

STUDIES ON THE AETIOLOGY OF  
HYPOPYON ULCER OF THE CORNEA,  
WITH PARTICULAR REFERENCE TO THE OCCURRENCE  
OF THIS CONDITION  
IN COAL AND SHALE MINE WORKERS

by

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EXPLANATORY NOTE.

For some years I have carried out investigations into the bacteriology of the conjunctiva and cornea under the auspices of the W.H. Ross Foundation for the Study of Prevention of Blindness, Edinburgh, while holding the posts successively of Assistant and Lecturer in Bacteriology, University of Edinburgh, under the direction of Professor T.J. Mackie.

These investigations were initiated in 1937 at the suggestion of Dr Arthur Sinclair, Chairman of the Ross Foundation, owing to the prevalence of cases of corneal ulcer of hypopyon type in coal and shale mine workers in the Edinburgh district. Thus, in one of the charges in the Edinburgh Royal Infirmary Eye Department, there were, from 1st October 1935 to 30th September 1936, 107 cases of hypopyon ulcer, 59 (55.1 per cent.) occurring in mine workers (coal or shale). This seemed an unduly high proportion of mine workers as compared with the rest of the population. It was suggested that to investigate this problem, in the first place the most suitable line of approach would be to undertake a field study of the conjunctival/

conjunctival flora of coal and shale mine workers, to see whether they normally harboured in their conjunctival sacs pathogenic organisms which would predispose them to infection following corneal injury. This work was duly carried out, and then the second aspect of the subject was investigated, namely the bacteriology of established cases of corneal ulcer of hypopyon type in coal and shale mine workers as well as other persons. It was hoped that these two lines of investigation would throw some light on the causation of hypopyon ulcer in general, and in particular explain why mine workers seemed to constitute such a high proportion of cases of the condition as seen in the Edinburgh Royal Infirmary.

This thesis contains the result of my work for the Ross Foundation up to the time of my leaving Edinburgh in June 1941, and is an elaboration of a number of shorter papers published in the British Journal of Ophthalmology (Rhodes, 1939, a, b, c).

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PREFACE: THE ECONOMIC IMPORTANCE OF CORNEAL ULCER  
IN MINE WORKERS.

Before describing first my work on the bacteriology of the conjunctiva in mine workers, and then the bacteriology of established cases of corneal ulcer, it may be as well to indicate the economic importance of hypopyon ulcer to the mining community.

I cannot do this more effectively than by quoting extensively from a communication made by Dr J.R.Paterson of Edinburgh and brought before the Ophthalmological Society of the United Kingdom some ten years ago (Paterson, 1931). Thus, out of a series of 500 instances of eye "compensation" cases studied in Edinburgh there were: 223 cases of hypopyon ulcer, 64 other traumatic conditions of the eye which included cases of milder ulceration and abrasions of the cornea, 92 penetrating injuries, 35 explosion injuries, 22 head injuries, 22 nystagmus cases and various other types of case.

It can thus be seen that in Paterson's series of eye injuries involving subsequent litigation, cases of corneal ulceration formed by far the most important single/

single group.

Next, an hypopyon ulcer has most serious after-effects, with regard to the resulting vision, and Paterson found the results "very disappointing". Thus, "out of 262 eyes with healed ulceration, 96 were below  $\frac{6}{60}$  and 158 below  $\frac{6}{24}$ ". To this number with poor vision must be added the number of 18 enucleations or eviscerations".

Lastly, hypopyon ulcers require lengthy periods of treatment, and with regard to the time "off work", Paterson found the average to be 6 months in his compensation cases, but estimated that  $2\frac{1}{2}$ -3 months would represent the actual average time of essential incapacity.

I can thus summarise the question of the economic importance of cases of hypopyon ulcer to the mining industry as follows:

- (1) About half the number of eye "compensation" cases are afforded by patients suffering from the effects of hypopyon ulcer.
- (2) The resulting vision, when work is resumed, is poor, so that the man cannot be as efficient a worker as he was/

was before the injury.

(3) In certain cases vision is so greatly reduced, or the eye actually enucleated, that return to skilled mining work is altogether out of the question.

(4) Cases of the disease are unable to work for a period of 3 to 6 months.

There is thus no doubt that, from the practical point of view, apart altogether from scientific interest, an investigation into the aetiology of hypopyon ulcer in mine workers would be of value, especially if it adduced evidence that the mine worker's conjunctival flora was such as to predispose him to infection on receipt of corneal injury. For such evidence would emphasize strongly the value of the wearing of prophylactic visors or eye shields by those most exposed to the risks of corneal injury, viz., the miners hewing at the face and the brushers or stone miners, and help the mining authorities in convincing these workers of the necessity for such protection.

SECTION A.THE NORMAL CONJUNCTIVAL FLORA.

It is generally known that the healthy conjunctival sac contains a small number of organisms, which are commonly regarded as commensals. The following bacteria have been described as forming the normal conjunctival flora. (It may here be stated that the bulk of observations, including my personal investigations, have, for obvious technical reasons, been carried out on the lower, rather than the upper, conjunctival sac.)

(1) Staphylococcus albus.

It is commonly agreed that "albus" strains of staphylococci occur in the conjunctival sacs of from 60 to 100 per cent. of normal persons (see, e.g., Randolph, 1893; Eyre, 1897; Pillat, 1922; Lucic, 1927; Keilty, 1930; Gowen, 1934). The organisms probably enter from the skin of the lower lid (Gowen, 1934). These strains have no unusual properties, and no special description of their characters is called for here. Keilty (1930) found 1 per cent. of strains of staphylococcus which I have described below as "chromogenic".

(2)/

(2) Staphylococcus aureus.

Eyre (1897) found this organism in a few normal conjunctival sacs, but it is not frequently encountered. Probably many strains in the past regarded as "aureus" should actually be classified as "chromogenic" staphylococci producing a golden pigment, but failing to ferment mannite, liquefy gelatin, or lyse blood.

(3) Diphtheroid bacilli.

Gram-positive, club-shaped bacilli with "metachromatic" granules commonly occur in the conjunctival sac, and are usually classified as B.xerosis. They are said to occur in the conjunctivae of from 50 to 100 per cent. of healthy persons (see, e.g., Eyre, 1897; Örtzen, 1899; Pillat, 1922; v.Pellathy, 1932).

(4) Pneumococcus.

Pneumococci may occur in healthy conjunctival sacs but it is difficult to present a precise figure for this incidence. The experience of British bacteriologists in general would incline probably to a figure of not more than 1 to 2 per cent., but there are/

are few published references to quote, except that of the American worker Keilty (1930) who isolated no pneumococci from 100 normal persons. Pillat (1922), on the continent, alleged that pneumococci might occur in the conjunctival sacs of up to 40 per cent. of normal people, but this is certainly not the experience in this country.

(5) The Diplobacillus of Morax.

Pillat (1922), a continental worker, claimed to have isolated this organism from the conjunctivae of 22 per cent. of normal persons. This figure cannot, however, be accepted as presenting any indication of the correct incidence of this organism in the conjunctival flora of healthy persons in this country, for it is generally believed that it practically only occurs in cases of angular conjunctivitis or corneal ulceration.

(6) B. Koch-Weeks.

Keilty (1930) found this organism in only one out of 100 normal persons. Lucic (1927) failed to find it at all in another series of 100 cases.

(7)/

(7) Other organisms.

Certain other organisms may on rare occasions occur in the normal lower conjunctival sac: Streptococcus haemolyticus (Eyre, 1897; Lucic, 1927); Streptococcus viridans (Keilty, 1930); sarcina (Eyre, 1897; Cavara, 1912; Keilty, 1930); gram-negative Neisseria (Verderame, 1910); anthracoid bacilli of the B. subtilis variety (Lucic, 1927); B. pyocyaneus (Pusey, 1908); B. proteus (Eyre, 1897); B. coli (Eyre, 1897); M. tetragenus (Eyre, 1897).

(8) No growth on culture.

It is very common for cultures made from the lower conjunctival sac to yield no growth. Thus, Lynch (1912) found no bacteria in stained smears from 40 per cent. of normal persons. Keilty (1930), examining 100 normal people, obtained no growth on culture from both eyes of 43 persons, and in 23 further instances he obtained no growth from one or other eye.

PERSONAL/

PERSONAL STUDIES.

At the outset of this investigation it was felt desirable to carry out some personal studies on the normal conjunctival flora and accordingly 40 healthy students were examined in October 1937. The detailed protocols are given in Table 1 and the results summarised in Table 2.

TABLE/

TABLE 1.

Results of the Examination of Healthy Students.

	Name	<u>Staphylococcus albus</u>		Diphtheroid bacilli		<u>Staphylococcus citreus</u>		Chromogenic staphylococci		Pneumococcus		<u>Streptococcus viridans</u>		Diplobacillus of Morax		<u>Micrococcus catarrhalis</u>		<u>B. Koch-Weeks</u>		Miscellaneous	
		R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L
* 1	J. Ramsay	#	+		+																
* 2	F. Valentine	#	#		+																
3	R. Burnett		+		#		+														
4	W. Cockayne		+		+		+														
5	J. Chalmers		+		+																
6	R. Duff		+		+		+		+												
7	Napier		+		##		#														
8	Batchelor		+		#				+												
9	Wilson		+		##																
10	Gilmour		+		+																
11	Cran		#		+		+		+												
12	Millar		+																		
13	Lowe		+		#		+		+												
14	Girdwood		+				+														
15	/																				

\* # = profuse growth  
 # = moderate growth  
 + = scanty growth

Ammonia  
 bacilli





T A B L E 2.40 Healthy Students.

Examination showing percentage of students  
harbouring various conjunctival organisms.\*

Organism	Percentage
<u>Staphylococcus albus</u>	92.5
Diphtheroid bacilli	62.5
<u>Staphylococcus citreus</u>	2.5
Chromogenic staphylococci	-
Pneumococcus	-
<u>Streptococcus viridans</u>	2.5
<u>Diplobacillus of Morax</u>	-
<u>Micrococcus catarrhalis</u>	-
<u>B. Koch-Weeks</u>	-
Anthracid bacilli	2.5
Coliform bacilli	-
<u>Micrococcus tetragenus</u>	-

\* In the tables of this format throughout the thesis, figures are given for the percentage of workers harbouring such and such an organism, without reference to whether the organism occurred in one or both conjunctival sacs.

From Table 2 it will be seen that it was exceptional for organisms other than Staphylococcus albus and diphtheroid bacilli to be encountered, only one strain of Streptococcus viridans and one strain each of Staphylococcus citreus and anthracoid bacilli being found.

It may be said therefore that in this country the general conception of a "normal" conjunctival flora is one which contains Staphylococcus albus and diphtheroid bacilli in almost every instance, and only on rare occasions other organisms such as Streptococcus viridans, pneumococcus, and certain other bacteria. The Diplobacillus of Morax and Bacillus Koch-Weeks would not be accepted as "normal" inhabitants of the conjunctival sac.

SECTION B.THE BACTERIOLOGY OF THE CONJUNCTIVAL SAC  
IN 690 COAL MINE WORKERS.(1) Introduction.

Several hundred representatives of all classes of mine worker were examined at four coal mines in Central Scotland, and it was soon found that these men harboured a very profuse conjunctival flora, quite different both quantitatively and qualitatively from that described as "normal" in the preceding section. Thus, in addition to the staphylococci and diphtheroid bacilli which were expected, significant numbers of men were found to harbour such organisms as the pneumococcus, Streptococcus viridans, the Koch-Weeks bacillus, and the Diplobacillus of Morax, all organisms commonly regarded as pathogens in conjunctival and corneal disease.

Careful search failed to reveal any reference in the literature to similar studies and it is accordingly believed that this is the first occasion on which such a survey has been carried out.

(2)/

(2) Methods.

In suitable rooms at the pit-head, workers were examined as they came off their "shift", and cultures were taken from both eyes. On one or two isolated occasions mine surface workers had to be tested during their "shift". On no occasion, however, were cultures made previous to men beginning their shift of work. A particular point was made of making cultures before the men washed their faces, thus obviating lachrymation due to soap suds and the possible dilution of the conjunctival bacteria.

Cultures were in every case taken from both right and left lower conjunctival sacs. The lower lid was pulled gently down, and a loopful of conjunctival secretion taken by drawing a smooth inoculating loop laterally, beginning just below the caruncle and passing to the outer canthus. Care was taken not to touch the skin or caruncle with the loop. The charged loop was then at once rubbed over the surface of a blood agar slope contained in a small round screw-topped glass vial. On return to the laboratory, these vials were incubated aerobically at 37°C. for 48/

48 hours. The cultures were then carefully inspected and note made of the type and numbers of the various colonies present. where necessary, films were then made from the growths and subcultures prepared on suitable media.

It was found during this part of the investigation that the conjunctival sacs, especially of "miners" (vide infra) often contained pieces of coal, which did not apparently cause any pain or result in inflammation of the conjunctiva. No definite case of conjunctival inflammation was seen in these coal mine workers.

### (3) Classes of mine worker examined.

At all four coal mines the following different types of worker were examined: the coal "miner", the "brusher", the "oncost worker", and the "surface worker", 690 men being tested altogether.

The "miner" is the worker who actually removes the "live" coal from the coal face. In some mines the coal is first cut with a machine and then dislodged by the miner, who is here known as a "stripper".

In/

In other mines, however, all coal is hewn out with picks, the miners here being known as "hewers". The term "miner" thus includes both "strippers" and "hewers".

The "brusher", or "stone miner", works after the miner has finished his shift, and trims up the stone or rock exposed by the miner.

Both miners and brushers are peculiarly liable to receive fragments of coal or stone in the eye during their work, and constitute the main proportion of workers treated by first-aid methods for foreign body on the cornea. As might be expected, as a corollary of this, miners and brushers form the majority of cases of hypopyon ulcer in coal mine workers. Thus, in my series of 221 cases in all classes of person, out of 136 coal mine workers no less than 113 cases were in miners and brushers (see Table 51; also Reid, 1929).

The "oncost workers" are concerned in the main with transporting the coal back from the face to the shaft bottom for conveyance to the surface. These workers seldom expose themselves to the risk of receiving fragments of coal or stone in the eye and are in no/

no particular danger from the point of view of trauma to the cornea. In my series, 17 cases of hypopyon ulcer out of 136 in coal mine workers, occurred in on-cost workers (vide infra).

Surface workers are all employed above ground on varied tasks such as mason work, labouring, bricklaying, engineering, tending the winding machines, pushing hutches of coal, and sorting coal. They are seldom exposed to corneal trauma and only 5 cases in surface workers occurred in my series of 136 hypopyon ulcers in coal mine workers.

In addition, at Arniston only, a class of men known as "repairers" was tested. These men are engaged chiefly in attending to the timber supports of the roofs.

(4) Coal mines visited.

Tests were carried out at the following mines:

- (1) Arniston, Gorebridge; (2) Whitrigg, Whitburn;  
 (3) Lady Victoria, Newtongrange; and (4) Loganlea,  
 West Lothian.

(5)/

(5) RESULTS AT ARNISTON COLLIERY.

The first coal mine visited was Arniston, Gore-bridge, Midlothian, where some 221 men were examined at the pit-head, the tests being carried out in the autumn and early winter months of 1937.

The classes of worker examined were miners, brushers, oncost workers, repairers, and surface workers.

At this colliery coal was hewn from the face by miners, coal-cutting machines not being in use at the time of examination. "Miners" were therefore more strictly speaking "hewers".

The following tables (3 to 7) give the results of the bacteriological examination of both lower conjunctival sacs of each worker separately, grouped according to the type of work performed by the man.

Table 8 summarises these detailed protocols by showing the percentage of workers harbouring the different conjunctival bacteria (page 41).

TABLE/





















Table 5 (continued).

Name	<u>Staphylococcus</u> <u>albus</u>		Diphtheroid bacilli		<u>Staphylococcus</u> <u>citreus</u>		Chromogenic staphylococci	Pneumococcus	<u>Streptococcus</u> <u>viridans</u>	Diplobacillus of Morax	<u>Micrococcus</u> <u>catarrhalis</u>	<u>B. Koch-Weeks</u>	Miscellaneous	
	R	L	R	L	R	L	R	L	R	L	R	L	R	L
15 A. Henderson	+	+	+	+										
16 W. Irvine					+	+				+	+			
17 M. Hoyle	+	+										+	+	
18 W. Mc Ginley														
19 J. Campbell	+	+	+	+										
20 J. Curran	+	+												
21 S. Rowley	+	+		+										
22 A. Russell	+	+	+	+										
23 W. Darling	+	+				+			+	+				
24 J. Jamieson				+		+		+						Stell +
25 W. Muirhead	+	+										+		
26 A. Pinkman	+		+	+										
27 S. Darling	+	+												





Table 6 (continued).

Name	<u>Staphylococcus</u> <u>albus</u>		Diphtheroid bacilli		<u>Staphylococcus</u> <u>citreus</u>		Chromogenic staphylococci		Pneumococcus		<u>Streptococcus</u> <u>viridans</u>		<u>Diplobacillus</u> of Morax		<u>Micrococcus</u> <u>catarrhalis</u>		<u>B. Koch-Weeks</u>		<u>Miscellaneous</u>	
	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L
15 A. Hamilton	+		+																	
16 J. Mc Cornell	+	#	+																	
17 C. Smith	+	+	+	+																
18 J. Row- ley	+	#							#	#										
19 R. Kirk	+	+	+	+							#	#								
20 J. Barrie	#	+			+	+														
21 J. Bell		+	#	#																
22 D. Dow			#																	
23 T. Mc Ilreavy		+																		
24 J. Gil- roy	+	+																		
25 G. Young	+	+											#							
26 W. Not- man	#	#																		
27/																				<u>Sub- tended bacilli</u> #



TABLE 7.

Examination of Surface Men, Arniston Colliery.

	Name	<u>Staphylococcus</u> <u>albus</u>		<u>Diphtheroid</u> <u>bacilli</u>		<u>Staphylococcus</u> <u>citreus</u>		Chromogenic staphylococci	Pneumococcus	<u>Streptococcus</u> <u>viridans</u>		<u>Diplobacillus</u> of Morax	<u>Micrococcus</u> <u>catarrhalis</u>		<u>B. Koch-Weeks</u>		<u>Miscellaneous</u>		
		R	L	R	L	R	L			R	L		R	L	R	L	R	L	R
1	D. Tait	+	#	+	+														
2	J. Howie			+	+														
3	J. Mc Ginley	+	+		#														
4	A. Tre- :nch	+	#	+	+														
5	A. Dick- :son	#	#	#	#														
6	H. Boul- :son		+	#	#														
7	T. Doug- :all	+	+	#					#										
8	W. Tay- :lor	+	+	#	+														
9	J. Bla- :ckie	+		+	+				#										
10	J. Black	+	+	+	+														
11	R. Fer- :rier	+							#										
12	J. Sib- :bald		+							#	+								
13	R. Turn- :bull	+	+	+	#														
14/																			

Subj-  
:oid +





T A B L E 8.

Arniston Colliery.

Examination showing percentage of workers  
harbouring various conjunctival organisms.

	Min- :ers	Brush- :ers	Oncost Work- :ers	Repair- :ers	Sur- face Work :ers	Total, all Classes of Workers
Total number of men examined	60	50	39	32	40	221
<u>Staphylococcus albus</u>	93.3	94	96.2	86.8	90	93.2
Diphtheroid bacilli	85	70	46.8	71.3	75	70.7
<u>Staphylococcus citreus</u>	10	10	20.8	3.1	-	9
Chromogenic staphylococci	1.7	4	-	-	-	1.4
Pneumococcus	13.3	6	7.8	6.2	12.5	9.9
<u>Streptococcus viridans</u>	3.4	16	20.8	15.5	7.5	11.25
<u>Diplobacillus of Morax</u>	6.7	6	15.6	9.3	2.5	7.7
<u>Micrococcus catarrhalis</u>	5	4	-	-	-	3.15
<u>B.Koch-Weeks</u>	3.3	-	10.4	3.1	-	3.15
Anthraxoid bacilli	-	-	-	3.1	-	0.45
Coliform bacilli	-	-	2.6	3.1	-	0.9

Arniston Colliery: discussion of results.

