems to be produced in some cases, but severe—though transient—pain results in others. In similar tests it was found that tetrachlorethane is usually free from severe irritant action. One consideration was the danger that these bodies when applied to the hair might accidentally reach and injure the eyes. It has been found in practice in hospital that the desired result is obtained when the hair is gone over carefully with pieces of cotton-wool moistened with either trichlorethylene or tetrachlorethane, and irritant effects to the scalp and eyes are obviated. In the great majority of cases one application has been sufficient to destroy all lice and nits, and rarely have more than two applications been required. Tetrachlorethane, although less powerful than trichlorethylene, is very actively insecticidal, and may be preferred to trichlorethylene on account of its less irritant properties, and this is of importance in dealing with verminous heads on which skin is broken.

Conclusions.

1. As Mr. Bacot has shown, and as my later experiments also demonstrate, lice do not survive immersion in boiling water.
2. Several insecticidal powders have been tested, and of these N.C.I. powder is the most destructive to lice.
3. Of the three constituents of N.C.I. powder, naphthalene and creosote have each a strong insecticidal action. The insecticidal action of iodoform is feeble.
4. Naphthalene appears, so far as my comparative tests have gone, to be the most suitable basis for use in the preparation of a powder destructive to lice. Commercial naphthalene is more actively insecticidal than pure naphthalene, and it appears that the lethal power of naphthalene for lice is dependent in great part on the presence of hydrocarbons and coal-tar derivatives other than pure naphthalene.
5. The immediate lethal effect of creosote when mixed with naphthalene is less than that of some other insecticidal liquids, but the longer period during which creosote continues to act more than compensates for the initial disadvantage.
6. In addition to its feeble insecticidal activity, iodoform greatly increases the adhesiveness of N.C.I. powder for cloth. The inclusion of iodoform in the powder is accordingly justified, although similar adhesiveness of the powder is obtainable at less cost by substituting the insecticidally inert but cheaper magnesium silicate for iodoform in the powder.
7. The insecticidal power of naphthalene-creosote powders gradually diminishes when they are exposed in the open air.
8. The moist nature of such powders precludes their being used successfully in perforated tins, and it has not been possible to dry the powders and at the same time retain the moist and volatile hydrocarbons and other coal-tar derivatives on which the insecticidal effect mainly depends.

9. It is desirable that naphthalene-creosote powders should be supplied in sealed tins of a uniformly small size, or of sizes suitable for the immediate requirements of a convenient number of persons proposed to be treated at one time.

10. In experiments with gases, sulphur dioxide has maintained its reputation as the most efficient gaseous insecticide, and all lice exposed to an atmosphere of the gas die within five seconds. As ordinarily used for disinfecting purposes and as a result of lack of penetration sulphur dioxide cannot be depended on to kill all lice in verminous clothing.

11. For the emergency cleansing of clothing by means of petrol, immersion of the verminous clothing in petrol remains the most suitable method. To secure the insecticidal action of the vapour of petrol a regulated oven would have to be employed.

12. The superior value of certain chlorine derivatives of ethylene and ethane as insecticides and their non-inflammable properties indicate their use in the cleansing of verminous heads. The desired result is obtained and irritant effect on the scalp is obviated when the hair is gone over carefully with pieces of cotton-wool moistened with either trichlorethylene or tetrachlorethane. Tetrachlorethane, although less powerful than trichlorethylene, is very actively insecticidal, and is to be preferred to trichlorethylene on account of its less irritant properties.

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MEMORANDUM ON

THE TREATMENT OF INFECTED WOUNDS
BY PHYSIOLOGICAL METHODS.

(*Drainage of Infected Tissues by Hypertonic Salt Solution, and Utilization of the Antibacterial Powers of the Blood Fluids and White Blood Corpuscles.*)

BY

COL. SIR ALMROTH E. WRIGHT, M.D., C.B., F.R.S.

1. INTRODUCTORY.

THE treatment of septic war wounds divides itself naturally into three therapeutic procedures:

(1) In the first we have a number of different aims to pursue concurrently, and have therefore to be ceaselessly on the watch. We have to promote the destruction of the microbes which have been carried into the deeper tissues. We have to re-establish normal conditions in those tissues, resolving the infiltration in the walls of the wound and getting rid of the infected sloughs, and we have to prevent "the corruption of the discharges," and inhibit microbic growth in the cavity of the wound.

Further, during the whole period occupied by these operations we have to be constantly on our guard to prevent active and passive movements which would propel bacteria along the lymphatics, and carry poisonous bacterial products into the blood.

