As regards the oxygen percentage in the gas of pneumothorax it is obvious that any leakage in the cavity will raise the percentage, owing to the entrance of air. In view of recent physiological research it seems that, if the gases are left undisturbed in the thoracic cavity, the oxygen percentage falls very slowly and finally becomes very much lower than that of the blood bathing the lung. It probably corresponds finally with the oxygen percentage in the surrounding tissue. In physiological experiments on monkeys Webb and his co-workers² obtained fairly low figures for oxygen percentage three days after the last injection of air and nitrogen, the percentages being 4.85 and 3.57 respectively; these figures probably represent the oxygen percentage of the surrounding tissues. They seem much too low for oxygen percentage in the blood of such monkeys. Henderson and Haggard⁹ obtained low figures (about 6 per cent.) for oxygen in gas in the abdominal cavity; nevertheless the percentages they found were much higher than those—1 per cent. and less—given by Edkins¹⁰ for oxygen in the stomach cavity.

Our own figures for oxygen percentage in gas in the abdominal cavity of normal animals resemble those of Henderson and Haggard.

Thus on November 3rd, 1922, at 12.30 p.m., 250 c.cm. of air were injected into the abdominal cavity of a rabbit (see Table IV); at

TABLE IV.
Rabbit: Urethane.

Date.	Time.	Conditions.	Percentage Composition of Air in Abdominal Cavity.	
			CO ₂ .	O ₂ .
1922. Nov. 3	12.30 p.m.	270 c.cm. air injected	—	—
	3.10	Sample withdrawn	4.67	15.66
Nov. 6	12.10 p.m.	Sample withdrawn	7.01	5.00
Nov. 7	1.50 a.m.	Sample withdrawn	6.42	5.31

3.10 p.m. on the same day the oxygen percentage was 15.66. On November 6th, at 12.10 p.m., the same gas being in the abdominal cavity, the percentage was 5.00, and on November 7th, at 11.50 a.m., the oxygen percentage was 5.31. We also obtained low oxygen percentages in air that had been under the skin of normal animals for some days. Thus air containing 10.93 per cent. oxygen was injected under the skin on February 2nd, 1923, at 5 p.m.; on February 5th, at 1 p.m., the percentage of oxygen was found to have fallen to 3.50 (see Table V).

TABLE V.
Rabbit: No anaesthetic.

Date.	Time.	Conditions.	Percentage Composition of Air under the Skin.	
			CO ₂ .	O ₂ .
1923. Feb. 2	5 p.m.	Air injected under skin	—	—
Feb. 5	1 p.m.	Sample withdrawn	8.23	3.50
Feb. 7	4.40 p.m.	Air injected under skin	—	—
Feb. 9	2.30 p.m.	—	8.13	3.55

It is possible that the oxygen tension varies somewhat in different tissues and also at different times in the same tissue. Very low figures, resembling those (1 per cent.) of Edkins for the stomach cavity, have been obtained in the gases in pneumothorax, so that in these cases the oxygen percentage in the surrounding tissue may have been the same. Pathological changes in the lungs and pleura, such as thickenings, would probably lower the oxygen percentage in these tissues,

TABLE VI.
Dr. Pask's patient.

Time.	Conditions.	Percentage Composition of Air in Thoracic Cavity.	
		CO ₂ .	O ₂ .
Hours. 0	450 c.cm. oxygen injected into left pleural cavity	—	—
48	Sample withdrawn	4.90	15.34

as would also the presence of pathological exudates. Grass⁴ found the percentage of oxygen to be about 1 in cases with exudate, whereas it averaged 4 in cases of dry pneumothorax.

Previous results, particularly those of Webb and his co-workers² and of Rist and Strohl,⁸ and our own results, prove

that any oxygen injected was very slowly absorbed by the tissues compared with the rate with which carbon dioxide diffused out from the tissues. Dr. Pask of High Carley, Ulverston, kindly allowed us to examine a sample of gas from the thoracic cavity of one of his patients. Two days after the injection of 450 c.cm. of pure oxygen the percentage of oxygen present in the cavity was still about 15 (see Table VI). Similar figures were obtained from patients by Webb and his co-workers.²

Summary.

1. The carbon dioxide percentage in the gases of pneumothorax appears to approximate very rapidly to that of the blood bathing the compressed lung. The volume of gas introduced in carrying out artificial pneumothorax may thus be increased at first, but not more than about 6 per cent.

2. The oxygen percentage in the gases of the pneumothorax cavity approximates very slowly to that in the tissues bounding the cavity. As nitrogen diffuses out equally, it makes little difference whether oxygen or air be used for inducing artificial pneumothorax.

3. Pathological fluids and tissues usually cause abnormally high percentages of carbon dioxide. Pathological changes probably lower the oxygen content.