It is evident from a comparison of the results for the different classes of worker as shown in Table 8, that the oncost workers at Arniston harboured a more profuse flora than did the other men with regard to Staphylococcus albus and citreus, Streptococcus viridans, the Diplobacillus of Morax and B. Koch-Weeks.

Apart from this, the table shows in its last column the average for the whole mine, the main points of interest here being that approximately 11 per cent. of men harboured Streptococcus viridans, 10 per cent. pneumococci, 8 per cent. the Diplobacillus of Morax, and 3 per cent. B. Koch-Weeks, all pathogenic organisms. These findings are obviously quite different in character from what has been regarded as "normal" for healthy persons in this country in the past, as these men evidently harboured significant numbers of ocular pathogens. It may again be specially emphasized that, on inspection of the conjunctival sacs on the occasion of taking cultures, no obvious cases of conjunctivitis were seen. It appears, therefore, that in their conjunctival sacs these mine workers carried pathogenic/

pathogenic organisms which for the time being were existing as commensals. Further studies were made on this question and are reported below.

(6) RESULTS AT WHITRIGG.

The next colliery visited was the Whitrigg mine at Whitburn, West Lothian, where 149 men were examined in October 1937. The classes of worker from whom cultures were made were miner, brusher, oncost worker, and surface worker.

As at Arniston, the coal here was hewn by pick, and not cut by machines.

Tables 9 to 12 show the results of the bacteriological examination of both lower conjunctival sacs of each man separately, grouped according to the type of work performed.

Table 13 summarises these details by showing the percentage of workers harbouring the various conjunctival bacteria. (page 57).

TABLE/











Table 10 (continued).

Name	<u>Staphylococcus</u> <u>albus</u>		Diphtheroid bacilli		<u>Staphylococcus</u> <u>citreus</u>		Chromogenic staphylococci		Pneumococcus		<u>Streptococcus</u> <u>viridans</u>		Diplobacillus of Morax		<u>Micrococcus</u> <u>catarrhalis</u>		<u>B. Koch-Weeks</u>		Miscellaneous	
	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L
26 S. More	+	+		#	#															
27 D. Mc Leinon		+	+	+																
28 J. Con- nolly	+	+	#	#																
29 J. Walk- inshaw	#	+	+	+																
30 T. Kerr		#	#	+																
31 T. Dun- can	+	+	#	#		+														
32 A. Clarke	+	+	+	+	+															
33 J. Fle- ming	+	#																		
34 J. Fle- ming (Jr.)			+									#	+							

TABLE 11.

## Examination of Oncost Workers, Whittrigg Colliery.

Name	Staphylococcus albus		Diphtheroid bacilli		Staphylococcus citreus		Chromogenic Staphylococci		Pneumococcus		Streptococcus viridans		Diplobacillus of Morax		Micrococcus catarrhalis		B. Koch-Weeks		Miscellaneous		
	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	
1 A. Ag- :new		+		+		+															
2 D. Sang- :ster	+	+		+		##				##											
3 G. Both- :well		##		##		##															
4 J. For- :est		+		+		+															
5 J. Camp- :bell		+		##		##															
6 J. Mays		##				+															
7 G. Cum- :mings		+		+		##															
8 A. Moore		+		+		##															
9 A. Gra- :ham						##															+
10 W. Hughes		+		##		+															
11 A. Mc Glauch- :lan		+		##		##					+										
12 A. Cum- :ming		+		+		##															
13/																					

M. tetra-  
:gens ##Subsidi-  
##

Table 11 (continued).

	Name	<u>Staphylococcus</u> <u>albus</u>		Diphtheroid bacilli		<u>Staphylococcus</u> <u>citreus</u>		<u>Chromogenic</u> <u>staphylococci</u>		Pneumococcus		<u>Streptococcus</u> <u>viridans</u>		Diplobacillus of Morax		<u>Micrococcus</u> <u>catarrhalis</u>		<u>B. Koch-Weeks</u>		<u>Miscellaneous</u>	
		R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L
13	H. Mc Meekin	+		+	##												##				
14	E. Mc Lay	+	##	+	+																
15	A. Fair- :ley		+	+	##																
16	F. Far- :ley	+		+	+							+									
17	H. Boyle	##	+	##						+	##										
18	J. Fer- guson	+	##							##	##										
19	J. Weir	##	##																		
20	H. Meek			##	##							##	##								
21	A. Peat	+	+	##	##		+														
22	J. Mc Donald		+	+	##												##				
23	J. Boyle	+		+						##	##										
24	R. Gibb	##			+														##		
25/																					













TABLE 13.

Examination showing percentage of workers  
harbouring various conjunctival organisms.

	Miners	Brushers	Oncost Work- :ers	Surface Workers	Total, all Classes of Workers
Total number of men examined	39	34	36	40	149
<u>Staphylococcus</u> <u>albus</u>	93.6	89.9	95.2	100	94.47
Diphtheroid bacilli	85.8	56.1	89.6	62.5	73.03
<u>Staphylococcus</u> <u>citreus</u>	13	14.5	11.2	12.5	12.73
Chromogenic staphylococci	-	-	-	-	-
Pneumococcus	2.6	-	11.2	8.4	5.36
<u>Streptococcus</u> <u>viridans</u>	15.6	5.8	22.4	2.5	11.39
<u>Diplobacillus</u> <u>of Morax</u>	2.6	2.9	2.8	2.5	2.68
<u>Micrococcus</u> <u>catarrhalis</u>	-	-	5.6	-	1.34
<u>B. Koch-Weeks</u>	-	-	2.8	-	0.67
Anthracid bacilli	2.6	-	2.8	2.5	2.01
Coliform bacilli	-	-	-	2.5	0.67
<u>Micrococcus</u> <u>tetragenus</u>	-	-	2.8	-	0.67

Whittrigg Colliery: discussion of results.

Comparing the respective classes of worker at Whittrigg (Table 13), it is seen that the incidence of the following organisms was approximately similar: Staphylococcus albus and citreus, the Diplobacillus of Morax, and anthracoid bacilli. The brushers were noticeable in that a low incidence of diphtheroid bacilli was obtained, and that no pneumococci were isolated. The oncost workers had the highest incidence of pneumococci and streptococci, and were the only workers to yield growths of Micrococcus catarrhalis and B. Koch-Weeks: they may therefore be regarded as having had a somewhat more profuse conjunctival flora than the other groups of worker.

(7) RESULTS AT LADY VICTORIA COLLIERY.

The third mine visited was the Lady Victoria at Newtongrange, a few miles only from Arniston; the visits were made in the early months of 1938, miners brushers, oncost workers, and surface workers being examined.

At this mine, coal was cut with machines, so that miners/

miners were, strictly speaking, "strippers".

Tables 14 to 17 contain the detailed results for each type of worker, which are summarised in Table 18.

(page 73)

TABLE/

TABLE 14.

Examination of Miners, Lady Victoria Colliery.

Name	<u>Staphylococcus albus</u>		<u>Diphtheroid bacilli</u>		<u>Staphylococcus citreus</u>		Chromogenic staphylococci		Pneumococcus		<u>Streptococcus viridans</u>		Diplobacillus of Morax		<u>Micrococcus catarrhalis</u>		<u>B. Koch-Weeks</u>		<u>Miscellaneous</u>	
	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L
1 F.Coul :an	#	#	+	#																
2 J.Mab- :en	+	#	+	#																
3 J.Camp :bell		+	#																	
4 R. Moore	+		#																	
5 S. Moore		+	+	#																
6 J.Craw :ford																				
7 C. Hobbs	#		#						#											
8 J.Corn :wall			#	#																
9 A. Clarke			#											+						
10 A.Ait- :ken	+	+		+																
11 W.Den- :holm	+	+		#																
12 W.Jef- :fray	+		+	+																
13/																				

Anthraxoid  
bacilli ##

Table 14 (continued).

Name	<u>Staphylococcus</u> <u>albus</u>		<u>Diphtheroid</u> <u>bacilli</u>		<u>Staphylococcus</u> <u>citreus</u>		<u>Chromogenic</u> <u>staphylococci</u>		<u>Pneumococcus</u>		<u>Streptococcus</u> <u>viridans</u>		<u>Diplobacillus</u> <u>of Morax</u>		<u>Micrococcus</u> <u>catarrhalis</u>		<u>B. Koch-Weeks</u>		<u>Miscellaneous</u>	
	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L
13 J. Pryde	+		+	+																
14 A. Beaton	+		+																	
15 C. Crawford	+	+	+	+																
16 W. Ramsay	+	+	##	##																
17 T. McIntosh	+	##		+							##									
18 J. Clark	+	+							##	+										
19 R. Melville	+	+				+														
20 J. Francis	##	##	##	##																
21 W. Jenkins	##	##											##							
22 A. Baxter		+																		
23 H. Clark	+	##		+																
24 J. Crawford	+	+		##																
25 J. Black	+	+																		
26/																				

Anthraxoid  
bacilli +

Table 14 (continued).

Name	<u>Staphylococcus</u> <u>albus</u>		<u>Diphtheroid</u> <u>bacilli</u>		<u>Staphylococcus</u> <u>citreus</u>		Chromogenic staphylococci		Pneumococcus		<u>Streptococcus</u> <u>viridans</u>		<u>Diplobacillus</u> of Morax		<u>Micrococcus</u> <u>catarrhalis</u>		<u>B. Koch-Weeks</u>		Miscellaneous	
	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L
26J. Pryde	+	+		+																
27W.Mc Intyre	+	+	#	#																
28J.Lock- :hart	+	+	#	#																
29W.Gib- :son		+	+	+								+								
30T. Fraser	+	+		+																
31D.Car- :son												##								
32J.Mc Farlane	+																			
33T.Col- :vin	+	+	+	#					+											
34 A. Deans	#	+	+	#																
35A.Sne- :ddon	+	+	+	+																
36W.Camp :bell	+	+	#	#																
37A.Mc Kenzie	+		#	+																
38G.Mor- :ris	+	+	#	#																
39J. Deans			#	#																
40C. Reid	+	+											#							



Table 15 (continued).

Name	<u>Staphylococcus</u> <u>albus</u>		<u>Diphtheroid</u> <u>bacilli</u>		<u>Staphylococcus</u> <u>citreus</u>		Chromogenic staphylococci		Pneumococcus		<u>Streptococcus</u> <u>viridans</u>		<u>Diplobacillus</u> of Morax		<u>Micrococcus</u> <u>catarrhalis</u>		<u>B. Koch-Weeks</u>		<u>Miscellaneous</u>	
	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L
15 J. Burt	+	+	+																	
16 R. Anderson	+	#	#						+											
17 D. Melville		+	+	+																
18 J. Bennett	+	#	+																	
19 D. Serice		#	#	+																
20 W. Mc Vitie	+	+	+	+		+														
21 T. Finlay	+	#	#																	
22 D. Masson	+	+	+	+					+											
23 G. Thomson	+	+	+	#							+									
24 A. Pryde	+	#	+	+																
25 J. Mil-lar	+	+	+	+		+														
26 A. Es-sen	+	+	#	#																
27 J. Sim- p-son	+	+	+	#																
28/																				

Anthraxoid  
bacilli +Anthraxoid  
bacilli +Anthraxoid  
bacilli +M. Anthracinus  
+

Table 15 (continued).

	Name	<u>Staphylococcus</u> <u>albus</u>		<u>Diphtheroid</u> <u>bacilli</u>		<u>Staphylococcus</u> <u>citreus</u>		<u>Chromogenic</u> <u>staphylococci</u>		<u>Pneumococcus</u>		<u>Streptococcus</u> <u>viridans</u>		<u>Diplobacillus</u> <u>of Morax</u>		<u>Micrococcus</u> <u>catarrhalis</u>		<u>B. Koch-Weeks</u>		<u>Miscellaneous</u>	
		R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L
28	B. Brown	#	#	#	#							+									
29	W. Gordon	+	+											#	#						
30	G. Potts	+	#	+	#	+															
31	R. Gilchrist	+	#	#	#																
32	H. McGuire	+	+	#	#																
33	T. Coulson	#	#	#						+											
34	J. Darling			+	+																
35	G. Brown			#	#	+															
36	A. Gordon	+								+	+								+		
37	R. Liddle	+	+	#	#																
38	W. Whitehead		#							#											
39	W. Cornwall		+																		
40	J. Burrows	+	+							#											

Anthraxoid  
bacilli +Anthraxoid  
bacilli +











Table 17 (continued).

Name	<u>Staphylococcus</u> <u>albus</u>		Diphtheroid bacilli		<u>Staphylococcus</u> <u>citreus</u>		Chromogenic staphylococci		Pneumococcus		<u>Streptococcus</u> <u>viridans</u>		<u>Diplobacillus</u> of Morax		<u>Micrococcus</u> <u>catarrhalis</u>		<u>B. Koch-Weeks</u>		Miscellaneous		
	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	
13 D. Mof- :fat												+	+								
14 R. Ram- :age	+	#	+	+																	
15 D. Ham- :ilton	+	+	#	#								#									
16 R. Rob- :ertson	+	#																			
17 F. Brown			#																		
18 D. Petrie	+	+	#																		
19 P. Kelly			+	+																	
20 J. Web- :ster		#	+																		
21 W. Barnes	+											#	+								
22 R. Pear- :son	+																				
23 A. Gill :am		#	#	#																	
24 J. Ir- :vine	+		#	+																	
25 A. Ram- :say	#	#	+	#																	
26/																					

Antitoxoid  
bacilli #

B. coli  
+



T A B L E 18.

Lady Victoria Colliery.

Examination showing percentage of workers  
harbouring various conjunctival organisms.

	Min- :ers	Brush- :ers	Oncost workers	Surface Workers	Total, all Classes of Workers
Total number of men examined	40	40	40	40	160
<u>Staphylococcus albus</u>	87.5	85	87.5	65	81.93
Diphtheroid bacilli	78.5	70	62.5	70	70.86
<u>Staphylococcus citreus</u>	2.5	15	17.5	7.5	10.7
Chromogenic staphylococci	-	-	-	-	-
Pneumococcus	7.5	22.5	5	5	9.63
<u>Streptococcus viridans</u>	7.5	5	10	15	8.97
Diplobacillus of Morax	7.5	2.5	2.5	-	3.1
<u>Micrococcus catarrhalis</u>	-	-	-	2.5	0.63
<u>B. Koch-Weeks</u>	-	2.5	2.5	-	1.3
Anthracid bacilli	5	10	2.5	5	5.7
Coliform bacilli	-	2.5	-	2.5	1.3
<u>Micrococcus tetragenus</u>	-	2.5	-	-	0.63

Lady Victoria Colliery: discussion of results.

From Table 18, which summarises the findings in the different classes of worker, it can be seen that a noteworthy feature was the high incidence (22.5 per cent.) of pneumococci in the brushers, who showed also a high incidence of anthracoid bacilli (10 per cent.). Another feature of some interest was the high proportion of men harbouring the Staphylococcus citreus, especially oncost workers, of whom 17.5 per cent. were infected. Apart from this, the results were fairly uniform in the various classes of worker.

(8) RESULTS AT LOGANLEA.

At this mine, 160 men were examined, there being 40 in each class of miner, brusher, oncost worker, and surface worker.

Coal was removed in this mine also by machines, and the "miners", therefore, were more accurately speaking "strippers", as they had not so much to hew the coal as to dislodge it and arrange it suitably for removal by the oncost workers.

The tests were performed in the spring of 1938 and the detailed results are given in Tables 19 to 22, while the summary is given in Table 23 (page 86).

TABLE/

T A B L E 19.

Examination of Miners, Loganlea Colliery.

	Name	Staphylococcus albus		Diphtheroid bacilli		Staphylococcus citreus		Chromogenic staphylococci		Pneumococcus		Streptococcus viridans		Diplobacillus of Morax		Micrococcus catarrhalis		B. Koch-Weeks		Miscellaneous	
		R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L
1	W. Hig- gins											+	+								
2	H. Brown	+	+	+	+																
3	T. Ton- er			+	+																
4	A. Mit- chell	+	+	+	+																
5	W. Currie	+	+									+	+								
6	J. Wil- son	+	+	+	+																
7	J. Wil- son	+	+																		
8	T. Coch- rane	+	+																		
9	J. Gren- orskie					+															+
10	E. Wynne	+	+	+	+																
11	J. Hut- ton	+	+																		
12	W. Red- mond	+	+	+	+																
13	/																				

Anthraxoid  
Bacilli +  
Anthraxoid  
Bacilli +Anthraxoid  
Bacilli +

Table 19 (continued).

Name	<u>Staphylococcus</u> <u>albus</u>		<u>Diphtheroid</u> <u>bacilli</u>		<u>Staphylococcus</u> <u>citreus</u>		<u>Chromogenic</u> <u>staphylococci</u>		<u>Pneumococcus</u>		<u>Streptococcus</u> <u>viridans</u>		<u>Diplobacillus</u> <u>of Morax</u>		<u>Micrococcus</u> <u>catarrhalis</u>		<u>B. Koch-Weeks</u>		<u>Miscellaneous</u>	
	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L
13J. Wood		#								+					#					
14 J. Miller			+	+																
15 J. Gillant	+	+	+																	
16W. Higgins	+	#	+																	
17 J. McCann																				
18 W. Inch	+	+	#	##																
19 M. Dougan	+	+	#	##																
20 W. Wynne	+								#		#									
21 W. Green	+			+																
22 S. Menzies		+		+																
23 A. McGurdy		#	##																	
24 J. Rhodie	+		+		#															
25 F. Fleider		#		+							##									
26/																				

Anthraxoid  
Bacilli +Anthraxoid  
Bacilli ##











T A B L E 21.

Examination of Oncost Workers, Loganlea Colliery.

Name	<u>Staphylococcus albus</u>		<u>Diphtheroid bacilli</u>		<u>Staphylococcus citreus</u>		<u>Chromogenic staphylococci</u>		<u>Pneumococcus</u>		<u>Streptococcus viridans</u>		<u>Diplobacillus of Morax</u>		<u>Micrococcus catarrhalis</u>		<u>B. Koch-Weeks</u>		<u>Miscellaneous</u>	
	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L
1 J. Duffy		+	+	+																
2 J. Ham- :pson	#	#		#																
3 R. Pras :her		#																		
4 W. Yard :ley		+	#																	
5 J. Ait- :chison		+	+																	
6 J. Wil- :son		+																		
7 Blaney	#	#	#	#																
8 J. Rod- :gers		+	#																	
9 H. Mc Comeskie	#	+		#																
10 J. Gray	+	#				+														
11 S. Fled :er				+	+															
12 J. Hean :ie		+				+														
13/																				

A-thyroid  
bacilli +











## T A B L E 23.

Loganlea Colliery

Examination showing percentage of workers  
harbouring various conjunctival organisms.

	Min- :ers	Brush- :ers	Oncost Workers	Surface Workers	Total, all Classes of Worker:
Total number of men examined	40	40	40	40	160
<u>Staphylococcus albus</u>	77.5	80.0	95	52.57	76.86
Diphtheroid bacilli	70	72.5	62.5	70.0	69.33
<u>Staphylococcus citreus</u>	10	5	5	7.5	6.9
Chromogenic staphylococci	-	-	-	-	-
Pneumococcus	10	2.5	10	2.5	6.3
<u>Streptococcus viridans</u>	17.5	15	2.5	22.5	14.5
Diplobacillus of Morax	-	2.5	-	2.5	6.3
<u>Micrococcus catarrhalis</u>	5	10	-	2.5	4.4
<u>B. Koch-Weeks</u>	-	2.5	-	-	.63
Anthracid bacilli	15	5	2.5	-	5.67
Coliform bacilli	-	2.5	-	-	.63
<u>Micrococcus tetragenus</u>	-	-	-	-	-

Loganlea Colliery: discussion of results.

There is really little to comment upon in the results as shown in Table 23, the findings in the four groups of worker being comparatively uniform. It may, however, be noted that the miners showed an unusually high incidence of anthracoid bacilli (15 per cent.).