(2) When the microbes in the deeper tissues have been exterminated and physiological conditions have been restored, and the wound has been rendered to naked eye inspection perfectly clean, the difficult portion of our task has been accomplished, and the time has come for dealing with the surface infection.

(3) As soon as this has been suppressed, or all but suppressed, all our thought ought to be given to promoting the processes of repair, bringing together the tissues, and covering over the denuded surfaces.

2. INADEQUACY OF THE TRADITIONAL METHOD OF TREATING
WOUNDS BY ANTISEPTIC APPLICATIONS, INCISION, AND
MECHANICAL DRAINAGE.

Inefficacy of Antiseptic Applications.—The ordinary antiseptic combines with every kind of albumin. It thereby loses its bactericidal and its penetrative power. Its bactericidal power is, of course, not finally abolished until the antiseptic has encountered and combined with its full complement of albumin. Its penetrative power—and penetrative power means capacity for diffusing outwards

through any medium in a chemically active condition—is, in the fluids of the wound, very rapidly abolished. For, when the medium which is to be penetrated contains even a trace of albumin, this will immediately quench the "antiseptic emanation"—meaning by this that fractional quantum of antiseptic which is carried out by diffusion into the surrounding fluids.

These general truths are firmly based upon experiment. It can be demonstrated that none of our ordinary antiseptics extirpate microbes enveloped in dead or living tissues, or in serous or purulent discharges; and that none diffuse into the walls or recesses of the wound. The sterilizing action of antiseptics applied in the wound will thus be strictly limited to the destruction of any microbes which may be lying bare; and sterilization will not extend beyond that portion of the wound surface to which the antiseptic is actually applied.

Inadequacy of Drainage as Usually Practised.—The theoretical requirements for a complete scheme of drainage are, first, that there shall be an outflow from the infected tissues to the external surface, or to the surface of a wound cavity; and, secondly, where a wound cavity exists, that there shall be drainage from that cavity to the exterior.

Drainage from the Tissues.—In the customary treatment of wounds, drainage from the tissues is not specially insisted upon—mere incision with or without fomentation being assumed to do in this respect what is necessary. In reality, however, in oedema only will sufficient drainage be given by this method. In tissues of normal density nothing like adequate effusion will be obtained, the lymph flow being here rapidly arrested by clotting and desiccation. And, where we are dealing with densely infiltrated tissues, incisions may fail to furnish even as much as a drop of exudation.

Drainage from the Cavity of the Wound.—Drainage tubes, of course, do not induce any outflow of lymph from the tissues. They drain only from the cavity of the wound—outflow ceasing as soon as ever the well head in the tissues dries up.

Summary of Criticisms on the Traditional Method of Treating Wounds.—It has appeared above (a) that antiseptics do not exert any effective action in the wound either in the direction of extinguishing the infection or keeping down bacterial growth; (b) that the usual procedure of incising and inserting drainage tubes provides, in place of that continuous weeling out from the lymph spaces to the exterior which we require, a drainage which rapidly stanches at the source; and (c) that in the ordinary treatment of wounds no steps are taken to disperse infiltration; or accelerate the separation of the sloughs; or bring antibacterial lymph or phagocytes to the seat of infection.

In short, the treatment of wounds by a combination of antiseptics, incision, and mechanical drainage, is a therapeutic method which constantly disappoints, because it fails to kill the infecting microbes and at the same time fails to give to the organism opportunity for ridding itself of the infection.

And lastly—and this point cannot be too much insisted upon—in the ordinary treatment of septic wounds not nearly enough care is taken to prevent those active and passive movements which lead to the mechanical impulsion of microbes along the lymphatics, and to auto-inoculations.

3. THE IDEAL OF PHYSIOLOGICAL TREATMENT IS TO GIVE
INTELLIGENT AID TO THE ORGANISM IN COMBATING THE
BACTERIAL INFECTION.

Saline dressings supply a means for evoking, in the infected wound, certain requisite physiological reactions. By their aid we can, while at the same time inhibiting bacterial growth, drain the tissues, resolve infiltration, and promote the separation of the sloughs—besides giving other assistance.

4. PHYSICAL AND PHYSIOLOGICAL ACTION OF CONCENTRATED
SALT SOLUTIONS.

(1) A concentrated salt solution will attract water; and, except in the case where a membrane which is impermeable to albumin is interposed, the outflowing current of water will carry out with it the whole of the protein substances which it holds in solution. This means that