4. Any leakage in the thoracic cavity lowers the carbon dioxide percentage, but increases the oxygen percentage in the imprisoned gas.

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STERILIZATION OF THE UNFIT.*

BY

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IF in this country the revolutionary suggestion be advanced of sterilizing the mentally defective children and preventing the marriage of those with mental weakness, or those having such a strong family history of insanity as to make it certain that idiots or mentally unfit offspring would result, it is quite evident that strong arguments in its favour must be adduced before legislation could be hoped for.

The Increase of Insanity.

On January 1st, 1922, the number of notified insane persons under care in England and Wales was 123,714, an increase of 3,370 on the number on January 1st, 1921. This increase followed one of 3,580 in 1920, and may be compared with the average annual increase of 2,251 for the ten years ending December 31st, 1914—the decade immediately preceding the war.¹ The mentally defective persons under care on January 1st, 1922, numbered 13,810 (males 6,326, females 7,484). Compared with the same date in the year previous this was a net increase of 1,784 patients.¹

In Scotland on January 1st, 1922, exclusive of insane persons maintained at home by their natural guardians, there were 18,027 insane persons of whom there was official cognizance, including the inmates of training schools for imbecile children, who have not been certified under the Mental Deficiency Act, and of the Criminal Lunatic Department of Perth Prison.² The increase over the previous year was 221.

In Ireland on December 31st, 1919, there were 22,578 insane in various district, auxiliary, private asylums and mental hospitals; so that in Great Britain and Ireland there were at the dates mentioned no fewer than 178,129 affected.³ This does not include all those cases affected mentally who are in sufficiently good circumstances to obviate the necessity of entering a public institution.

As the foregoing shows that there is an annual increase in these numbers, it is clear that there is urgent need to do all in our power to ameliorate this state of affairs.

It has been estimated⁴ by an eminent authority that there are at present in the United States of America⁴ 42 institutions for the feeble-minded, 350 hospitals for the insane,

* Read before the Westminster and Holborn Division of the British Medical Association on April 12th, 1923. The discussion is reported at page 760.

23,000 juvenile delinquent institutions, 100,000 criminals, and 300,000 insane and feeble-minded.

This same authority estimates that two-thirds of these defective individuals are parents of defective children; this is evidence of the enormous importance of heredity and family history.

Heredity.

Heredity has been defined by Professor Thomson as "The genetic relation between successive generations." Lock defines it as "The transference of similar characters from one generation of organisms to another, a process effected by means of the germ cells, or gametes."⁶

The hereditary substance represented by the sexual pronuclei which fuse together in the act of fertilization Nägeli calls by the name of *idioplasm*.⁷ The resulting germ contains the images of two persons, and is therefore capable of transmitting by heredity their characteristics to the individual developed from it. In Mendel's experiments with the pea he called the character that prevailed *dominant*, and the character that was suppressed *recessive*. He found that a cross between a plant with a dominant character and a plant with a recessive character yielded offspring all resembling the dominant parent as regards the character in question. In the next generation the cross-bred plants were allowed to fertilize themselves, with the result that their offspring exhibited the two original forms, in the proportion on the average of three dominants to one recessive. When the recessives were allowed to fertilize themselves, they gave rise to recessives only for any number of generations.⁸ Mendel's interpretation of the important set of facts he discovered was expressed in the theory of gametic segregation:

"The essential part of the discovery is the evidence that the germ cells or gametes produced by cross-bred organisms may, in respect of given characters, be of the pure parental types, and consequently incapable of transmitting the opposite character; that when such pure similar gametes of opposite sexes are united in fertilization, the individuals so formed are free from all taint of the cross; that there may be, in short, perfect, or almost perfect, discontinuity between these germs in respect of one of each pair of opposite characters."

It must be remembered that heredity and environment cannot be studied apart in relation to the development of children, for, however good the heredity may be in the case of a child, it cannot accomplish much without the influence of wholesome environment, which can be of such service in altering or modifying certain tendencies which are inborn. What Sir Frederick Mott calls "the fundamentals of the mind" are begotten with the body, and predetermine character and conduct. This has been demonstrated by Francis Galton's inquiry into the history of similar and dissimilar twins, which proves that dissimilar twins remain dissimilar in mental and bodily characters when brought up in the same environment, whilst similar twins brought up in different environment remain similar in mental and bodily characters. Environment, however, cannot produce mental power.⁹ The experience and studies of numerous other investigators have led them to agree with Dr. Goddard's conclusion that two-thirds of all feeble-mindedness is due to heredity.¹⁰ Dr. Barr, chief physician, Pennsylvania Training School for Feeble-minded Children, Elwyn, states:

"The family histories collated in the institutions and hospitals of our land form in themselves a library of tragedies which would convince the most sceptical of the magnitude of race suicide, increasing with each generation. In my individual study of 4,050 cases of imbecility I find 2,651, or 65.45 per cent., caused by malign heredities, and of these 1,030, or 25.43 per cent., are due to a direct inheritance of idiocy, and 280, or 6.91 per cent., to insanity."