(9) ANALYSIS OF ABOVE RESULTS.

The above results are analysed in Tables 24 and 25. Thus, Table 24 shows the incidence of the various conjunctival bacteria in the miners, brushers, oncost workers, and surface workers from all four pits; for example, instead of the findings for the miners from all four pits being shown separately, they have all been added together and compared with the findings for all the brushers and all the other classes of worker:

TABLE/

T A B L E 24.

*Incidence of Conjunctival Bacteria in the Various Classes of Workers.*

	Miners	Brushers	Oncost Work- :ers	Surface Workers
Total number of men examined	179	164	155	160
<u>Staphylococcus albus</u>	90.16%	87.84%	93.6%	72.26%
Diphtheroid bacilli	80.08%	67.71%	65%	68.82%
<u>Staphylococcus citreus</u>	8.96%	10.98%	13.65%	6.82%
Chromogenic staphylococci	0.56%	1.22%	-	-
Pneumococcus	9.52%	7.93%	8.45%	6.82%
<u>Streptococcus viridans</u>	9.52%	10.96%	13.65%	11.78%
Diplobacillus of Morax	4.48%	3.66%	5.2%	1.86%
<u>Micrococcus catarrhalis</u>	2.8%	3.66%	1.30%	1.24%
<u>B. Koch-Weeks</u>	1.12%	1.22%	3.9%	1.24%
Anthracid bacilli	5.04%	3.66%	1.95%	1.86%
Coliform bacilli	-	1.22%	0.65%	1.24%
<u>Micrococcus tetragenus</u>	-	0.61%	0.65%	-

It will be seen from Table 24 that there was really a closely similar incidence of conjunctival organisms in the four groups of worker. It might have been expected on first thought that the below-ground workers (miners, brushers, and oncost workers) would have shown a more profuse flora than the surface workers, and there is some evidence that this may have been the case as far as staphylococci, pneumococci, the Diplobacillus of Morax, and anthracoid bacilli are concerned. I feel that it is unwise, however, to emphasize this point unduly. In point of fact, no great difference should be expected, as many mine surface workers are engaged in occupations which constantly expose them to coal and other dust, and the conditions under which they work in many instances are not very dissimilar to those of the below-ground group of worker.

TABLE/

T A B L E 25.

*Incidence of Conjunctival Bacteria compared at different mines.*

	Arniston	Whitrigg	Lady Victoria	Loganlea
Total number of men examined	189	149	160	160
<u>Staphylococcus albus</u>	94.87%	94.47%	81.93%	76.86%
Diphtheroid bacilli	71.02%	73.03%	70.56%	69.3%
<u>Staphylococcus citreus</u>	10.07%	12.73%	10.71%	6.93%
Chromogenic staphylococci	1.59%	-	-	-
Pneumococcus	10.6%	5.36%	10.08%	6.3%
<u>Streptococcus viridans</u>	10.6%	11.39%	9.45%	14.49%
Diplobacillus of Morax	7.42%	2.68%	3.15%	1.26%
<u>Micrococcus catarrhalis</u>	2.65%	1.34%	0.63%	4.41%
<u>B. Koch-Weeks</u>	3.18%	0.67%	2.52%	0.63%
Anthracid bacilli	-	2.01%	5.67%	5.67%
Coliform bacilli	0.53%	0.67%	1.26%	0.63%
<u>Micrococcus tetragenus</u>	-	0.67%	0.63%	-

In Table 25 an attempt is made to ascertain whether any particular organisms enjoyed undue prevalence at individual mines, without reference to the particular type of worker affected. Thus, all the Arniston workers are totalled together and compared with all the Whitrigg, Lady Victoria, and Loganlea men.

Certain interesting features emerge from consideration of these figures in Table 25:

(a) At Arniston there seemed to be a high prevalence of the Diplobacillus of Morax, the incidence here being 7.42 per cent., a figure well over double that of the next pit (Lady Victoria, with 3.15 per cent.).

(b) Pneumococci were found definitely more frequently at Arniston (10.6 per cent.) and Lady Victoria (10.08 per cent.) than at the other mines (Whitrigg, 5.36 per cent., and Loganlea, 6.3 per cent.)

(c) B. Koch-Weeks was considerably more prevalent at Arniston and Lady Victoria than at the other two mines.

(d) Anthracoid bacilli were strikingly absent from Arniston men, although not infrequently encountered at Lady Victoria (5.67 per cent.) and Loganlea (5.67 per cent.).

(e) The type of staphylococcus known as the chromogenic staphylococcus (see page 92 for details of its properties) was only encountered at Arniston.

Thus,

Thus, it does seem that certain types of organism may enjoy undue prevalence in individual mines, and on general principles of bacterial ecology one might expect an organism, having once gained entrance to, and established itself in, a particular community, to spread widely throughout the individual members.

(10) BIOLOGICAL CHARACTERS OF THE VARIOUS CONJUNCTIVAL BACTERIA ISOLATED FROM COAL MINE WORKERS.

Staphylococci.

The commonest type of staphylococcus isolated was the albus variety, and this was almost universally encountered. These strains had no unusual properties, but it may be said that the majority were non-haemolytic, although a few haemolytic strains (on horse-blood agar plates) were found.

Staphylococci giving an abundant yellow pigment on agar at 37°C. were not uncommon and were classified on this account as citreus.

A few strains producing golden yellow "aureus"-like pigment were encountered. These strains, however, did not ferment mannite, liquefy gelatin, affect litmus milk, or cause haemolysis on horse-blood plates. Accordingly they were designated chromogenic staphylococci/

staphylococci and considered as probable dust-borne organisms rather than as the pathogenic Staphylococcus aureus.

Diphtheroid bacilli.

This organism was the second most frequently encountered of the conjunctival bacteria. Strains corresponded in morphology to the type known as B. xerosis, being club-shaped; colonies were small, dry, rather opaque, and circular; some strains growing on horse-blood agar produced a faint zone of haemolysis round the colonies. No further tests on these organisms were considered necessary.

Pneumococcus.

The frequent occurrence of this organism was rather unexpected. The following table (26) sets out the characters of some 54 strains encountered in this part of the work. All strains were, of course,  $\alpha$ -lytic, gram-positive, lanceolate diplococci, and when growing on boiled blood slopes always produced a marked green coloration. Colonial appearance was often rather unlike the characteristic "draughtsman" colony, many strains having rather dry and somewhat opaque domed colonies. In fact, in many cases it was not possible to distinguish by colonial appearances/

appearances between the pneumococcus and Streptococcus viridans. In morphology also there were often resemblances, as both streptococci and pneumococci tended to be lanceolate, and occurred in pairs and short chains. Bile solubility was tested by adding 1/5th part of bile to a 24-hour broth culture, and examining <sup>naked-eye</sup> for the presence of lysis after about 1 hour's incubation at 37° C. Inulin fermentation was carried out with Hiss's serum water at 37° C. Cultures thought to be pneumococcal after the above tests had been performed were injected intraperitoneally in mice, and the animal killed (if necessary) after 24 hours. The peritoneal cavity was then washed out with normal saline, and drops of the washings placed in the centre of each of three slides. One drop of rabbit pneumococcal antiserum to Types 1, 2, or 3 was then placed on the appropriate slide, a coverslip applied and the characteristic Neufeld reaction, consisting of capsular swelling and agglutination of cocci, looked for microscopically. Unfortunately, at the time of this part of my investigation, antisera to Types 4 to 33 were not readily available, consequently I perforce had to classify pneumococci which did not react to antisera 1, 2, or 3, as belonging to Group 4.

TABLE/

T A B L E 26.

Biological Reactions of Strains of Pneumococcus  
Isolated from Coal Mine Workers.

Name	Type of work and pit	Bile solubility	Inulin fermentation	Reaction on intraperitoneal injection in mice.
1 A.Philip	Repairer Arniston	-	+	Type 3 pneumococcus present
2 J.Friskey	Miner Whitrigg	+	+	Type 3 pneumococcus present
3 J.Blackie	Surface worker Arniston	+	+	Pneumococci of Group 4 present.
4 D.Bunyan	Surface worker Arniston	+	+	Pneumococci of Group 4 present.
5 J. Clark	Miner Lady Victoria	+	+	Pneumococci of Group 4 present.
6 W.Whitehead	Brusher Lady Victoria	+	+	Pneumococci of Group 4 present.
7 R.Hewison	Oncost worker Loganlea	+	+	Pneumococci of Group 4 present.
8 J.Bowman	Oncost worker Loganlea	+	-	Pneumococci of Group 4 present.
9 J. Brown	Miner Arniston	+	+	No pneumococci found.
10 W.Learmonth	Miner Arniston	+	+	No pneumococci found.
11 P.Darling	Miner Arniston	+	+	No pneumococci found.
12 R.Robertson	Miner Arniston	+	+	No pneumococci found.
13/				

(a) see p.

(b)

(c)

Table 26 (continued).

Name	Type of work and pit	Bile solubility	Inulin fermentation	Reaction on intraperitoneal injection in mice.
13 J. Young	Miner Arniston	+	+	No pneumococci found.
14 J. Jun- :ers	Miner Arniston	+	+	No pneumococci found.
15 A. Mc Guff	Miner Arniston	+	+	No pneumococci found.
16 R. Lear- :month	Brusher Arniston	+	+	No pneumococci found.
17 R. Cun- :ningham	Brusher Arniston	+	+	No pneumococci found.
18 J. Rob- :ertson	Brusher Arniston	+	+	No pneumococci found.
19 J. Hors- :burgh	Repairer Arniston	+	+	No pneumococci found.
20 J. King	Oncost worker Arniston	+	+	No pneumococci found.
21 J. Mur- :ray	Oncost worker Arniston	+	+	No pneumococci found.
22 J. Jam- :ieson	Oncost worker Arniston	+	+	No pneumococci found.
23 T. Doug- :all	Surface worker Arniston	+	+	No pneumococci found and none on culturing from peritoneum.
24 R. Fer- :rier	Surface worker Arniston	+	+	No pneumococci found and none on culturing from peritoneum.
25 W. Hay	Surface worker Arniston	+	+	No pneumococci found and none on culturing from peritoneum.
26/				

(c)

Table 26 (continued).

Name	Type of work and pit	Bile solubility	Inulin-fermentation	Reaction on intraperitoneal injection in mice.
26 C. Roy	Miner Lady Victoria	+	+	No pneumococci found.
27 T. Colvin	Miner Lady Victoria	+	+	No pneumococci found.
28 J. Golden	Brusher Lady Victoria	+	+	No pneumococci found.
29 A. Darling	Brusher Lady Victoria	+	+	No pneumococci found.
30 A. Melrose	Brusher Lady Victoria	+	+	No pneumococci found.
31 D. Mason	Brusher Lady Victoria	+	+	No pneumococci found.
32 T. Coulman	Brusher Lady Victoria	+	+	No pneumococci found.
33 A. Gorman	Brusher Lady Victoria	+	+	No pneumococci found.
34 G. Walker	Oncost worker. Lady Victoria	+	+	No pneumococci found.
35 G. Aitken	Oncost worker. Lady Victoria	+	+	No pneumococci found.
36 J. Williams	Surface worker. Lady Victoria	+	+	No pneumococci found.
37/				

(C)

Table 26 (continued).

Name	Type of work and pit	Bile solubility	Inulin fermentation	Reaction on intraperitoneal injection in mice.
37 Mr X.Y. Z.	Surface worker Lady Victoria	+	+	No pneumococci found.
38 J.Wood	Miner Loganlea	+	+	No pneumococci found.
39 W. Wynne	Miner Loganlea	+	+	No pneumococci found.
40 W.Finley	Miner Loganlea	+	+	No pneumococci found.
41 J.Nicol	Miner Loganlea	+	+	No pneumococci found.
42 R.Dundas	Oncost worker Lady Victoria	+	+	No pneumococci found.
43 G.Bryson	Brusher Loganlea	+	+	No pneumococci found.
44 R.Black	Surface worker Loganlea	+	+	No pneumococci found.
45 R.Anderson	Brusher Lady Victoria	+	-	No pneumococci found.
46 J.Lally	Oncost worker Loganlea	+	-	No pneumococci found.
47 W.Ferguson	Surface worker Whitrigg	-	+	No pneumococci found.
48/				

(c)

(d)

(e)

Table 26 (continued).

Name	Type of work and	Bile solubility	Inulin fermentation	Reaction on intraperitoneal injection in mice.
48 W.Mackie	Surface worker Whitrigg	-	+	No pneumococci found.
49 T.Nayavhas	Surface worker Whitrigg	-	+	No pneumococci found.
50 D.Sangster	Oncost worker Whitrigg	-	+	No pneumococci found.
51 H.Boyle	Oncost worker Whitrigg	-	+	No pneumococci found.
52 J.Ferguson	Oncost worker Whitrigg	-	+	No pneumococci found.
53 J.Boyle	Oncost worker Whitrigg	-	+	No pneumococci found.
54 J.Burrows	Brusher Lady Victoria	-	+	No pneumococci found.

(e)

From the above table (26), it will be seen that various varieties of pneumococcus were isolated:

(a) There were only two strains of pneumococcus belonging to types other than Group 4, and both of these were Type 3.

(b) In six instances pneumococci were encountered in the peritoneal exudate after mouse inoculation which did not react with antisera to Types 1, 2, or 3, and were thus classified as belonging to Group 4. Unfortunately, at that time, as has been explained, they could not be typed further.

(c) Thirty-six strains appeared to be typical pneumococci, being bile-soluble and fermenting inulin, yet on intraperitoneal inoculation in mice they proved quite avirulent and had disappeared from the peritoneal cavity after 24 hours. In some of these cases, cultures were made from the mouse peritoneal washings, but with negative results. These organisms were presumably "rough", although no particular difference was necessarily observed in their colonial appearances.

(d) Two strains only were bile-soluble but did not ferment inulin.

(e) Eight strains were inulin-fermenters but proved insoluble in bile.

Both/

Both these last categories of organism were accepted as pneumococci, as it is generally held that not all strains are necessarily inulin-fermenters or bile-soluble (Berger and Silberstein, 1926; Reimann, 1927). On the other hand, there seems to be no doubt that organisms with such properties are intermediate in position between the true Streptococcus viridans and the genuine pneumococcus. It has already been stated above that these organisms, as encountered in the conjunctival sac, often have similar morphological features and colonial appearances, so it is not unreasonable to expect to find strains which have intermediate biochemical reactions. Precise differentiation of these intermediate types is purely academic as they have all been found in cases of hypopyon ulcer, and so are clearly potential ocular pathogens (vide infra).  
Streptococcus viridans.

It is unnecessary to present a detailed table showing the properties of these strains, as all were  $\beta$ -haemolytic, gram-positive streptococci occurring in pairs and short chains, often being somewhat lanceolate, which were not soluble in bile, and did not ferment inulin. At the outset of the investigation a number/

number of strains were injected intraperitoneally in mice, but no organisms survived and none could be seen in peritoneal washings made when the mouse was killed after 24 hours.

The Diplobacillus of Morax.

This organism was encountered regularly, and all strains were characterised by typical "pitting" of Loeffler's serum medium at 37° C., the morphology in all cases being that of a gram-negative diplobacillus. Strains were also tested to see if growth occurred on ordinary agar at 37° C. and at 22° C., and gelatin stab-cultures were also prepared and incubated at 22° C. A few strains grew on agar at 37° C. and in some instances this property was found to persist throughout four sub-cultures. No strains grew on agar at 22° C. and none liquefied gelatin. Thus, no strains corresponding to the B. liquefaciens of Petit were encountered. Table 27 shows the detailed reactions of the 27 strains of the Diplobacillus of Morax encountered in coal mine workers.

TABLE/

T A B L E 27.Biological Properties of Strains  
of Diplobacillus of Morax.

	Name	Work and mine	Growth on agar at		Liquefaction of gelatin at 22°C.
			37° C.	22° C.	
1	W.Runciman	Miner, Arniston	-	-	-
2	J.Dunlop	Miner, Arniston	-	-	-
3	D.Watson	Miner, Arniston	-	-	-
4	A.Nicoll	Miner, Arniston	-	-	-
5	A.Wilson	Repairer, Arniston	-	-	-
6	G.Hood	Repairer, Arniston	-	-	-
7	R.Weir	Repairer, Arniston	-	-	-
8	A.Steel	Brusher, Arniston	-	-	-
9	J.Nelson	Brusher, Arniston	-	-	-
10	P.Nicol	Brusher, Arniston	+	-	-
11	W.Scott	Oncost worker, Arniston	-	-	-
12	W.Irvine	Oncost worker, Arniston	+	-	-
13	W.McGinley	Oncost worker, Arniston	+	-	-
14	G.Walkin- shaw	Oncost worker, Arniston	+	-	-
15/					

Table 27 (continued).

	Name	Work and mine	Growth on agar at		Liquefaction of gelatin at 22°C.
			37°C.	22°C.	
15	W.Millican	Oncost worker, Arniston	-	-	-
16	J.Connor	Surface work- :er, Arniston	-	-	-
17	C.Lindsay	Miner, Whitrigg	+	-	-
18	J.Hamilton	Oncost worker Whitrigg	-	-	-
19	J.Fleming	Brusher, Whitrigg	+	-	-
20	D.McFarlane	Surface work- :er, Whitrigg	not tested	not tested	not tested
21	A.Clarke	Miner, Lady Victoria	-	-	-
22	W.Jenkins	Miner, Lady Victoria	-	-	-
23	C.Reid	Miner, Lady Victoria	-	-	-
24	W.Gorman	Brusher, Lady Victoria	-	-	-
25	D.Duncan	Oncost worker Lady Victoria	not tested	not tested	not tested
26	W.Grenorskie	Brusher, Loganlea	-	not tested	not tested
27	W.Dunlop	Surface work- :er, Loganlea	not tested	not tested	not tested

Micrococcus catarrhalis.

Some strains of gram-negative diplococci were encountered, and these were tested for ability to grow on agar at 37° C. and at 22° C., for fermentation of glucose, saccharose, and maltose (in Hiss's serum water medium), and by the oxydase test. Table 28 shows the reactions of the 16 strains which were isolated.

From Table 28 it will be seen that the great majority of strains grew on agar at 37° C., while only a few grew at 22° C. The carbohydrates were not fermented, although growth occurred, as estimated by increased turbidity of the medium. Most of the strains reacted positively to the oxydase test. No hesitation was felt, in view of the presence of growth on agar at 37° C., and the failure to ferment carbohydrates, in classifying these organisms as Micrococcus catarrhalis.

TABLE/



Table 28 (continued).

	Name	Work and mine	Growth on agar at		Fermentation of			Oxydase test	
			37°C.	22°C.	glucose	saccharose	maltose		
11	J.Wood	Miner, Loganlea	+	-	-	-	-	+	
12	J.Mc Ilroy	Brusher, Loganlea	+	-	-	-	-	not test- :ed	
13	J. Brown	Brusher, Loganlea	+	-	-	-	-	weak +	
14	J.O' Hare	Brusher, Loganlea	Subculture not obtainable						
15	W.Som- :mer- :ville	Brusher, Loganlea	+	-	No growth			+	
16	T. Meikle	Surface worker, Loganlea	+	-	-	-	-	not test- :ed	

B. Koch-Weeks.

A dozen strains of B. Koch-Weeks were encountered. These organisms were all gram-negative bacilli of small size, often showing a tendency to beading. All the strains grew well on blood agar, whether boiled or unheated blood was used. Ten strains failed to grow on agar without blood, while two appeared to grow thereon. Table 29 shows the properties of these strains in detail.

TABLE/

T A B L E 29.Biological Properties of Strains  
of B. Koch-Weeks.

	Name	Work and Mine	Growth on boiled blood	Growth on agar at 37° C.
1.	J.Carmichael	Miner, Arniston	+	-
2	Wm. Duncan	Miner, Arniston	+	-
3	A.Rowley	Miner, Arniston	+	+
4	J.McConnell	Repairer, Arniston	+	+
5	M.Boyle	Oncost worker, Arniston	+	-
6	W.Muirhead	Oncost worker, Arniston	+	-
7	A.Cornwall	Oncost worker, Arniston	+	-
8	J.Ross	Oncost worker, Arniston	+	-
9	R. Gibb	Oncost worker, Whitrigg	+	-
10	A. Gorman	Brusher, Lady Victoria	+	-
11	R. Casson	Oncost worker, Lady Victoria	+	-
12	J. Brown	Brusher, Loganlea	+	-

Miscellaneous organisms.

A few large gram-positive sporing aerobes corresponding to the B. subtilis variety in morphology and colonial appearances were encountered, also some few strains of B. coli, B. proteus, and Micrococcus tetragenus. There were no unusual features in the morphological appearances or colonial characters of these organisms and they were not studied in particular.

Cases in which no growth was obtained on culture.

Cultures from the conjunctival sac yielded no growth in certain instances, and it is considered of value to include the following details:

TABLE/

T A B L E 30.

Men from whom no growth was obtained  
on culturing the conjunctival sacs.

1. J. Juners. Right eye. Arniston miner.
2. H. Sweeney. Left eye. Arniston repairer.
3. W. Scott. Right eye. Arniston repairer.
4. J. Slight. Both eyes. Arniston repairer.
5. J. Weir. Left eye. Arniston repairer.
6. J. Drummond. Left eye. Arniston brusher.
7. W. Miller. Right eye. Arniston surface worker.
8. C. Reilly. Right eye. Arniston surface worker.
9. B. Muirhead. Right eye. Arniston surface worker.
10. P. McIntosh. Both eyes. Arniston surface worker.
11. N. Burns. Both eyes. Arniston surface worker.
12. D. Bunyan. Left eye. Arniston surface worker.
13. R. Whitson. Left eye. Arniston surface worker.
14. T. Marshall. Right eye. Whitrigg miner.
15. D. Pennycook. Right eye. Whitrigg miner.
16. J. McIntyre. Both eyes. Whitrigg brusher.
17. R. Thomson. Both eyes. Whitrigg brusher.
18. E. Clarkson. Left eye. Whitrigg brusher.
19. R. Moore. Left eye. Lady Victoria Miner.
20. A. Beaton. Left eye. Lady Victoria Miner.

21/

Table 30 (continued).

21.	A. Baxter.	Right eye.	Lady Victoria miner.
22.	D. Carson.	Left eye.	Lady Victoria miner.
23.	J. McFarlane.	Left eye.	Lady Victoria miner.
24.	J. King	Both eyes.	Lady Victoria brusher.
25.	D. Ross.	Left eye.	Lady Victoria brusher.
26.	M. Murphy.	Right eye.	Lady Victoria brusher.
27.	W. Graham.	Right eye.	Oncost worker, Lady Victoria.
28.	J. Lockhart.	Right eye.	Lady Victoria oncost worker.
29.	J. Birrell.	Left eye.	Lady Victoria oncost worker.
30.	T. Reid.	Right eye.	Lady Victoria oncost worker.
31.	A. Wilson.	Left eye.	Lady Victoria oncost worker.
32.	J. Williamson.	Right eye.	Lady Victoria surface worker.
33.	Mr X.	Right eye.	Lady Victoria surface worker.
34.	F. Brown.	Left eye.	Lady Victoria surface worker.
35.	R. Pearson.	Left eye.	Lady Victoria surface worker.
36.	W. Weston.	Right eye.	Lady Victoria surface worker.
37.	R. Gray.	Left eye.	Lady Victoria surface worker.
38.	/		

Table 30 (continued).

38.	J. O'Donnell.	Both eyes.	Lady Victoria surface worker.
39.	A. Goodall.	Right eye.	Lady Victoria surface worker.
40.	J. Beaton.	Right eye.	Lady Victoria surface worker.
41.	S. Menzies.	Right eye.	Loganlea miner.
42.	W. Shields.	Left eye.	Loganlea brusher.
43.	G. Weir.	Left eye.	Loganlea brusher.
44.	P. Bardon.	Right eye.	Loganlea brusher.
45.	J. Lugman.	Both eyes.	Loganlea brusher.
46.	S. Hayburn.	Right eye.	Loganlea brusher.
47.	R. Gillies.	Right eye.	Loganlea oncost worker.
48.	R. Glogely.	Right eye.	Loganlea oncost worker.
49.	R. Prasher.	Right eye.	Loganlea oncost worker.
50.	J. Wilson.	Right eye.	Loganlea oncost worker.
51.	P. Burns.	Both eyes.	Loganlea surface worker.

It can be seen from Table 30 that from 40 out of a total of 690 workers (i.e. 5.6 per cent.) no growth was obtained on culture from the lower conjunctival sac of one or other eye, while from 11 workers (1.54 per cent.) no growth was obtained from <sup>both</sup> either eyes.

By contrast it may be recalled (see page 10 ) that about 40 per cent. of normal persons have been alleged to yield no cultivable bacteria when examined by similar methods to those here adopted.

(11) STUDIES ON VARIATIONS IN THE CONJUNCTIVAL FLORA WITH THE PASSAGE OF TIME.

Three series of tests were carried out to see whether the conjunctival flora altered with the lapse of time.

(a) First of all, twenty workers at Arniston who harboured either the Diplobacillus of Morax, or the Koch-Weeks bacillus in August 1937 were re-examined three months later, i.e., in November 1937, and the results are shown in Table 31.

TABLE/

T A B L E 31.

Results of Re-examination of Arniston Workers Who  
Harboured B.Koch-Weeks or the Diplobacillus of Morax  
Three Months Previously.

	Name	Result in August		Result in Nov- ember	
		Right eye	Left eye	Right eye	Left eye
1	W.Scott	Diplobacillus of Morax	Diplobacillus of Morax	-	-
2	J.Dunlop	Diplobacillus of Morax	-	-	-
3	D.Watson	Diplobacillus of Morax	Diplobacillus of Morax	-	-
4	J.Ross	-	<u>B.Koch-Weeks</u>	-	-
5	W.Irvine	Diplobacillus of Morax	Diplobacillus of Morax	Diplobac- :cillus of Morax	-
6	A.Nicoll	Diplobacillus of Morax	Diplobacillus of Morax	Diplobac- :cillus of Morax	Diplobac- :cillus of Morax
7	J.Car- :Michael	<u>B.Koch-Weeks</u>	<u>B.Koch-Weeks</u>	Diplobac- :cillus of Morax	Diplobac- :cillus of Morax
8	W.Muirhead	<u>B.Koch-Weeks</u>	-	-	-
9	G.Walkin- :shaw	Diplobacillus of Morax	-	-	-
10	W.Runci- :man	-	Diplobacillus of Morax	-	-
11	A.Corn- :wall	<u>B.Koch-Weeks</u>	<u>B.Koch-Weeks</u>	-	-
12	W.Milli- :can	-	Diplobacillus of Morax	-	-
13/					

Table 31 (continued).

Name	Result in August		Result in Nov- ember	
	Right eye	Left eye	Right eye	Left eye
13 A.Wilson	Diplobacillus of Morax	-	-	-
14 G.Hood	-	Diplobacillus of Morax	-	-
15 P.Nicol	Diplobacillus of Morax	Diplobacillus of Morax	-	-
16 A.Rowley	<u>B.Koch-Weeks</u>	-	-	-
17 J.Nelson	-	Diplobacillus of Morax	-	-
18 R.Weir	Diplobacillus of Morax	Diplobacillus of Morax	-	-
19 A.Steel	Diplobacillus of Morax	-	-	-
20 W.Mc Ginlay	Diplobacillus of Morax	Diplobacillus of Morax	-	-

From Table 31 it will be seen that at the first examination 15 workers harboured the Diplobacillus of Morax, while on re-examination only 2 of these men still harboured the organism. Similarly, of 5 men harbouring the Koch-Weeks bacillus in August not one still yielded a growth of this organism from the conjunctival sacs in November. The case of J. Carmichael is of great interest, for, as will be seen from the table, in August this worker harboured B. Koch-Weeks, and in November Morax's diplobacillus.

(b) 28 miners at Whitrigg were re-examined after 8 months, and the results are shown in Table 32.

TABLE/

## T A B L E 32.

Results of Re-examination of Whitrigg MinersAfter Eight Months.

	Name	Result in October 1937		Result in June 1938	
		Right eye	Left eye	Right eye	Left eye
1	R.McDonald	<u>St.albus</u> <u>Diphtheroid</u> <u>bacilli</u>	<u>St.albus</u> <u>Diphtheroid</u> <u>bacilli</u>	Diphther- oid bacilli	<u>St.albus</u> <u>Diphther-</u> <u>oidbacilli</u>
2	J.Keeman	<u>St.albus</u>	<u>St.albus</u> <u>Diphtheroid</u> <u>bacilli</u>	<u>St.albus</u>	<u>St.albus</u>
3	D.Pennycook	-	<u>St.albus</u> <u>St.citreus</u>	<u>St.albus</u>	<u>St.albus</u>
4	J.Hailstones	<u>St.albus</u> <u>Diphtheroid</u> <u>bacilli</u> <u>St.citreus</u>	<u>St.albus</u> <u>Diphtheroid</u> <u>bacilli</u>	<u>St.albus</u> <u>Diphther-</u> <u>oid</u> <u>bacilli</u> <u>S-viridans</u>	Diphther- oid bacilli
5	C.Lindsay	Diphtheroid bacilli	<u>Strep.</u> <u>viridans</u> <u>Diplbacillus</u> of Morax	<u>St.albus</u> <u>Diphther-</u> <u>oid bacilli</u>	<u>St.albus</u> <u>Diphther-</u> <u>oidbacilli</u>
6	J.Boyd	<u>St.albus</u> <u>Diphtheroid</u> <u>bacilli</u>	<u>St.albus</u> <u>Diphtheroid</u> <u>bacilli</u>	<u>St.albus</u> <u>Diphther-</u> <u>oid bacilli</u>	<u>St.albus</u> <u>Diphther-</u> <u>oidbacilli</u>
7	G.Murphy	<u>St.albus</u> <u>Diphtheroid</u> <u>bacilli</u>	<u>St.albus</u> <u>Diphtheroid</u> <u>bacilli</u>	<u>St.albus</u> <u>Diphther-</u> <u>oid bacilli</u>	<u>St.albus</u> <u>Strep.</u> <u>viridans</u>
8	H.McKay	<u>St.albus</u> <u>Diphtheroid</u> <u>bacilli</u>	<u>St.albus</u>	Group 4 Pneumo- :coccus	<u>St.albus</u> <u>Diphther-</u> <u>oidbacilli</u>
9	W.Marley	<u>Strep.</u> <u>viridans</u>	<u>St.albus</u>	<u>St.albus</u>	<u>St.albus</u> <u>St.citreus</u> Group 4 Pneumo- :coccus
10	G.Wilson	<u>St.albus</u> <u>Diphtheroid</u> <u>bacilli</u>	<u>St.albus</u> <u>Diphtheroid</u> <u>bacilli</u>	<u>St.albus</u> <u>Diphther-</u> <u>oid bacilli</u>	<u>St.albus</u> <u>Diphther-</u> <u>oid bacilli</u>
11/					

Table 32 (continued).

	Name	Result in October 1937		Result in June 1938	
		Right eye	Left eye	Right eye	Left eye
11	D. Wilson	<u>St.albus</u> Diphtheroid bacilli	<u>St.albus</u> Diphtheroid bacilli	Diphther- :oid bacilli	Diphther- :oid bacilli
12	J.Bryce	<u>St.albus</u> Diphtheroid bacilli	<u>St.albus</u> Diphtheroid bacilli	Diphther- :oid bacilli	<u>St.albus</u> Diphther- :oid bacilli
13	T.Charge	Diphtheroid bacilli	<u>St.albus</u> Diphtheroid bacilli	-	Diphther- :oid bacilli
14	T.Carrigan	<u>St.albus</u> Diphtheroid bacilli	<u>St.albus</u> Diphtheroid bacilli	<u>St.albus</u> Group 4 Pneumococcus	<u>St.albus</u> Diphther- :oid bacilli
15	P. Gray	<u>St.albus</u> Diphtheroid bacilli	<u>St.albus</u> Diphtheroid bacilli	<u>St.albus</u>	<u>St.albus</u>
16	A.McAlpine	<u>St.albus</u> Diphtheroid bacilli	<u>St.albus</u> Diphtheroid bacilli <u>S.citreus</u>	<u>St.albus</u>	Diphther- :oid bacilli
17	J.Allan	<u>St.albus</u> Diphtheroid bacilli	<u>St.albus</u> Diphtheroid bacilli	Diphther- :oid bacilli	<u>St.albus</u> Diphther- :oid bacilli
18	T.Marshall	-	<u>St.albus</u>	<u>St.albus</u> Diphther- :oid bacilli	Diplobacilli- :us of Morax
19	J. Millar	Diphtheroid bacilli	<u>St.albus</u>	Diphther- :oid bacilli	<u>St.albus</u> Diphther- :oid bacilli
20	R. Potter	<u>St.albus</u> Diphtheroid bacilli	<u>St.albus</u> Diphtheroid bacilli	<u>St.albus</u>	<u>St.albus</u> Diphther- :oid bacilli
21	J.Strang	<u>St.albus</u> Diphtheroid bacilli	<u>Strep.</u> <u>viridans</u>	Diphther- :oid bacilli	<u>St.albus</u> Diphther- :oid bacilli
22/					

Table 32 (continued).

	Name	Result in October 1937		Result in June 1938	
		right eye	Left eye	Right eye	Left eye
22	J. McLay	<u>St. albus</u> Diphtheroid bacilli <u>Mic. catar-</u> <u>halis</u>	<u>St. albus</u> Diphtheroid bacilli <u>S. citreus</u>	<u>St. albus</u> Diphther- oid bacilli	<u>St. albus</u> Diphther- oid bacilli
23	N. McLeish	<u>St. albus</u> Diphtheroid bacilli	<u>St. albus</u>	-	<u>St. albus</u>
24	R. Sangster	Diphtheroid bacilli	<u>St. albus</u> <u>Strep.</u> <u>viridans</u>	<u>St. albus</u>	<u>Strep.</u> <u>viridans</u>
25	D. Gallacher	<u>St. albus</u>	<u>St. albus</u> Diphtheroid bacilli	<u>St. albus</u> <u>Mic. catar-</u> <u>halis</u>	<u>St. albus</u> Diphther- oid bacilli
26	J. Greig	<u>St. albus</u> <u>Strep.</u> <u>viridans</u>	<u>St. albus</u> <u>Strep.</u> <u>viridans</u>	<u>St. albus</u> Diphther- oid bacilli	-
27	R. Liddell	<u>St. albus</u>	<u>St. albus</u> Diphtheroid bacilli	<u>St. albus</u> Diphtheroid bacilli	Diphther- oid bacilli
28	A. Meek	<u>St. albus</u> Diphtheroid bacilli	<u>St. albus</u> Diphtheroid bacilli	<u>St. albus</u> Diphther- oid bacilli	<u>St. albus</u>

These results in Table 32 are of considerable interest and may be summarised as follows:

Staphylococci and diphtheroid bacilli tended on the whole to persist in the conjunctival sac, as these organisms were usually found on re-examination. The case was quite different, however, with regard to the more pathogenic organisms. Thus, on re-examination of six conjunctival sacs which harboured Streptococcus viridans on the first occasion, only one was found still to contain this organism. Further, Streptococcus viridans was found on two occasions, at the second examination, in conjunctival sacs where it had not before occurred. Two strains of Group 4 pneumococcus, one strain of the Diplobacillus of Morax, and one of Micrococcus catarrhalis were also encountered at the second test in sacs previously free from them.

On one occasion both the Diplobacillus of Morax and Micrococcus catarrhalis were found at the first test, but had disappeared by the time of the second.

It is thus obvious that many of the conjunctival bacteria are not usually carried for a long period. Individual mine workers, it is suggested, carry conjunctival pathogens for a short period only.

(c) Table 33 shows a similar series of investigations on the oncost workers at Whitrigg.

TABLE/

T A B L E 33.

Results of Re-examination of Whitrigg Oncost Workers,  
after eight months.

	Name	Previous Findings		Present Findings	
		Right eye	Left eye	Right eye	Left eye
1	G.Bothwell	Diphtheroid bacilli	<u>St.albus</u> Diphtheroid bacilli	Diphtheroid bacilli	Diphtheroid bacilli
2	A.Peat	<u>St.albus</u> Diphtheroid bacilli	<u>St.albus</u> Diphtheroid bacilli <u>St.citreus</u>	<u>St.albus</u> Diphtheroid bacilli Anthracoïd bacilli	<u>St.albus</u> Diphtheroid bacilli Anthracoïd bacilli
3	R.Gibb	<u>St.albus</u> <u>B.Koch-Weeks</u>	Diphtheroid bacilli	-	-
4	J.Ferguson	<u>St.albus</u> <u>Strep.</u> <u>viridans</u>	<u>St.albus</u> <u>Strep.</u> <u>viridans</u>	Diphtheroid bacilli	<u>St.albus</u>
5	A.Moore	<u>St.albus</u> Diphtheroid bacilli	<u>St.albus</u> Diphtheroid bacilli	<u>St.albus</u> Diphtheroid bacilli	<u>St.albus</u> Diphtheroid bacilli
6	A.Carstairs	<u>Strep.</u> <u>viridans</u>	<u>St.albus</u> Diphtheroid bacilli <u>Strep.</u> <u>viridans</u>	<u>St.albus</u> Diphtheroid bacilli	<u>St.albus</u> Diphtheroid bacilli
7	E.McLay	<u>St.albus</u> Diphtheroid bacilli	<u>St.albus</u> Diphtheroid bacilli	<u>St.albus</u> Diphtheroid bacilli	<u>St.albus</u> Diphtheroid bacilli
8	A.Agnev	Diphtheroid bacilli	<u>St.albus</u> Diphtheroid bacilli	-	-
9	M.Whelan	<u>St.albus</u> Diphtheroid bacilli	<u>St.albus</u> Diphtheroid bacilli	<u>St.albus</u>	<u>St.albus</u> Diphtheroid bacilli
10	A.Fairlie	Diphtheroid bacilli	<u>St.albus</u> Diphtheroid bacilli	Diphtheroid bacilli	<u>St.albus</u> Diphtheroid bacilli
11/					

Table 33 (continued).

	Name	Previous Findings		Present Findings	
		Right eye	Left eye	Right eye	Left eye
11	J. Mazs	<u>St. citreus</u>	<u>St. albus</u>	Diphtheroid bacilli	-
12	A. Graham	<u>St. citreus</u> <u>M. tetra-</u> <u>:genus</u>	Diphtheroid bacilli	<u>St. albus</u> Diphtheroid bacilli	Diphtheroid bacilli
13	J. McManus	<u>St. albus</u>	<u>St. albus</u> Diphtheroid bacilli	<u>St. albus</u>	-
14	H. Boyle	<u>St. albus</u> Diphtheroid bacilli <u>Strep. viridans</u>	<u>St. albus</u> <u>Strep. viridans</u>	Diphtheroid bacilli	<u>St. albus</u> Diphtheroid bacilli
15	G. Mazs	<u>St. albus</u> Diphtheroid bacilli	Diphtheroid bacilli	Diphtheroid bacilli	<u>St. albus</u>
16	J. Forrest	<u>St. albus</u> Diphtheroid bacilli	Diphtheroid bacilli	-	<u>St. albus</u> Diphtheroid bacilli
17	J. Weir	<u>St. albus</u>	<u>St. albus</u>	Diphtheroid bacilli	<u>St. albus</u> Diphtheroid bacilli
18	G. Cummings	<u>St. albus</u>	<u>St. albus</u> Diphtheroid bacilli	<u>Strep. viridans</u>	Diphtheroid bacilli

From Table 33 it will be seen that the results on re-examination of the oncost workers were very similar to those shown in Table 32. For instance, the Koch-Weeks bacillus was present in one case at the first test but not at the second, while the Streptococcus viridans was found on the first occasion in six conjunctival sacs but in none of these on re-testing.