Dr. Paul Bowers, who is superintendent of a hospital for the insane at Logansport, Indiana, has gathered data from a personal examination of more than 5,000 prisoners; he found that the antecedents of 44 per cent. of the examined convicts were psychopathic individuals, who were insane, feeble-minded, epileptic, criminal, or suffered from organic or functional disease of the nervous system.

On the other hand, careful inquiry into the family histories of the progenitors and the collateral members of ancestral stocks will generally show that a child born sound in mind and body is begotten by parents sound in mind and body themselves, whose stocks are free from any neuropathic or physical taint. Some consider that the heredity of mental deficiency is in accordance with the Mendelian laws if mental normality be regarded as the dominant and mental deficiency the recessive character. It has never been known for two mentally defective individuals to become the parents of a normal child.

The Sterilization of Mental Defectives.

The time has surely arrived when, instead of fostering the growth of the mentally defective, we should seriously consider the important problem of endeavouring to prevent their propagation. This can only be done by the sterilization of those who are definitely unfit to bring into the world healthy children. By the suggestion of sterilization, I do not mean asexualization, which has been practised in many countries for thousands of years. Experience has proved that the quieting of nerves and exaggerated emotional excitement is a primary and necessary factor in developing and training mental defectives, and as they suffer not only from mental and moral debility, but greatly exaggerated sexual impulses, asexualization is often of great service.¹¹ In ordinary sterilization there is nothing new, for it was known and practised by the Hebrews and Egyptians, in the South Sea Islands, among the American Indians, and in Scotland, on the insane, idiotic, epileptic, and on those suffering from transmissible disease. Plato suggested that the State should marry the best with the best, and the worst with the worst, and that the former should be encouraged to breed freely, while the offspring of the unfit should be destroyed. Aristotle was in favour of allowing children in excess of those required to die from exposure, all deformed children not being permitted to live.

The most frequent cause of congenital weak-mindedness is regarded by many to be neuropathic heredity. The subjects of mental deficiency are classified into idiots, semi-idiots, imbeciles or backward children, and moral imbeciles.¹² The incidence of idiocy among first-born is abnormally great, whilst the last child of a large family is liable to be weak-minded, apparently owing to the mother's nutrition being lowered by frequent pregnancies. Most children who acquire organic disease of the brain during infancy remain mentally defective, and epilepsy is responsible for about one-third of the cases.

Difficult labours are of considerable importance in the causation of mental deficiency, but in collective statistics in regard to these "difficult" labour is frequently accepted solely on the assertion of the mother. These statistics, however, seem to prove that a long labour is more prone to interfere with mental development late in life than forceps extraction.¹³

My own view, as that of others, is that when a child has been definitely pronounced by alienists to be of feeble mind, he or she ought to be prevented from ever having the chance of being a parent. Although this would be done for the advantage of the State, yet it is certainly for the benefit of the child, who, with no idea of responsibility, should be prevented in the future from bringing children into the world to be looked after by others. There is no interference with the sexual functions in the high-grade imbeciles, and moral imbeciles are especially apt to be troublesome.

In 1907 a law was enacted in the State of Indiana for the sterilization of confirmed criminals, idiots, imbeciles, and rapists. Since then other States have passed bills authorizing sterilization, and among them New York, Washington, New Jersey, California, Iowa, Connecticut, Utah, and Nebraska, as well as others. The terms of the Indiana law are:

"Whereas heredity plays an important part in the transmission of crime, idiocy, and imbecility, therefore be it enacted by the general assembly of the State of Indiana that on and after the passage of this Act it shall be compulsory for each and every institution in this State entrusted with the care of confirmed criminals, idiots, rapists and imbeciles, to appoint upon its staff, in addition to the regular institutional physician, two skilled surgeons of recognized ability, whose duty it shall be, in conjunction with the chief physician of such institution, to examine the mental and physical condition of such inmates as are recommended by the institutional physician and Board of Managers. If in the judgement of the Committee of Experts and the Board of Management procreation is inadvisable, and there is no probability of the improvement of the mental conditions of the inmate, it shall be lawful for the surgeon to perform such operation for the prevention of procreation as shall be decided upon as best and most effective. But this operation shall not be performed except in cases that have been pronounced unimprovable."

Prevention of Marriage with the Certainty of Mentally Deficient Offspring.