(12) CONCLUSIONS.

From the various observations recorded above I feel justified in making the following statements with regard to the conjunctival flora in coal mine workers:

First, it would seem that Staphylococcus albus and diphtheroid bacilli are present in the majority of conjunctival sacs at all times and probably "colonise" so that they become permanently commensal. (This does not, however, preclude these organisms on occasions from causing infection after corneal <sup>side injury</sup> injury.)

Secondly, on examination of any group of workers at any given time, a considerable number of men will be found to harbour pathogenic organisms such as the pneumococcus/

pneumococcus, Streptococcus viridans, the Koch-Weeks bacillus, and the Diplobacillus of Morax. These organisms, however, probably only remain in the conjunctival sac for a short period, and do not appear to "colonise". These bacteria probably pass from worker to worker in much the same way as meningococci, for example, will spread and infect the throats of men living together in barracks. These pathogens can be regarded as intrinsically harmless unless the man happens to sustain a corneal injury at a period when one of these organisms is present in his conjunctival flora. In this case, infection is likely to develop and a corneal ulcer result.

SECTION C.THE BACTERIOLOGY OF THE CONJUNCTIVAL SAC  
IN 187 SHALE MINE WORKERS.(1) Introduction.

Tests were carried out at two shale mines in Central Scotland, the Duddingston and Westwood mines.

The working arrangements in these two shale mines were somewhat different from those obtaining in the coal mines already mentioned. Thus, the working places were comparatively superficial and the conditions under which certain of the men worked were neither so warm nor so dusty as those in coal mines.

The classes of men examined were shale miners, oncost workers, and surface workers. The miners as a rule were working in warm dusty surroundings, dislodging shale already loosened by explosive. The oncost workers were engaged in transport, and the surface workers in a variety of labouring, engineering and other tasks, including tipping trucks of shale.

The tests were carried out in the winter, at the end of 1937.

The findings in these workers will be described following/

following the same lines as those employed above in the case of coal workers.

(2) Methods.

The methods adopted were identical with those used in the investigation of coal mine workers, and have been already described.

(3) RESULTS AT DUDDINGSTON.

At this mine, 102 men were examined, and the results of cultures obtained from both right and left lower conjunctival sacs of miners and oncost workers are shown in Tables 34 and 35. The results of the examination of 22 surface workers will be found later in Table 39, as they have been tabulated together with the Westwood surface workers, owing to the comparatively few men available at each pit. Table 36 summarises these findings (page 134).

TABLE/









Table 35 (continued).

Name	<u>Staphylococcus</u> <u>albus</u>		Diphtheroid bacilli		<u>Staphylococcus</u> <u>citreus</u>		Chromogenic staphylococci		Pneumococcus		<u>Streptococcus</u> <u>viridans</u>		Diplobacillus of Morax		<u>Micrococcus</u> <u>catarrhalis</u>		<u>B. Koch-Weeks</u>		Miscellaneous		
	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	
13 R. Dun- :can	+		+	#																	
14 P. Green			+																		
15 H. Henry	+		#	+																	
16 G. Sned- :don		+	#	+								#									
17 J. Quati	+	#	+	+																	
18 A. Grah- :am	#	+	+	+																	
19 J. Geekie			#	#																	
20 P. O' Donnell	#	+	+	+																	
21 D. Bartle- :man	#	+																			
22 J. Mc Caudlan		+	#	#																	
23 J. Shand	#	#	+									#									
24 H. Liv- :ingston		+																			
25 P. Tur- :ney	#	+	#	#		+															
26 J. Doch- :erty	#	#	#	#																	
27 A. Innes	+	#	+							#											
28/																					

Serratia  
marcescens  
+

S. coli +



T A B L E 36.

Duddingston Shale Mine.Examination of Workers.

	Miners	Oncost work- :ers	Total, miners and oncost work :ers.
Total number of men examined	40	40	80
<u>Staphylococcus albus</u>	95%	87.5%	91.25%
Diphtheroid bacilli	90%	85%	88.75%
<u>Staphylococcus citreus</u>	7.5%	7.5%	7.5%
Chromogenic staphylococci	-	-	-
Pneumococcus	20%	7.5%	13.75%
<u>Streptococcus viridans</u>	2.5%	7.5%	5%
Diplobacillus of Morax	5%	-	2.5%
<u>Micrococcus catarrhalis</u>	-	-	-
<u>B.Koch-Weeks</u>	-	-	-
Anthracid bacilli	-	2.5%	1.25%
Coliform bacilli	2.5%	5%	3.75%
<u>Micrococcus tetragenus</u>	-	-	-

Duddingston Shale Mine: Discussion of Results.

From Table 36 it will be seen that, as a whole, the findings in miners and oncost workers were similar, although it should be noted that 20 per cent. of the miners harboured pneumococci against 7.5 per cent. of the oncost workers, and that no Diplobacilli of Morax occurred in the oncost workers.

(4) RESULTS AT WESTWOOD.

At this mine, 85 men were examined, and the results for miners and oncost workers are given in Tables 37 and 38. With regard to surface workers, the relative table (39) has been compiled by considering together the surface workers at Duddingston and Westwood, as only comparatively few men were available at either pit. The results of these examinations are summarised in Table 40 (Page 145).

TABLE/



















T A B L E 40.Westwood Shale Mine.

Examination showing percentage of workers  
harbouring various conjunctival organisms.

	Miners	Oncost workers	Total, miners and oncost workers together	Surface workers from both shale mines
Total number of men examined	40	27	67	40
<u>Staphylococcus albus</u>	75	88.8	81	80
Diphtheroid bacilli	67.5	70.3	69	70
<u>Staphylococcus citreus</u>	2.5	-	1.5	5
Chromogenic staphylococci	-	-	-	-
Pneumococcus	5	7.4	6	5
<u>Streptococcus viridans</u>	7.5	7.4	7.5	12.5
Diplobacillus of Morax	2.5	-	1.5	-
<u>Micrococcus catarrhalis</u>	5	-	3	-
<u>B. Koch-Weeks</u>	-	-	-	2.5
Anthracid bacilli	-	-	-	-
Coliform bacilli	2.5	3.7	3	-
<u>Micrococcus tetragenus</u>	5	-	3	-

Westwood: Discussion of Results.

From Table 40 it appears that the findings in Westwood miners and oncost workers were very similar, and resembled the results in the surface workers for the two mines.

(5) ANALYSIS OF ABOVE RESULTS.

In Table 41 all the miners are considered together, and contrasted with all the oncost workers and all the surface workers. These results serve again to emphasize the similarity between the various groups of shale mine worker with regard to the incidence of conjunctival bacteria.

TABLE/

T A B L E 41.

Incidence of Organismsin Miners, Oncost Workers, and Surface Workers.

	Miners	Oncost workers	Surface workers
Total number of men examined	80	67	40
<u>Staphylococcus albus</u>	85%	88.5%	80%
Diphtheroid bacilli	80%	79.5%	70%
<u>Staphylococcus citreus</u>	5%	4.5%	5%
Chromogenic staphylococci -	-	-	-
Pneumococcus	12.5%	7.5%	5%
<u>Streptococcus viridans</u>	5%	7.5%	12.5%
Diplobacillus of Morax	3.75%	-	-
<u>Micrococcus catarrhalis</u>	2.5%	-	-
<u>B. Koch-Weeks</u>	-	-	2.5%
Anthracoïd bacilli	-	1.5%	-
Coliform bacilli	2.5%	4.5%	-
<u>Micrococcus tetragenus</u>	2.5%	-	-

In Table 42 an attempt is made to see whether any particular organism enjoyed an unusual distribution in one of the mines as compared with the other.

T A B L E 42.

	Duddingston Miners and Oncost Workers	Westwood Miners and Oncost workers
Total number of men examined	80	67
<u>Staphylococcus albus</u>	91.25%	81%
Diphtheroid bacilli	88.75%	69%
<u>Staphylococcus citreus</u>	7.5%	1.5%
Chromogenic staphylo- cocci	-	-
Pneumococcus	13.75%	6%
<u>Streptococcus viridans</u>	5%	7.5%
Diplobacillus of Morax	2.5%	1.5%
Micrococcus catarrhalis	-	3%
<u>B.Koch-Weeks</u>	-	-
Anthracid bacilli	1.25%	-
Coliform bacilli	3.75%	3%
<u>Micrococcus tetragenus</u>	-	3%

It will be seen from Table 42 that there was apparently a somewhat higher incidence of staphylococci, diphtheroid bacilli, and pneumococci at Duddingston than at Westwood.

(6) CHARACTERS OF THE VARIOUS ORGANISMS GROWN ON CULTURE.

Staphylococci and diphtheroid bacilli.

The bulk of the organisms encountered were of the "albus" type, with only a few "citreus" strains. There is no need to comment further on these organisms nor on diphtheroid bacilli, as they were all quite typical and similar to those already described as occurring in coal mine workers.

Pneumococcus.

Seventeen strains of pneumococcus were isolated and their various biological properties are shown in Table 43.

T A B L E/

T A B L E 43.

Biological Properties of Pneumococci  
Isolated from Shale Mine Workers.

	Name	Type of work and pit	Bile sol- :ubil- :ity	Inul- :in -ferm- :ent- ation	Reaction on intraperitoneal injection in mice.
1	J.Haul- :on	Miner, Dudding- :ston	+ -	+	Group 4 pneumococci present
2	T.Ruth- :erford	Oncost worker, Dudding- :ston	+	+	Group 4 pneumococci present
3	H. Moyes	Miner, Dudding- :ston	+	+	No pneumococci seen
4	T.Kerr	Oncost worker, Dudding- :ston	+	+	No pneumococci seen
5	A. Innes	Oncost worker, Dudding- :ston	+	+	No pneumococci seen
6	A.Turn- :bull	Miner, Westwood	+	+	No pneumococci seen
7	W.Bruce Jr.	Miner, Westwood	+	+	No pneumococci seen
8	M.Gra- :ham	Surface worker, Westwood	+	+	No pneumococci seen
9	D.Mand- :erson	Surface worker, Westwood	+	+	No pneumococci seen
10/					

Table 43 (continued).

Name	Type of work and pit	Bile sol-:ubil-:ity	Inul-:in-ferm-:ent-ation	Reaction on intraperitoneal injection in mice.
10 K. Mc Kenzie	Oncost worker, Westwood	+	+	No pneumococci seen
11 J. Reid	Oncost worker, Westwood	+	+	No pneumococci seen
12 T. Gil-:lon	Miner, Dudding-:ston	-	+	No pneumococci seen
13 S. Quati	Miner, Dudding-:ston	-	+	No pneumococci seen
14 J. Pat-:erson	Miner, Dudding-:ston	-	+	No pneumococci seen
15 A. Orme	Miner, Dudding-:ston	-	+	No pneumococci seen
16 J. Mc Court	Miner, Dudding-:ston	-	+	No pneumococci seen
17 T. Reid Jr.	Miner, Dudding-:ston	-	+	No pneumococci seen

It will be seen from the above table that no pneumococci were found belonging to Types 1, 2, or 3, and only two belonging to Group 4. In the other cases all pneumococci had disappeared from the mouse peritoneal cavity and so could not be typed. All strains fermented inulin, but six failed to dissolve in bile, all these being isolated from one group of worker, namely, Duddingston miners. This is another example of the tendency for an organism once having gained entrance to a community to spread therein.

The Diplobacillus of Morax.

Four strains of this organism were isolated and their reactions were as follows:

TABLE/

T A B L E 44.Biological Properties of Strains of Diplobacillus of  
Morax Isolated from Shale Workers.

	Name	Work and Mine	Growth on agar	
			at 37°C.	at 22°C.
1	W.Kerr	Miner, Duddingston	-	-
2	D.McKenzie	Oncost worker, Westwood	-	-
3	A.Orme	Miner, Duddingston	+	-
4	J.Stewart	Miner, Westwood	+	-

The properties were thus similar to those recorded for the strains isolated from coal mine workers, some growing on agar at 37°C. and some failing to do so, all, however, being incapable of growth on agar at room temperature.

Micrococcus catarrhalis.

The following table (45) indicates the properties of three strains of this organism, and of a further strain which seems from its biochemical reactions more accurately to belong to the Diplococcus pharyngis sicc-  
:us group.

TABLE/

T A B L E 45.

Biological Properties of Strains of Micrococcus catar-  
:rhalis Isolated from Shale Mine Workers.

Name	Work and mine	Growth on agar at		Fermentation of			Oxydase test
		37°C.	22°C.	glu- cose	sac- char ose	malt- ose	
1 A.Hood	Oncost worker, Dudding- :ston	+	-	-	-	-	+
2 J.Kirke	Miner, West- :wood	+	±	-	-	-	+
3 A. Shanks	Miner, West- :wood	+	-	-	-	-	+
4 S. Walker	Oncost worker, Dudding- :ston	+	+	+	+	-	-

B. Koch-Weeks.

Only one strain of this organism was isolated, being identified by its failure to grow on agar while growing readily on blood agar.

Cases in which no growth was obtained on culture.

As with coal workers, no growth was obtained on culture on blood agar after inoculation from the conjunctival sac, on a number of occasions, and full details will be found in Table 46.

TABLE/

T A B L E 46.

Showing Details of Cases in Which  
Culture Yielded No Growth.

Name	Type of work and pit	Side from which no growth was obtained
1 W.Parker	Miner, Duddingston	Right eye
2 H.Living- :ston	Oncost worker, Duddingston	Right eye
3 A.Wishart	Oncost worker, Duddingston	Right eye
4 J.Dick- :son	Oncost, Duddingston worker	Right eye
5 W.Stirling	Oncost, Duddingston worker	Left eye
6 B.Hogg	Surface worker, Duddingston	Right eye
7 M. Ivy	Surface worker, Duddingston	Left eye
8 J.Smith	Miner, Westwood	Left eye
9 D.Lock	Miner, Westwood	Right eye
10 A.Bird	Miner, Westwood	Left eye
11 H.Gord- :on, Jr.	Miner, Westwood	Both eyes
12 W.Bruce, Jr.	Miner, Westwood	Left eye
13 D.Carey	Miner, Westwood	Both eyes
14 W.Samson	Miner, Westwood	Right eye
15 G.Salmond	Miner, Westwood	Left eye
16/		

Table 46 (continued).

Name	Type of work and pit	Side from which no growth was obtained
16 P.Mc Gurvie	Miner, westwood	Right eye
17 M.Graham	Surface worker, Westwood	Right eye
18 J.Hair	Surface worker, Westwood	Left eye
19 J.Henderson	Surface worker, Westwood	Both eyes
20 D.Jamieson	Surface worker, Westwood	Right eye
21 W.Easton	Surface worker, Westwood	Right eye
22 R.Gervis	Surface worker, Westwood	Right eye
23 T.Brown	Oncost worker, Westwood	Right eye
24 A.Townseley	Oncost worker, Westwood	Both eyes
25 W.Gowan	Oncost worker, Westwood	Right eye
26 J.McNab	Oncost worker, Westwood	Right eye
27 A.Callander	Oncost worker, Westwood	Right eye

From this table (46) it will be seen that no growth on culture was obtained from one or other eye in 23 men out of a total of 187 examined (12.19 per cent.), and from both eyes of 4 men (2.12 per cent.).

It is interesting to compare these figures with those already given for coal workers:

	<u>Coal workers</u>	<u>Shale workers</u>
No growth, one or other eye	5.6 per cent.	12.19 per cent.
No growth, both eyes.	1.54 per cent.	2.12 per cent.

From these figures it is evident that it was considerably commoner to obtain no growth on culture from the conjunctival sacs of shale workers than of coal workers.

SECTION D.A COMPARISON BETWEEN THE CONJUNCTIVAL FLORA  
OF COAL AND SHALE MINE WORKERS.

(A).

In Table 47 a comparison is made between coal miners and shale miners with regard to the percentage of men harbouring the various conjunctival bacteria. It is, I think, clearly shown that there was little significant difference between the two groups of worker.

TABLE/

T A B L E 47.

COMPARISON OF FLORA OF COAL AND SHALE MINERS.

	Coal Miners	Shale Miners
<u>Staphylococcus albus</u>	90.16%	80%
Diphtheroid bacilli	80.08%	85%
<u>Staphylococcus citreus</u>	8.96%	5%
Chromogenic staphylococci	0.56%	-
Pneumococcus	9.52%	12.5%
<u>Streptococcus viridans</u>	9.52%	5%
Diplobacillus of Morax	4.48%	3.75%
<u>Micrococcus catarrhalis</u>	2.8%	2.5%
<u>B. Koch-Weeks</u>	1.12%	-
Anthracid bacilli	5.04%	-
Coliform bacilli	-	2.5%
<u>Micrococcus tetragenus</u>	-	2.5%

(B).

Then in Table 48 the oncost workers are compared, and here there is definitely some difference shown, for the coal oncost workers had higher rates for the incidence of most organisms, e.g., staphylococci, Streptococcus viridans, the Diplobacillus of Morax, and B. Koch-Weeks.

TABLE/

T A B L E 48.

COMPARISON OF FLORA OF COAL AND SHALE ONCOST WORKERS.

	Coal oncost workers	Shale oncost workers
<u>Staphylococcus albus</u>	93.6%	88.5%
Diphtheroid bacilli	65%	79.5%
<u>Staphylococcus citreus</u>	13.65%	4.5%
Chromogenic staphylococci	-	-
Pneumococcus	8.45%	7.5%
<u>Streptococcus viridans</u>	13.65%	7.5%
Diplobacillus of Morax	5.2%	-
<u>Micrococcus catarrhalis</u>	1.3%	-
<u>B. Koch-Weeks</u>	3.9%	-
Anthracid bacilli	1.95%	1.5%
Coliform bacilli	0.65%	4.5%
<u>Micrococcus tetragenus</u>	0.65%	-

(C).

Summarising the position, then, it may be said that, although there was no marked qualitative difference between coal and shale mine workers, the evidence shows that quantitatively shale mine workers harboured a somewhat less profuse flora than did coal workers. This statement is confirmed by considering the percentage of workers from whom no growth was obtained on culturing the conjunctivae. This point has already been referred to, but it may be restated here that in coal workers 5.6 per cent., and shale workers 12.19 per cent. of persons yielded no growth from one or other conjunctival sac.

In conclusion, I would postulate that the conjunctival flora in coal and shale mine workers is considerably more profuse than that of normal persons and contains substantial numbers of organisms which are potentially pathogenic.

SECTION E.  
A REVIEW OF THE LITERATURE

ON THE BACTERIOLOGY OF CORNEAL ULCER OF HYPOPYON TYPE\*

The clinical condition of ulceration of the cornea, with the collection of pus in the anterior chamber (hypopyon) has been known to medicine for a considerable time, and many old text-books on diseases of the eye specifically mention the condition. Thus, William Rowley, writing in 1771, referred to ophthalmia and ulcers associated with injury to the eye from "dirt". Scarpa (1802) alluded to corneal ulcers, complicated by hypopyon, produced by contact with corrosive material, glass, wood, iron, thorns, and pieces of corn.

Wardrop/

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\* This review is expressly limited to the literature on the bacteriology of that type of corneal ulcer where hypopyon is either present at the time of examination, or else would certainly develop if the case were left untreated, i.e., corneal ulcer of hypopyon type. Other types of corneal ulceration, such as, Mooren's, marginal, dendritic, and mycotic ulcers, are not discussed.

Wardrop (1808) clearly described cases of corneal ulcer with hypopyon and mentioned that he believed lime to be a frequent cause of the condition owing to devitalisation of the tissues. It is of interest to note that he included in his monograph a picture of a corneal ulcer in a coal miner who had been struck in the eye by a piece of coal.

Following Saemisch (1870), hypopyon ulcer of the cornea is often alternatively termed serpiginous ulcer, or ulcus serpens, and it was first shown by Gasparini (1893) that pneumococci are frequent causal agents of the condition. Gasparini's original observations have been repeatedly confirmed by Uthoff (1895), Holden (1898), and many others (vide infra). The term "pneumococcal ulcer" is often used by ophthalmologists as synonymous with hypopyon ulcer, although many other organisms have, of course, been isolated from cases of corneal ulcer of hypopyon type. The rôle of these various bacteria in the aetiology of corneal ulcer of hypopyon type will now be discussed.

(1)/

(1) Pneumococci.

Following Gasparini's (1893) original work, numerous workers have succeeded in cultivating pneumococci from the edge of the lesion in cases of hypopyon ulcer (Uhthoff and Axenfeld, 1896a,b; Paterson and Ritchie, 1904; Jensen, 1910; Löwenstein, 1910; Zur Nedden, 1913; Schmelzer and Eckstein, 1934).

To quote some representative figures, Hertel (1901-1902) isolated pneumococci in 66 per cent. of 50 cases, Paterson and Ritchie (1904) in 66 per cent. of 30 cases, McNabb (1927) in 64 per cent. of 25 cases, McNabb (1927) in 64 per cent. of 25 cases, Gasteiger (1929) in 77 per cent. of 75 cases, and Schmelzer (1935) in 60 per cent. of 114 cases. Other workers have referred to the frequent isolation of pneumococci (Gallemaerts, 1907; Fuchs, 1909; Cheney, 1922; Wright, 1927).

With regard to the serological type of pneumococcus isolated, there is great unanimity of opinion that those belonging to Group 4 are by far the commonest. Thus, of Cheney's (1922) twelve strains, eight belonged to Group 4 and the remaining four to Type/

Type 3. Wright's (1927) twenty-four strains were composed of twenty-two Group 4 organisms, and one each belonging to Types 1 and 2. Of Schmelzer's (1935) sixty-three strains, one was Type 2, nine Type 3, and fifty-three Group 4 (see also Jahnke, 1930; Gundel, 1933).

Fodor and Vlasits (1934) also found only Group 4 strains in their series of cases and referred to 106 strains described in the literature which were typed as follows:

Type 1, nine; Type 2, thirteen; Type 3, eleven; Group 4, seventy-three.

It is thus evident that the great majority of pneumococci isolated from corneal ulcers belong to Group 4.

So firmly has it been believed that the majority of cases of hypopyon ulcer are due to the pneumococcus that various specific methods of treatment directed against this organism have been recommended, even without insisting on a preliminary cultivation to make certain that pneumococci ~~are~~<sup>were</sup> in fact present.

Thus, one of the first methods of treatment on these lines to be introduced was the conjunctival instillation of antiserum to the pneumococcus (Römer, see/

see, e.g., 1905, 1909). Sometimes these instillations were combined with the parenteral injection of antiserum, and sometimes pneumococcal vaccines were used. Many workers used these biological methods of treatment, but the results were, on the whole, unsatisfactory (Zur Nedden, 1904b; Reis, 1908; Gebb, 1911, 1913; Salvati, 1923).

In these early days, of course, it was not realised that many different serological types of pneumococcus existed, and that one could, therefore, expect no specific therapeutic action unless a specific antiserum to the type of pneumococcus concerned was used (see Fromaget, 1907; Fodor and Vlasits, 1934). These remarks apply also to treatment by vaccine therapy, which could only exert beneficial effects if autogenous (see Browning, 1927).

That any beneficial effect claimed for serum therapy must have been purely non-specific is shown by the fact that equally good results were claimed for instillations of diphtheria antitoxin (Fradking, 1912). Recently, however, specific serum therapy was used by Scheie and Collins (1939) who identified a Type 23 pneumococcus in one case and treated it successfully with monovalent antiserum.

Other/

Other substances have also been used in treatment, and Weekers (1908) suggested that bile be employed to lyse the pneumococcus in situ.

Various workers have used drugs known to exert a special antiseptic action towards the pneumococcus. Thus, optochin and derivatives were used by Goldschmidt (1913, 1914), Schur (1914), Cavara (1915), and Bedell (1920). Ginsberg and Kaufmann (1913) used optochin in experimental pneumococcal ulcers of the rabbit.

Rodigina (1938) employed a pneumococcal 'phage in treatment.

More recently, acting on the assumption that most cases of hypopyon ulcer are due to the pneumococcus, sulphonamide has been used in treatment. Thus, Johnstone (1941) treated forty-one cases with "sulphapyridine eye-drops as a 0.07 per cent. solution in saline isotonic with the lacrimal secretion." He reported that "the results were encouraging without being phenomenal". Of course, it must be remembered that this treatment would probably exert a beneficial effect on ulcers where other organisms such as streptococci and staphylococci were concerned.

(2)/

(2) Diplo-bacilli.

The Diplobacillus of Morax, or as it is often called, the Morax-Axenfeld bacillus, has been isolated from the ulcer of cases of corneal ulcer by numerous workers (Erdmann, 1905; Paul, 1905; Agricola, 1906; Pusey, 1906; McKee, 1906, 1907; Gallemaerts, 1907; Zade, 1908; Weekers, 1909; Löwenstein, 1910; Brown: ing, 1927; Gasteiger, 1929; Schmelzer, 1935).

The closely related Diplobacillus of Petit, distinguished by its ability to grow on agar at room temperature, has also been isolated (Paul, 1905; Benedetti, 1908; Oreste, 1909; Rosenhauch, 1909; Leser, 1911; Piotrowski and Frydmann, 1927; Ohm, 1929; Reid, 1933; Soudakoff, 1936).

With regard to the frequency of diplobacilli in corneal ulcers, Paul found such organisms in about a third of his cases, Gasteiger in a seventh, and Schmelzer in about an eighth.

Scarlett (1916) studied the various diplobacilli of corneal ulcers and classified them into four groups as follows:

Scarlett's/

Scarlett's (1916) Classification of Diplobacilli.

	Bacillus Duplex			
	I (Morax's bacillus)	II (Petit's bacillus)	III (B. non- liquefac- :iens)	IV (B. Josephi)
<i>Effect on the following:-</i>				
Coagulated serum	liquefied	liquefied	not liquefied	not liquefied
Gelatin	not liquefied	liquefied	liquefied	not liquefied
Growth on ordin- :ary agar at 37°C.	-	+	+	+
Growth on ascit- :ic agar at 37°C.	+	+	+	+
Growth on potato at 37°C.	-	±	-	-
Growth in broth at 37°C.	±	±	+	+
Growth on ascitic agar at room temperature	-	+	+	?
Reaction to Gram's stain	-	-	-	+

From/

From Scarlett's table it will be seen that his Bacillus Duplex I and II correspond to the classical Morax and Petit strains respectively. He was the first author to describe Bacillus non-liquefaciens (Duplex III) as a cause of corneal ulcer. Oliver and Wherry (1921) later found this organism to occur also in sputum. The classification of Scarlett's Bacillus Duplex IV in the Morax-Petit group seems scarcely justified, as it is gram-positive.

### (3) Staphylococci.

Staphylococci have been isolated by a number of workers from corneal ulcers (e.g., Gallemaerts, 1907; Rosenhauch, 1909; Magruder, 1911; McNabb, 1927; Pacalin, 1922; and Schmelzer, 1935). Thus, McNabb found staphylococci in 5 out of 25 cases, and Schmelzer isolated them in 4 per cent. of his cases. In the majority of instances such staphylococci have been of the "aureus" type, although "albus" strains have been found. McCally, Farmer, and Loomis (1933) specially referred to a "citreus" strain in one case.

(4)/

(4) Streptococcus haemolyticus.

This organism has only rarely been encountered. Thus Schmelzer found 4 strains out of 114 cases.

(5) Streptococcus viridans.

Organisms having the characters of Streptococcus viridans have been isolated by certain workers. Thus McNabb (1927) found one strain in a series of 25 cases, and Schmelzer sixteen strains out of 114 cases (see also Löwenstein, 1910).

It is possible that many of the strains recorded by earlier workers as pneumococcus, on account of morphological and colonial appearances only, may really have been streptococci of the viridans type. I have drawn attention, when discussing the properties of these organisms in coal workers (see page 94 ), to the fact that it is difficult to separate them without bile and inulin tests (see also Newman, 1938).

(6) B. Koch-Weeks.

This organism is evidently only a rare cause of corneal ulceration of hypopyon type (Morax, 1894; Paterson and Ritchie, 1904).

(7)/

(7) Zur Nedden's bacillus.

Following the original observations of Zur Nedden (1902, 1904a), other workers have referred to the isolation of this bacillus from cases of corneal ulcer (Bietti, 1909; Leser, 1911; Browning, 1927). The organism is a small, gram-negative bacillus of a size similar to that of the Koch-Weeks bacillus but distinguished from it by growing on agar, gelatin, and potato.

(8) Gram-negative (coliform) bacilli.

Organisms of this type have been isolated from corneal ulcers by various workers.

(a) B. coli. Typical lactose-fermenting B. coli strains have been isolated from a few cases of hypopyon ulcer (De Berardinis, 1903b; Bietti, 1906; Rosenhauch, 1909; Macleish, 1915).

(b) Paracolon bacillus. A coliform bacillus with the biochemical properties of the paracolon bacillus was isolated by Bencini (1932).

(c) B. pyocyaneus. Gram-negative, coliform bacilli producing green pigmentation on agar have frequently been isolated from cases of corneal ulcer of hypopyon type/

type (e.g., De Berardinis, 1903a; McNab, 1904; Szczybalski, 1904-5; Bietti, 1906; Friedenber, 1907; Löwenstein, 1910; Mauersberg, 1910; Salani, 1910; Krinitzki, 1911; Pagenstecher, 1911; Jacobi, 1914; Lamb and Calhoun, 1916; Morelli, 1922; Browning, 1927; Giannini, 1934).

(d) Although the case did not follow corneal injury it is of interest to record that B. paratyphosus A was isolated from a corneal ulcer occurring in a child suffering from paratyphoid fever (Sedan and Herrmann, 1923).

(9) Corynebacteria.

True B. diphtheriae was isolated by Buchanan (1912) from a case of corneal ulcer. The "Xerosis" type of diphtheroid bacillus was isolated from ~~330~~ of Paterson and Ritchie's (1904) cases, but other workers ~~did~~ not find it a common cause of the condition.

(10) Anthracoïd bacilli.

Large gram-positive, sporing aerobes of the B. subtilis variety have been isolated from cases of corneal ulcer of hypopyon type on occasions (Filatow, 1912; Fuchs, 1915).

(11)/

(11) Neisseria organisms.

Guglianetti (1919) claimed to have isolated a genuine meningococcus from a case of corneal ulcer.

(12) Streptothrices.

Organisms of the streptothrix group have been found by De Berardinis (1904; see also De Berardinis and Donna, 1905).

(13) Pasteurella organisms.

Lindner (1924) described cases of fulminating hypopyon ulcer due to organisms of this group.

(14) Cases in which no growth has been obtained on cultures.

Schmelzer (1935) in two of his 114 cases was unable to obtain any growth on culture, but otherwise records of no growths being obtained are unusual. Kipp (1904), however, found no organisms in stained smears made from the edge of the lesion in cases of hypopyon ulcer on an unspecified number of occasions.

SECTION F.THE BACTERIOLOGY OF 221 ESTABLISHED CASES OF  
HYPOPYON ULCER IN MINE WORKERS AND OTHER PERSONS.(1) Introduction.

Since the end of 1937, I have had access to the great majority of cases of corneal ulcer of hypopyon type\* in the Eye Wards of the Edinburgh Royal Infirmary, through the courtesy of Dr H.M. Traquair and Dr E.H. Cameron, Surgeons in this Department.

(2) Methods.

Cultures were prepared in the Eye Department as follows:

First, a loopful of conjunctival secretion from the lower fornix <sup>of the affected eye</sup> was taken and rubbed over the surface of a blood agar slope (in a screw-capped vial).

Second, material was taken, using a small sharp spud, or straight wire, from under the edge of the corneal ulcer, at its most active-looking part. This material was then inoculated onto a blood agar slope.

All/

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\* As already mentioned, cases of marginal ulcer, dendritic ulcer, etc., were excluded.

All cultures were incubated aerobically at 37°C. for at least 48 hours, appropriate tests being carried out on subcultures, where indicated.

In practically every case I took the cultures personally, but in a few instances this was performed by a member of the staff of the Eye Department, or by my deputy.

(3) RESULTS.

The following table (49) shows the detailed results in each of the 221 cases, which are summarised in Tables 50, 51, and 52 (*see p 198 et seq.*).

TABLE/

T A B L E 49.

The Bacteriological Findings  
in 221 Cases of Hypopyon Ulcer.

Date of Examination	Patient		Result of cultures from:	
	Name	Occupation	Edge of ulcer	Conjunctiva of affected side.
1.11:10:37	T.Crowe	Agricultural labourer	Group 4 Pneumococcus	Group 4 Pneumococcus
2.15:10:37	J.Horne	Brusher	Diphtheroids	Diphtheroids
3.16:10:37	A.Totten	Miner	<u>Staph.albus</u> <u>Strep.haemolyticus</u>	<u>Staph.albus</u> <u>Strep.haemolyticus</u>
4.18:10:37	W.MacNab	Miner	Diphtheroids	Diphtheroids. <u>Staph.albus</u>
5.21:10:37	W.Kirkland	Miner	No growth	<u>Staph.albus</u> Diphtheroids
6.8:11:37	R.Heggie	Brusher	Group 4 Pneumococcus	Group 4 Pneumococcus
7.20:11:37	T.Devlin	Steel dresser	Diphtheroids	Diphtheroids <u>Staph.albus</u>
8.6:12:37	T.Horsburgh	Miner	Group 4 Pneumococcus	Diphtheroids <u>Staph.albus</u>
9.11:12:37	R.Wilson	Miner	<u>Strep.viridans</u>	<u>Strep.viridans</u>
10.15:12:37	D.Lindsay	Miner	Diphtheroids	Diphtheroids <u>Staph.albus</u>

Table 49 (continued).

Date of Examination	Patient		Result of cultures from:	
	Name	Occupation	Edge of ulcer	Conjunctiva of affected side.
11.14:12:37	L.Forrest	Labourer	Group 4 Pneumococcus	Group 4 Pneumococcus
12.19:12:37	D.Allan	Mine-surface worker	Diphtheroids	Diphtheroids
13.20:12:37	J.Baxter	Miner	Pneumococcus	<u>Staph.albus</u>
14.29:12:37	J.Brien	Steel plater	Pneumococcus	Pneumococcus
15.30:12:37	R.Cunningham	Miner	Pneumococcus	Pneumococcus
16.11:1:38	J.Adamson	Brusher	Diphtheroids	Diphtheroids
17.13:1:38	P.Allan	Miner	Diplobacillus of Morax	No growth
18.19:1:38	W.McKinlay	Oncost worker	Diplobacillus of Morax	<u>Staph.albus</u>
19.24:1:38	Mrs Barnes	Housewife	Group 4 Pneumococcus	Group 4 Pneumococcus
20.31:1:38	R.McKinlay	Brusher	<u>Staph.aureus</u>	<u>Staph.aureus</u>
21.31:1:38	J.Duffy	Bricklayer	<u>Staph.albus</u> <u>Anthracoïds</u>	<u>Staph.albus</u> <u>Anthracoïds</u>
22.31:1:38	J.Scott	Brewery worker	Diphtheroids	Diphtheroids
23.14:2:38	T.Gibb	Steel dresser	Diplobacillus of Morax	<u>Staph.albus</u>
24.16:2:38	A.Campbell	Miner	Group 4 Pneumococcus	Group 4 Pneumococcus

Table 49 (continued).

Date of Examination	Patient		Result of cultures from:	
	Name	Occupation	Edge of ulcer	Conjunctiva of affected side.
25.24:2:38	R. Johnston	Miner	<u>Strep.viri-</u> <u>:dans</u>	Diplobac- :illus of Morax
26.24:2:38	H. Barnes	Schoolboy	Diphther- :oids	Group 4 Pneumococcus
27.1:3:38	J. Reid	Hewer	<u>Staph.albus</u> Diphther- :oids	<u>Staph.albus</u> Diphther- :oids
28.1:3:38	J. Malloy	Oil worker	Diphther- :oids	Diphther- :oids <u>Staph.albus</u> <u>M.tetragenus</u>
29.8:3:38	T. McGowan	Miner	Diphther- :oids	Diphther- :oids
30.14:3:38	T. Callaghan	Labourer	Type 28 Pneumococcus	Type 28 Pneumococcus
31.31:3:38	J. Flynn	Brusher	Type 29 Pneumococcus	Type 29 Pneumococcus
32.30:4:38	M. Beveridge	Miner	Diphther- :oids	Diphther- :oids
33.3:5:38	W. Briggs	Brusher	No growth	No growth
34.5:5:38	N. Munn	Bricklayer	No growth	<u>Strep.viri-</u> <u>:dans</u>
35.12:5:38	J. Graham	Miner	Diphther- :oids	<u>Staph.albus</u>
36.16:5:38	J. Torbet	Miner	Diphther- :oids	Diphther- :oids
37.17:5:38	J. Watson	Miner	<u>Staph.albus</u> Diphther- :oids	<u>Staph.albus</u> Diphther- :oids <u>Strep.viri-</u> <u>:dans</u>

Table 49 (continued).

Date of Examination	Patient		Result of cultures from:	
	Name	Occupation	Edge of ulcer	Conjunctiva of affected side.
38.18:5:38	W.Cavanagh	Shale miner	Diphtheroids	Diphtheroids
39.14:5:38	H.McConnell	Repairer	No growth	<u>Staph.albus</u> Diphtheroids
40.21:5:38	W.Forbes	Miner	No growth	<u>Staph.albus</u>
41.14:6:38	A.Drummond	Brusher	Diphtheroids	Diphtheroids
42.15:6:38	G.Brunton	Stonemason's labourer.	<u>Staph.albus</u>	<u>Staph.albus</u>
43.10:7:38	H.Preston	Steel-dresser	<u>Staph.albus</u>	<u>Staph.albus</u>
44.14:7:38	J.Dryburgh	Brusher	<u>Staph.aureus</u>	<u>Staph.aureus</u>
45.29:7:38	G.Hay	Night warden	Diphtheroids <u>Staph.albus</u>	<u>Staph.albus</u> Diphtheroids. <u>Mic. catarrhalis</u>
46.2:8:38	R.McMeekin	Hewer	<u>Staph.albus</u>	No growth
47.1:8:38	T.Chalmers	Hewer	No growth	No growth
48.9:8:38	A.Henderson	Weaver	No growth	<u>Staph.albus</u>
49.11:8:38	W.Anderson	Brusher	Diphtheroids	<u>Staph.albus</u>
50.13:8:38	A.Stirling	Miner	Diphtheroids	Diphtheroids
51.13:8:38	W.Beveridge	Oncost worker	Type 29 Pneumococcus	Type 29 Pneumococcus

Table 49 (continued).

Date of Examination	Patient		Result of cultures from:	
	Name	Occupation	Edge of ulcer	Conjunctiva of affected side.
52.18:8:38	J.Bunyan	Miner	No growth	No growth
53.18:8:38	D.Dryllie	Brusher	No growth	<u>Staph.albus</u> <u>Anthracoïds</u>
54.22:8:38	J.Clark	Miner	Diphther- :oids	<u>Staph.albus</u>
55.26:8:38	P.Campbell	Miner	Diphther- :oids	<u>Staph.albus</u>
56.29:8:38	M.Duffy	Farmworker	Anthracoïds	No growth
57.3:9:38	J.Purdie	Shale miner	No growth	Diphther- :oids
58.13:9:38	J.Finnan	Road labour- :er	Diphther- :oids	<u>Staph.albus</u>
59.17:9:38	S.Aitken	Miner	No growth	No growth
60.25:9:38	M.McDonald	Stone quarryman	Diphther- :oids	Diphther- :oids
61.5:10:38	D.McFarlane	Machine man (wood-working)	<u>Staph.aureus</u>	<u>Staph.albus</u>
62.9:10:38	R.Beveridge	Oncost worker	<u>Staph.albus</u>	<u>Staph.albus</u> <u>Diphther- :oids</u>
63.13:10:38	A.Haig	Miner	Diphther- :oids	<u>Staph.albus</u> <u>Diphther- :oids</u>
64.13:10:38	G.Macintosh	Miner	No growth	<u>Staph.albus</u>
65.17:10:38	J.Weir	Miner	No growth	No growth

Table 49 (continued).

Date of Examination	Patient		Result of cultures from:	
	Name	Occupation	Edge of ulcer	Conjunctiva of affected side.
66.15:10:38	W.Whitehead	Mining engineer	<u>Staph.albus</u> Diphther- :oids	<u>Staph.albus</u>
67.15:10:38	G.Easton	Miner	Diphther- :oids	<u>Staph.albus</u>
68.18:10:38	W.McIntyre	Brusher	<u>Staph.albus</u>	<u>Staph.albus</u> Diphther- :oids
69.18:10:38	Mrs Easton	Housewife	No growth	Anthracoids
70.19:10:38	A.Kerr	Oncost worker	<u>Staph.albus</u>	<u>Staph.albus</u>
71.19:10:38	A.Welsh	Labourer	Diphther- :oids	Diphther- :oids
72.24:10:38	J.Reid	Shale miner	Diphther- :oids	Diphther- :oids
73.31:10:38	J.Westwood	Hewer	No growth	<u>Staph.albus</u>
74.31:10:38	W.Fraser	Miner	Diphther- :oids	No growth
75.7:11:38	Mrs Macdonald	House- :wife	Diphther- :oids	Diphther- :oids
76.4:11:38	J.Carrigan	Brusher	Anthracoids	No growth
77.11:11:38	J.Reidy	Miner	No growth	Diphther- :oids
78.12:11:38	W.Wilson	Miner	No growth	<u>Staph.albus</u>
79.17:11:38	S.Finlay	Brusher	<u>Staph.albus</u> Diphther- :oids	Diphther- :oids

Table 49 (continued).

Date of Examination	Patient		Result of cultures from:	
	Name	Occupation	Edge of ulcer	Conjunctiva of affected side.
80.19:11:38	M.Petrie	Miner	<u>Staph.albus</u> Diphther- :oids	No growth
81.29:11:38	A.Walker	Shale miner	Diphther- :oids	Diphther- :oids
82.5:12:38	E.Masson	Quarryman	<u>Staph.albus</u>	<u>Staph.albus</u>
83.4:12:38	R.Mackie	Foundry work- :er	<u>Staph.albus</u>	No growth
84.6:12:38	J.Lamont	Mine surface worker	Pneumococcus	Pneumococcus
85.12:12:38	A.Mackie	Night watch- :man	Diphther- :oids	<u>Staph.albus</u> Diphther- :oids
86.12:12:38	J.Wilkie	Miner	<u>Staph.albus</u>	No growth
87.12:12:38	J.Smith	Miner	No growth	Diphther- :oids
88.10:12:38	D.Gallacher	Labourer	Diphther- :oids	<u>Staph.albus</u>
89.10:12:38	J.Robertson	Miner	<u>Staph.albus</u>	Diphther- :oids
90.14:12:38	A.Lauder	Printer	<u>Staph.albus</u>	Diphther- :oids
91.13:12:38	J.Forgie	Miner	No growth	<u>Staph.albus</u>
92.19:12:38	T.Gregory	At home	<u>Staph.albus</u> Diphther- :oids	Diphther- :oids
93.19:12:38	D.McGoldrich	Oncost worker	Diphther- :oids	No growth

Table 49 (continued).

Date of Examination	Patient		Result of Cultures from:	
	Name	Occupation	Edge of ulcer	Conjunctiva of affected side.
94.6:1:39	J.Russell-Hall	Labourer	Anthracoïds	No growth
95.9:1:39	J.Frame	Miner	Diphtheroïds	<u>Staph.albus</u>
96.10:1:39	G.Bird	Roadman	Pneumococcus	Pneumococcus
97.12:1:39	D.Miller	Cattleman	<u>Staph.albus</u>	Diphtheroïds
98.17:1:39	J.Lessels	Mine surface worker	Diphtheroïds	Diphtheroïds
99.23:1:39	J.Wilson	Repairer	Diphtheroïds	Diphtheroïds
100.24:1:29	J.McDonald	Miner	Diphtheroïds	Diphtheroïds
101.1:2:39	G.King	Miner	Diplobacillus of Morax	Diplobacillus of Morax
102.3:2:39	R.Borrowman	Quarry worker	<u>Staph.albus</u>	No growth
103.6:2:39	W.Falconer	Miner	<u>Staph.albus</u>	Diphtheroïds
104.10:2:39	W.Martin	Iron foundry worker	<u>Staph.albus</u>	<u>Staph.albus</u>
105.8:2:39	J.Logie	Oncost worker	Anthracoïds	<u>Staph.albus</u> Diphtheroïds
106.17:2:39	M.Murphy	Railway shunter	<u>Staph.albus</u>	<u>Staph.albus</u>

107./

Table 49 (continued).

	Date of Examination	Patient		Result of Cultures from:	
		Name	Occupation	Edge of ulcer	Conjunctiva of affected side
107	20:2:39	G.Peters	Miner	No growth	<u>Staph.albus</u>
108	1:3:39	H.Fisher	Brusher	<u>Staph.albus</u> Diphther- :oids	<u>Staph.albus</u> Diphther- :oids
109	13:3:39	R.Russell	Paper mill worker	No growth	<u>Staph.albus</u>
110	20:3:39	J.McEwan	Miner	Diphther- :oids	Diphther- :oids
111	19:3:39	J.Wright	Miner	No growth	No growth
112	15:5:39	A.White	Oncost worker	<u>Staph.</u> albus	Diphther- :oids
113	21:3:39	T.Gray	At home	No growth	<u>Staph.albus</u>
114	21:3:39	J.Small	Brusher	No growth	No growth
115	27:3:39	H.Cargill	Oncost worker	No growth	No growth
116	2:4:39	W.Lennie	Oncost worker	<u>Strep.</u> viridans	<u>Strep.</u> viridans
117	6:4:39	C.Hogg	Mason	<u>Staph.</u> aureus	Diphther- :oids
118	12:4:39	J.Hannen	Hewer	Diphther- :oids	<u>Staph.albus</u> Diphtheroids
119	12:4:39	N.Purves	Farm labourer	No growth	<u>Staph.albus</u>
120	16:4:39	J.McAuley	Oncost worker	No growth	<u>Staph.albus</u>

121/

Table 49 (continued).

Date of Examination	Patient		Result of Cultures from	
	Name	Occupation	Edge of ulcer	Conjunctiva of affected side
121 21:4:39	D.Ferris	Brusher	<u>Staph.albus</u>	<u>Staph.albus</u>
122 8:5:39	J.Pollock	Hewer	Diphther- :oids	Diphther- :oids <u>Staph.albus</u>
123 14:5:39	T.Roe	Rubber worker	No growth	No growth
124 15:5:39	Mrs Douglas	Housewife	Type 3 Pneumococc- :us	<u>Staph.albus</u>
125 19:5:39	D.Sneddon	Brusher	No growth	No growth
126 22:5:39	J.Knox	Miner	Diphther- :oids	No growth
127 24:5:39	J.Clark	At home	<u>Staph.albus</u>	<u>Staph.albus</u> Diphther- :oids
128 31:5:39	D.Aitken	Pithead work- :er	Type 3 Pneumococc- :us	Diphther- :oids <u>Staph.albus</u>
129 2:6:39	F.O'Brien	Labourer	Type 3 Pneumococc- :us	Type 3 Pneumococc- :us <u>Staph.albus</u>
130 5:6:39	D.McCulloch	Hewer	<u>Strep.</u> viridans	<u>Strep.</u> viridans
131 12:6:39	W.Brennan	Miner	Diphther- :oids	<u>Staph.albus</u>
132 13:6:39	T.Cannon	Brusher	No growth	No growth

Table 49 (continued).

Date of Examin- ation	Patient		Result of Cultures from:	
	Name	Occupation	Edge of ulcer	Conjunctiva of affected side
133 16:6:39	W.Quigley	Miner	<u>Staph.albus</u>	No growth
134 20:6:39	P.Main	Miner	No growth	No growth
135 24:6:39	H.Cairns	Quarryman	No growth	Diphther- :oids
136 27:6:39	J.Pearson	Brusher	<u>Staph.albus</u>	Diphther- :oids
137 3:7:39	P.Collins	Miner	No growth	<u>Staph.albus</u>
138 8:8:39	J.Quinn	Miner	No growth	No growth
139 11:7:39	R.Colquhoun	Brusher	<u>Staph.albus</u>	<u>Staph.albus</u>
140 11:7:39	T.Spowart	Kiln-burner	<u>Staph.albus</u>	No growth
141 31:7:39	G.Stein	Miner	Diphther- :oids	<u>Staph.albus</u>
142 31:7:39	H.Lennox	Compositor	Diphther- :oids	No growth
143 8:8:39	A. Miller	Labourer	Pneumo- :coccus	Diphther- :oids
144 8:8:39	J.Brown	Shale miner	No growth	Diphther- :oids
145 8:8:39	J.McLean	Miner	Pneumo- :coccus Diphther- :oids	Diphther- :oids
146 11:8:39	J.Selkirk	Miner	<u>Staph.albus</u>	Diphther- :oids

Table 49 (continued).

Date of Examination	Patient		Result of Cultures from:	
	Name	Occupation	Edge of ulcer	Conjunctiva of affected side
147 11:8:39	W.Beveridge	Oncost worker	Pneumo-coccus	<u>Staph.albus</u>
148 18:8:39	J.Bostock	Brusher	No growth	No growth
149 21:8:39	J.Davidson	Schoolboy	Diphtheroids	<u>Staph.albus</u> Diphtheroids
150 21:8:39	T.Welsh	Carter	No growth	No growth
151 25:8:39	J.Waddell	Miner	Anthracooids	<u>Staph.albus</u> <u>M.catarrhalis</u>
152 9:9:39	R.Hewitson	Miner	Diphtheroids	<u>Staph.albus</u>
153 10:9:39	J.Penman	Miner	Diphtheroids	<u>Staph.albus</u> Diphtheroids
154 18:9:39	D.Sneddon	Miner	No growth	Diphtheroids <u>Staph.albus</u>
155 3:10:39	J.Punton	Limestone breaker	Diphtheroids	Diphtheroids
156 3:10:39	P.Wallace	Miner	Pneumo-coccus	Pneumo-coccus
157 9:10:39	C.Wright	Iron dresser	<u>Staph.albus</u>	<u>Staph.albus</u> Diphtheroids
158 10:10:39	F.Greig	Oncost worker	No growth	No growth
159 10:10:39	J.Brown	Oncost worker	Pneumo-coccus	Pneumo-coccus

160/

Table 49 (continued).

Date of Examination	Patient		Result of Cultures from:	
	Name	Occupation	Edge of ulcer	Conjunctiva of affected side
160 12:10:39	Mrs Govan	Housewife	Diphtheroids	<u>Staph.albus</u> Diphtheroids
161 12:10:39	A.Fotheringham	Miner	<u>Staph.albus</u> Diphtheroids	No growth
162 18:10:39	A.Robertson	Brusher	Diphtheroids	Diphtheroids
163 18:10:39	T.Lumsden	Steel grinder	<u>Staph.albus</u> Diphtheroids	No growth
164 19:10:39	J.Currie	Railwayman	<u>Strep.</u> viridans	No growth
165 24:10:39	J.Walton	Oncost worker	No growth	Diphtheroids
166 26:10:39	W.Stein	Shale miner	No growth	No growth
167 27:10:39	P.Reid	Shale miner	<u>Strep.</u> viridans	Anthracoïds
168 30:10:39	R.Yardey	Oncost worker	No growth	No growth
169 30:10:39	Mrs Lambert	Farmworker	No growth	No growth
170 1:11:39	J.McKeon	Oncost worker	Type 13 Pneumo- coccus	Type 13 Pneumo- coccus
171 4:11:39	J.Bryce	Miner	<u>Staph.albus</u> Diphtheroids	Diphtheroids
172 4:11:39	T.Clelland	Blacksmith	No growth	No growth

Table 49 (continued).

Date of Examination	Patient		Result of Cultures from:	
	Name	Occupation	Edge of ulcer	Conjunctiva of affected side
17328:11:39	J. Smith	Miner	Diphtheroids	Type II Pneumococcus
174 5:12:39	J. Bain	Miner	Diplobacillus of Morax	No growth
175 13:12:39	J. Hunter	Miner	<u>Staph. albus</u>	Diphtheroids
176 23:12:39	G. Carswell	Miner	Diphtheroids	Diphtheroids
177 22:12:39	G. Lindsay	Oncost worker	Diphtheroids	Diphtheroids
178 28:12:39	R. Purdie	Miner	No growth	Diphtheroids
179 29:12:39	Mrs Heriot	Housewife	Diphtheroids	Diphtheroids
180 3:1:30	A. Anderson	Miner	Type 6 Pneumococcus	Pneumococcus
181 9:1:40	J. McMurdo	Roadman	Diphtheroids	Diphtheroids
182 9:1:40	T. Gray	Miner	Diphtheroids	Diphtheroids
183 19:2:40	D. Gregory	Engineer	<u>Staph. albus</u>	<u>Staph. albus</u>
184 22:2:40	J. Lacey	Shale miner	<u>Strep. viridans</u>	<u>Strep. viridans</u>
185 23:2:40	J. Flannigan	Cement worker	Diphtheroids	Diphtheroids

186/

Table 49 (continued).

Date of Examination	Patient		Result of Cultures from:	
	Name	Occupation	Edge of ulcer	Conjunctiva of affected side
186 26:2:40	J.McPhee	Fitter	No growth	No growth
187 8:3:40	J.Cowan	Miner	No growth	No growth
188 19:3:40	Mrs Burnie	Housewife	Diphther- :oids	Diphther- :oids
189 26:3:40	R.Arthur	Miner	Pneumo- :coccus	Pneumo- :coccus
190 29:3:40	J.Ballantyne	Miner	Diphther- :oids	No growth
191 29:3:40	W.Trail	Miner	No growth	No growth
192 5:4:40	E.Gullan	Miner	Diphther- :oids Staph.albus	<u>Staph.albus</u>
193 8:4:40	J.Wilson	Miner	No growth	No growth
194 11:4:40	J.Struthers	Farmer	Type 6 Pneumo- :coccus	Type 6 Pneumo- :coc cus
195 11:4:40	A.Cowan	Hewer	No growth	No growth
196 15:4:40	Mrs Douglas	Housewife	No growth	No growth
197 15:4:40	T.Ballantyne	Miner	Diphther- :oids Staph.albus	No growth
198 17:4:40	A.Cherry	Miner	No growth	No growth
199 24:4:40	Fleming	Miner	Type 4 Pneumo- :coccus	Type 4 Pneumo- :coccus
200 8:5:40	A.Harrower	Miner	Diphther- :oids	Diphther- :oids

201/

Table 49 (continued).

	Date of Examination	Patient		Result of Cultures from:	
		Name	Occupation	Edge of ulcer	Conjunctiva of affected side
201	10:5:40	W.Sneddon	Miner	Diphtheroids	No growth
202	1:6:40	Mrs Fergus	Housewife	No growth	No growth
203	3:6:40	W.McIntyre	Brusher	No growth	No growth
204	3:6:40	J.Henderson	Boiler fireman	No growth	No growth
205	14:6:40	J.Clark	Miner	<u>Staph.albus</u>	No growth
206	18:6:40	J.Crawford	Brusher	No growth	No growth
207	27:6:40	J.Hamilton	Hewer	No growth	<u>Staph.aureus</u> <u>M..catarrhalis</u>
208	18:7:40	D.Doig	Hewer	Diphtheroids	Diphtheroids
209	19:7:40	D.Rodger	Engineer	Diphtheroids	Diphtheroids
210	21:7:40	J.McKenna	Cement worker	<u>Staph.albus</u>	<u>Staph.albus</u>
211	29:7:40	W.Moore	Cooper	No growth	Diphtheroids
212	31:7:40	A.Moyes	Hewer	Diphtheroids	Diphtheroids
213	12:8:40	J.Kane	Miner	No growth	<u>Staph.albus</u>
214	14:8:40	Mrs McGee	Housewife	Diphtheroids	Diphtheroids

215/

Table 49 (continued).

	Date of Examination	Patient		Result of Cultures from:	
		Name	Occupation	Edge of ulcer	Conjunctiva of affected side
215	21:8:40	E.Wood	Firewood factory worker	<u>Staph. aureus</u>	<u>Staph. aureus</u>
216	23:8:40	W.Scott	Miner	<u>Diphtheroids</u>	<u>Diphtheroids</u>
217	29:8:40	J.Logan	Farm worker	<u>Diphtheroids</u>	<u>Diphtheroids</u>
218	9:9:40	A.Low	Miner	<u>Strep. viridans</u> <u>Staph.albus</u>	<u>Diphtheroids</u> <u>Strep. viridans</u> <u>Staph.albus</u>
219	9:9:40	D.Robertson	Ploughman	<u>Staph.albus</u>	<u>Staph.albus</u>
220	25:9:40	R.Veitch	Mine surface worker	<u>Staph.albus</u>	<u>Strep. viridans</u> <u>Diphtheroids</u>
221	27:9:40	T.Innes	Hewer	No growth	No growth

(4) INCIDENCE OF VARIOUS BACTERIAL GROWTHS IN THE  
ABOVE CASES.

The various types of growth which were obtained in these 221 cases, from the edge of the ulcer, are indicated in Table 50, from which it will be seen that a wide variety of organisms are associated with corneal ulcer.

TABLE/

T A B L E 50.

Percentage Incidence of Various Conjunctival Bacteria  
in 221 Cases of Hypopyon Ulcer.

Type of growth from edge of ulcer	Percentage of Total
<u>Staphylococcus albus</u> only	14.0
<u>Staphylococcus albus</u> and diphtheroid bacilli together	5.9
Diphtheroid bacilli only	29.4
Pneumococcus only	11.3 )
Pneumococcus and diphtheroid bacilli together	0.9 )
	12.2
<u>Streptococcus viridans</u> only	3.2 )
<u>Streptococcus viridans</u> and <u>Staphylococcus albus</u> together	0.5 )
	3.7
Anthracid bacilli only	2.3 )
Anthracid bacilli and <u>Staphylococcus albus</u> together	0.5 )
	2.8
Diplobacillus of Morax only	2.3
<u>Staphylococcus aureus</u> only	2.3
<u>Streptococcus haemolyticus</u> and <u>Staphylococcus albus</u> together	0.5
No growth obtained on culture	27.2

(5) OCCUPATIONAL INCIDENCE.

The 221 cases of hypopyon ulcer were distributed over the various types of worker as follows:

T A B L E 51.

Coal miners .....	87	Shale miners .....	8
Coal brushers .....	26		
Coal oncost workers .	17		
Coal repairer.....	1		
Coal surface workers	<u>5</u>		
Total coal workers..	136	Total shale workers	8
Total coal and shale workers .....	144		
Total other classes of person .....	<u>77</u>		
	<u>221</u> :		

from which it will be seen first, that the majority of cases were in mine workers, and, second, that the bulk of the cases in mine workers occurred in miners and brushers.

(6)/

(6) Results in mine workers compared with those in non-  
mine workers.

In Table 52, the percentage occurrence of the various bacteria in cases of hypopyon ulcer in coal and shale workers is compared with the incidence in other persons.

TABLE/

T A B L E 52.

Percentage  
Incidence of Various Organisms in Cases of Hypopyon  
Ulcer in Mine Workers as Compared to Other Persons.

Type of growth	Mine workers	Other persons
<u>Staphylococcus albus</u> only	10.1	20.8
<u>Staphylococcus albus</u> and diphtheroid bacilli together	6.5	4.9
Diphtheroid bacilli only	31.6	25.6
Pneumococcus only	11.5	11
Pneumococcus and diphtheroid bacilli together	0.7	1.2
<u>Streptococcus viridans</u> only	4.3	1.2
<u>Streptococcus viridans</u> and <u>Staphylo-</u> <u>coccus albus</u> together	0.7	-
Anthracid bacilli only	2.2	2.4
Anthracid bacilli and <u>Staphylococ-</u> <u>coccus albus</u> together	-	1.2
Diplobacillus of Morax only	2.9	1.2
<u>Staphylococcus aureus</u> only	1.4	3.7
<u>Streptococcus haemolyticus</u> and <u>Staphylococcus albus</u> together	0.7	-
No growth obtained on culture	30.9	20.8

From Tables 51 and 52 it will be seen that there was little significant difference between the incidence of the various types of conjunctival bacteria in mine and non-mine workers, the same types of organism being found in both groups.

(7) BIOLOGICAL CHARACTERS OF THE ORGANISMS ISOLATED.

Staphylococcus albus and diphtheroid bacilli.

The staphylococci of the "albus" type presented no unusual features and no special comment is necessary, Diphtheroid bacilli were all of the usual "Xerosis" type normally found in the conjunctival sac.

Streptococcus haemolyticus.

One strain of this organism only was isolated, and was found to belong to Lancefield's Group C.

Streptococcus viridans.

Seven strains of this organism were isolated. They were all insoluble in bile, and failed to ferment inulin. These strains resembled closely in morphology and colonial characters those described above as occurring in the conjunctival sacs of healthy coal and shale mine workers.

Pneumococcus/

Pneumococcus.

Some twenty-seven strains of this organism were encountered and their properties are shown in Table 53. With regard to the typing of pneumococci, at the outset of the investigation it was only possible to type Types 1, 2, and 3, the remainder being classified as Group 4. Later, however, mono-specific sera to all types were available and accurate typing of Group 4 strains became possible.

TABLE/

T A B L E 53.

Biological Properties of Pneumococcus Isolated  
from Cases of Hypopyon Ulcer.

Serial No. of strain	Bile solubility	Inulin fermentation	Reaction of injection in peritoneal cavity of mouse	
1	124	Not tested	+	Type 3 pneumococcus
2	128	±	+	Type 3 pneumococcus
3	129	±	+	Type 3 pneumococcus
4	1	+	+	Group 4 pneumococcus
5	6	+	+	Group 4 pneumococcus
6	8	+	+	Group 4 pneumococcus
7	11	+	-	Group 4 pneumococcus
8	19	+	+	Group 4 pneumococcus
9	24	+	+	Group 4 pneumococcus
10	30	+	+	Type 28 pneumococcus
11	31	±	+	Type 29 pneumococcus
12	51	+	+	Type 29 pneumococcus
13	170	Not tested	Not tested	Type 13 from culture only
14	180	Not tested	Not tested	Type 6 pneumococcus
15	194	+	+	Type 6 pneumococcus
16	199	Not tested	Not tested	Type 4 pneumococcus
17	96	+	+	No pneumococci seen
18/				

Table 53 (continued).

Serial No. of strain	Bile solubility	Inulin fermentation	Reaction of injection in peritoneal cavity of mouse
18 189	+	+	No pneumococci seen
19 13	+	-	No pneumococci seen
20 14	+	-	No pneumococci seen
21 15	+	-	No pneumococci seen
22 84	-	+	No pneumococci seen
23 143	Not tested	+	No pneumococci seen
24 145	Not tested	+	No pneumococci seen
25 147	Not tested	+	No pneumococci seen
26 156	Not tested	+	No pneumococci seen
27 159	Not tested	+	No pneumococci seen

It will be seen from Table 53 that only three pneumococci of types other than Group 4 were isolated, and that these all belonged to Type 3. Thirteen strains belonged to Group 4, and when sera were available typing of seven such strains showed two to belong to Type 29, two to Type 6, and one each to Types 4, 13, and 28. The remaining eleven strains proved avirulent to mice and thus could not be typed. This predominance of Group 4 strains has previously been recorded by numerous workers, and this has been referred to above (see page 168 ). The various Group 4 strains all belonged to types which have been commonly encountered in Edinburgh in cases of respiratory infection during the past few years (Rhodes, personal observations).

It is interesting to compare this table (53) with Table 26 and Table 43 on pages 95 and 150 where the characters of the pneumococci isolated from the normal conjunctival sacs are detailed. It will be remembered that the only non-Group 4 pneumococci present in the normal eyes of coal miners belonged to Type 3, and these were the only non-Group 4 pneumococci isolated from cases of hypopyon ulcer. All the/

the special varieties of pneumococci shown in Tables 26 and 43 as occurring in the normal mine worker's eye were also found in cases of hypopyon. Thus, it was not only those strains which were virulent to mice that were associated with hypopyon, but also those which were avirulent on intraperitoneal inoculation.

The Diplobacillus of Morax.

Five typical strains of this organism were isolated. None of these grew on agar at 37° C.

Staphylococcus aureus.

Five strains of this organism were encountered and were distinguished from chromogenic staphylococci by the fact that gelatin was liquefied, mannite fermented and haemolysis produced on blood plates. It will be recalled that no genuine Staphylococcus aureus strains were isolated from the conjunctival sacs of normal coal or shale mine workers. The reactions of these five strains of Staphylococcus aureus follow in Table 54.

TABLE/

T A B L E 54.

Properties of Strains of Staphylococcus aureus  
Isolated from Cases of Hypopyon Ulcer.

Name	Gelatin liquefied	Mannite fermented	Haemolysis produced
1. R.McKinley	+	+	No
2. J.Drysburgh	No details available.		
3. McFarlane	+	+	Yes
4. Hogg	No details available.		
5. E. Wood	+	+	Yes

Anthracoïd bacilli.

Spore-bearing, gram-positive, aerobes of the "subtilis" type were isolated from three cases. These organisms resembled in their morphology and cultural characters the anthracoid bacilli found in normal coal and shale workers.

No growth on culture.

A feature of the investigation was the fact that no organisms were isolated from the edge of the corneal ulcer in 27.2 per cent. of persons, and this requires some discussion. In the first place, it is possible that I may have failed to obtain growths of some organisms which were actually present, either because I did not pass the spud or wire deeply enough under the edge of the ulcer, or because I may have inadvertently selected a part of the ulcer which was not the most active area. It must, I feel, be frankly admitted that this explanation accounts for certain of these cases. After all, one who is not an ophthalmologist and who does not have hypopyon ulcer cases under his care cannot be expected to take material from under the edge of the ulcer too vigorously, the danger of perforation of the thinned and inflamed cornea/

cornea seeming considerable. But, if this is the whole explanation, one fact remains to be answered. In the great majority of the 221 cases described above the particular organism which was isolated from the edge of the ulcer could also be found in the conjunctival sac of the affected eye; therefore, if no growth was obtained from the edge of the ulcer due to the employment of an insufficiently vigorous technique, these cases should nevertheless have yielded cultures from the conjunctival sac of the affected eye. However, in no less than 31 of the 60 cases, where no growth was obtained from the edge of the ulcer, no growth was likewise obtained from the conjunctival sac. In 29 of the cases where no growth was obtained from the ulcer, organisms were actually found in the conjunctival sac of the affected eye. If it be agreed, therefore, that in 29 out of 221 cases a more vigorous use of the spud might have produced material which would have yielded a growth on culture, there still remains a residue of 31 cases, or 14 per cent., where no growth was obtained from either ulcer or conjunctival sac of the affected eye.

I must definitely claim, therefore, that in approximately/

approximately 14 per cent. of cases of hypopyon ulcer no organisms can be demonstrated either in the ulcer or the conjunctival sac of the affected eye, by the technique adopted.

(8) DISCUSSION AND SUMMARY.

The most striking features of this investigation were the comparatively low incidence of pneumococci as compared with the findings of other workers, the absence of obvious cultivable organisms in about a quarter of the cases, and generally the wide variety of organisms which appeared to be associated with corneal ulcer of hypopyon type.

First, with regard to pneumococci, it is possible that my series included milder cases than featured in other workers' series, and that pneumococci may be more frequently isolated from severer cases. My cases were all of "hypopyon type" although many of them showed no hypopyon at the time of examination, and were treated before it had time to develop. It is probable that in the majority of cases described in the literature as yielding growths of pneumococci, hypopyon had already developed. I, of course, was unfortunately/

unfortunately not in a position to correlate the clinical features and severity of the cases with the bacteriological findings. Another possible factor to be considered is that my series of cases (221) is very much larger than any others reported in the literature. Many authors reported on only 20-30 cases; Schmelzer (1935) had the next largest number of cases (114).

It is possible, therefore, that both the factors just mentioned may be partly responsible for the lower incidence of pneumococci in my series. I do not, however, believe that either of these factors is of great importance, and wish definitely to postulate that, at any rate in the South-Eastern area of Scotland, the pneumococcus is only one of numerous causal agents of corneal ulcer of hypopyon type.

It is of interest in this connection to record that MacCallan (1927) gave details of some 3,693 cases of corneal ulcer seen in Egyptian Eye Hospitals in 1921. In 369 of these cases hypopyon was present. Smears were examined microscopically and in only 143 were pneumococci found. He concluded, therefore, that in Egypt the pneumococcus was only one of many causes/

causes of corneal ulcer.

With regard to the serological types of pneumococci isolated my results are in complete agreement with those of other workers. This question has been fully discussed above (page 168), but here it may be said that the pneumococci found in cases of corneal ulcer had characters similar to those found in the normal conjunctival flora of coal and shale mine workers.

Considering the reason for my failure to cultivate any organisms from the edge of the corneal ulcer in about one quarter of the cases, I have mentioned above that technical reasons, viz., the difficulty in some cases of actually reaching the organisms, may have accounted for bacteria not being cultivated in about 13 per cent. of cases. Nevertheless, there remains a nucleus of 14 per cent. of cases where no growth was obtained either from the ulcer or from the conjunctival sac of the affected eye.

I therefore definitely hold the opinion that in some cases of corneal ulcer of hypopyon type, it is not possible to isolate bacteria from the edge of the ulcer, nor in many of these cases can organisms be found/

found in the conjunctival sac.

There may be various reasons to account for this. Perhaps the organisms are deeply situated in the corneal tissue and cannot be reached (see Nugent, 1932). But even so one would expect bacteria to be cultivable from the conjunctival sac.

Secondly, it is possible that a filterable virus, possibly the herpes virus, may be concerned in these cases. The herpes febrilis virus is thought to occur in the conjunctival sac in an inactive condition, as herpetic keratitis may follow corneal injury (Grüter, 1924; Busacca, 1925). The virus may also cause a severe conjunctivitis (Granström, 1937). In rabbits, of course, the herpes virus produces a very severe keratitis (see van Rooyen and Rhodes, 1940, for a general review of its properties). However, herpetic keratitis in man is a very well recognised entity, and cannot be mistaken for the type of ulcer which I examined. It is, of course, conceivable that the herpes virus may cause a few cases of ulcer of hypopyon type, but it is considered unlikely that any were included in my series. It was particularly wished to investigate this possibility but it did not prove/

prove practicable, as by the time one could state definitely that no growth was obtained on culture, the patient had received vigorous antiseptic treatment. With regard to the possibility of the presence of a virus at present unknown, this is pure speculation, and serves little useful purpose.

Then, there is one more factor to mention when discussing this question of why no growth was obtained from the edge of the ulcer in certain cases. I have considered whether the traumatising particle, e.g., of coal, stone, or steel, may in certain instances not have acted as an irritant. It is not possible to obtain definite evidence on this point, and many ophthalmologists definitely hold all corneal ulcers to have the features of an infective condition. Duke-Elder (1938), however, believes that in some cases of hypopyon ulcer the irritant nature of the traumatic agent may have more effect than the infective element, and quotes the opinion of Stevenson (1927) that scales from steam boilers have this irritant action. I feel that an open mind should be kept upon this question, and more evidence sought as to whether or not "aseptic" corneal ulcers may be produced by irritant substances per/

per se, without the presence of bacteria.

My findings in 221 cases show, therefore, that in the South-Eastern area of Scotland corneal ulcer of hypopyon type in mine workers and other persons can apparently be caused by a variety of organisms. Thus, pneumococci (mainly Group 4), Streptococcus haemolyticus, Streptococcus viridans, Staphylococcus albus, Staphylococcus aureus, the Diplobacillus of Morax, anthracoid bacilli, and diphtheroid bacilli have all been isolated. Further, in some cases no cultivable bacteria could be found.

SECTION G.MY WORK ON THE AETIOLOGY OF CORNEAL ULCER  
OF HYPOPYON TYPE, ESPECIALLY IN MINE WORKERS:CONCLUSIONS.

The almost invariable history in cases of corneal ulcer of hypopyon type is that the patient has been struck in the eye by a piece of coal, stone, or steel, or by twigs, or pieces of corn, or by thorns. Then after a few days, the corneal ulcer develops. Obviously, as has been recognised for a considerable time (see, e.g. Abadie, 1895), there are two possible sources of this corneal infection, exogenous from the traumatising particle, or endogenous from the conjunctival sac of the infected eye.

First, with regard to the rôle of the traumatising particle, I have made some personal observations by making cultures from unhewn coal and shale, and from coal or shale lying in trucks near the pit bottom. The former cultures were made from virtually untouched "virgin" coal or shale, while the latter cultures were made from material which had been handled freely, and probably breathed upon, by many workers/

workers on its way back from the face.

I descended three mines personally in order to make the necessary cultures, the method being to soak a throat swab in sterile broth and rub it hard over the surface of the coal or shale and then return it to the broth. After incubation aerobically at 37°C., the broth was plated out on suitable media and colonies investigated. The results at Arniston follow in Table 55, at Duddingston in Table 56, and at Westwood in Table 57.

TABLE/

T A B L E 55.Cultural Examination of Arniston Coal.A. Two cultures made at coal-face.

One completely sterile, the other showing only a very scanty growth of Staphylococcus albus.

B. Two cultures made from hutch-coal, after handling.

Both showed profuse growths of Staphylococcus albus and coliform bacilli, and one showed a growth of Streptococcus viridans as well.

T A B L E 56.Cultural Examination of Shale, Duddingston.A. Three cultures made at site of hewing shale.

- (1) Completely sterile.
- (2) Scanty growth of Staphylococcus  
albus.
- (3) Moderate growth of Staphylococcus  
albus.

B. Three cultures made of handled shale in  
hutches.

All showed most luxurious growths of coliform organisms, staphylococci, and anthracoid bacilli.

T A B L E 57.Cultural Examination of Shale, Westwood.

- A. Shale in stooping (unhewn).
- (1) Growth of Staphylococcus albus.
  - (2) Sterile.
  - (3) Sterile.
- B. Handled shale in hutches.
- (4) Profuse growth of anthracoid and coliform bacilli.
  - (5) Profuse growth of anthracoid and coliform bacilli.
  - (6) Profuse growth of Staphylococcus albus and coliform bacilli.

From the above three tables it will be seen that untouched coal or shale was usually sterile, and if a growth was obtained it was only a scanty one of Staphylococcus albus. The examination of handled coal or shale showed, on the other hand, a very different state of affairs. In this case, profuse growths of coliform bacilli, anthracoids, and staphylococci were obtained, while in one instance, Streptococcus viridans was also isolated.

My work in this connection therefore suggests that if a mine worker is injured by a piece of fresh coal or shale which strikes his cornea after being dislodged from the coal or shale face, he is most unlikely to contract infection of the cornea from the traumatising particle itself, as this is almost certainly sterile. If a corneal ulcer does develop in such a person, the source of infection must be endogenous from the conjunctival sac of the traumatised eye.

If, however, a man such as an oncost or surface worker is struck in the eye by coal or shale, it is possible that the infecting organisms may enter deeply into the traumatised cornea on the piece of coal or shale/

shale. On the other hand, in these persons also the traumatising particle may merely serve to allow the entry of an organism already present in the conjunctiva.

No actual observations were made on the bacteriology of stone such as that chipped by the brushers. On general grounds, however, one would have expected this to be sterile, as was virgin coal. Accordingly, one can include miners and brushers together as workers in whom the source of infection in corneal ulcer is most usually endogenous.

Authorities on diseases of the eye (e.g. Wolff, 1934) state that the infection in corneal ulcer may be endogenous or exogenous, but in the case of mine workers this statement requires qualifying in keeping with the remarks made above.

Secondly, with regard to the rôle of endogenous infection in the aetiology of corneal ulcer, it has been, I think, clearly brought out in my work, described earlier in this thesis, that coal and shale mine workers harbour an unduly abundant conjunctival flora. Apart from the usual staphylococci and diphtheroid bacilli, such organisms as pneumococci, streptococci/

streptococci, the Diplobacillus of Morax, B.Koch-Weeks, anthracoid and coliform bacilli were all isolated with regularity. Practically every type of bacterium isolated from my cases of hypopyon ulcer had also been isolated from the conjunctiva of normal mine workers.

I have suggested that there are two types of conjunctival flora in mine workers. First, the ordinary Staphylococcus albus and diphtheroid bacilli which are virtually always present, and second, such pathogenic organisms as pneumococci, Streptococcus viridans, and the Diplobacillus of Morax which are only carried for a short time. I would suggest, therefore, that if a mine worker is struck in the eye by a piece of sterile coal or shale no infection will as a rule develop unless his eye harbours pneumococci, or other pathogenic organisms. Of course, any infective condition such as dacryocystitis (see Cramer, 1915), or conjunctivitis would greatly increase the worker's risk of developing infection after receipt of an injury to the cornea. It is of interest, however, here to mention that in Paterson's (1931) series of 223 cases of hypopyon ulcer referred to above in only 24 was there evidence of involvement of the tear sac. In certain cases, undoubtedly, the usually harmless diphtheroid bacilli and Staphylococcus albus can apparently act as the aetiological agents of infection after/

after corneal trauma. It is possible in these cases that there is some special lowering of the resistance of the corneal tissue to infection due to general ill-health (see Peter, 1932; Duke-Elder, 1938).

In short, in the aetiology of any particular case of corneal ulcer there are four variable factors concerned. First, the traumatising particle may be sterile or may be infected. Second, the worker's conjunctival flora may contain harmless organisms only, or it may contain pathogens. There is also the third rather speculative variable of the resistance of the corneal tissue to invasion by bacteria, and, fourth, the question raised above of whether the traumatising particle itself may not exert a harmful effect on the corneal tissues.

Having discussed the aetiology of corneal ulcer of hypopyon type in mine workers as a whole, it is of interest now to turn to its incidence in the various individual groups of mine workers (see page 200 ). From these figures it is evident that miners and brushers constitute by far the greater proportion of cases of hypopyon ulcer, oncost and surface workers only contributing a few cases. The explanation for this/

this marked occupational incidence in miners and brushers cannot be related to differences in the conjunctival flora, for this has been shown to be very similar in all groups of mine worker. It is simply dependent on the fact that miners and brushers are constantly hewing and chipping, and thus receiving corneal injuries, while oncost and surface workers, although their conjunctival flora is as profuse as that of miners and brushers, are seldom exposed to the risk of corneal injury and consequently only rarely develop corneal ulcers.

No mention has yet been made of the mechanism of production of corneal infection in persons other than mine workers, but it is not, I think, unreasonable to suggest that the same principles hold. Thus, certain traumatising agents will by their nature be sterile (e.g., hot sparks, cinders, chemicals) and others will be infected (e.g., household coal). Next, pathogenic organisms are presumably distributed in the conjunctival flora of the general population, although to a very much lesser extent than in coal workers. Therefore, the same variable factors, namely, the infectivity or otherwise of the traumatising particle and the/

the state of the person's conjunctival flora, obtain and determine the final outcome.

In conclusion, this study has shown, I suggest, that the conjunctival flora of healthy mine workers is such as definitely to predispose them to infection following corneal injury. Having due regard, therefore, to the economic importance of hypopyon ulcer, as indicated in the Preface, my work may be said to furnish a scientific basis for the prosecution of a campaign amongst mine workers to lower the incidence of corneal ulcer by insisting, first, on the use of prophylactic measures to minimise the risk of corneal trauma especially in miners and brushers, and, secondly, on the prompt and expert treatment of all cases of established corneal injury, however trivial, in the mines.

*Very important & has since been put to practical proof with great advantage*

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