In a paper on "Sterility with reference to the State," which I read before the Section of Obstetrics and Gynaecology of the Royal Society of Medicine in March, 1922, I advocated, in order that mentally defective children should not be brought into the world, a State certificate of marriage. This would mean an Act of Parliament, and although one object

I have in view is legal sanction for sterilization of the unfit, yet such a certificate would obviate as far as possible the risk of marriage in persons affected mentally, or infected by the gonococcus, the *Spirochaeta pallida*, or tubercle bacillus. The ordinary family physician could give a certificate of health in the case of the female married for the first time; it would entail no more examination than is necessary for insuring life in any insurance office. The reasons which lead me to urge some such certificate are potent ones. The discovery of the presence of the infective organisms would enable the family attendant to advise the postponement of marriage until health was re-established. Gonorrhoea lessens the birth rate by preventing conception, and is the commonest cause of both absolute and relative sterility in women, the percentage being about 50 of all cases, and about 70 per cent. of the inflammatory infections in women are due to the gonococcus.¹⁴

It is estimated that syphilis causes about 25 per cent. of stillbirths and abortions, and at least 20 per cent. of the ante-natal and neo-natal deaths.¹⁵ This does not include those children with congenital syphilis surviving a month after birth, and who die later from debility, or who grow into delicate, puny children, always requiring extra care and attention. Of syphilitic women about 80 per cent. are married, and of the latter, according to Fournier, 75 per cent. have acquired it from the husband. Statistics regarding ten thousand consecutive labours in each of two American hospitals (the Johns Hopkins and Sloane) show that in the former the stillbirths due to syphilis were 32 per cent. of the total births up to fourteen days after birth, and that in the latter, 9 per cent. of the stillbirths were syphilitic, although all recognized cases of maternal syphilis were refused admission.¹⁶ I do not suggest that men would willingly marry knowing themselves to be diseased, but examination would prove that they are or are not well enough for marriage, which could be postponed.

The strongest argument in favour of this certificate is that it would prevent the union of those with strong tendencies to insanity on either side, or those who showed signs of mental weakness, for they cannot be cured, and their offspring are defective. In the case of those with a strong history of insanity, or in presence of any mental deficiency, the certificate could be granted on the condition that one or both parties should be sterilized. This would prevent the unhappiness following the withholding of a certificate. The certificate would only be withheld in the case of the feeble-minded, or of a strong history of insanity on one or both sides, and in such cases the family physician would be bound to have the opinion of one—or if desired two—alienists. There is no suggestion that every possible care should not be taken with reference to withholding a certificate, for, as such a step necessarily entails an Act of Parliament, stringent regulations to safeguard the individual concerned, as well as the State, would be drawn up.

In some States of America, as already mentioned, sterilization of those mentally affected, as well as certain criminals, is already enforced. Although this is excellent as far as it goes, if sterilization were carried out earlier the vast majority of such persons would not be born. Although syphilis cannot be traced with certainty in Europe before the fifteenth century, it must, like gonorrhoea, have existed amongst the Egyptians from early times, and the reason more attention has not been paid to it until lately may be found in the fact that in former days its treatment was considered, especially by the Roman physicians, beneath their dignity. Although the effects of both the gonococcus and the *Spirochaeta pallida* are frequently terrible, yet, as there is now a possibility of complete cure, they cannot be compared with the appalling calamity of bringing into the world idiots and mentally affected children, whose condition cannot be cured, and who will, we know, if they survive and marry, certainly produce mentally defective offspring.

It is extraordinary how prolific these mental defectives are. Dr. Barr states that the sexual impulses are ever exaggerated, and they reproduce their kind from two to six times more rapidly than normal people. Dr. Bontor mentions a report of fifteen mentally deficient women who produced 116 children.¹⁷

Experience shows what such children will turn out to be in the future if they survive. They are feeble-minded, and more or less useless in the world, in spite of all the care bestowed on them in the training schools and other institutions in which they are well looked after. Although the cost to the State for the upbringing of these mental defectives is great it would not be complained of if permanent success

followed the treatment. But, as Dr. Stansfield truly says,¹⁸ the trend of modern civilization, by its Poor Law system and its treatment of the unfit during childhood, tends to foster the growth of this class. The care given to physically and mentally unfit children may reduce the degree of unfitness, but if their improvement is such as to enable them to escape the Mental Deficiency Act they are turned out mental, moral, and physical weaklings, to return to the environment which was associated with the development of this unfitness. This supports my suggestion; and is also a strong argument in favour of sterilizing confirmed criminals.

In my opinion sterilization ought to be regarded as a social relief to prevent the advent of mentally defective children. State certificate of marriage will confer a blessing upon our country, for it will ensure the advent of healthy children only. If it became legal to sterilize mentally defective children their survival would be productive of no harm. But even though legislative power be never given in respect of the mentally defective I have said enough upon the *Spirochaeta pallida* and the gonococcus to support the argument in favour of a State certificate of marriage.

Method of Sterilization.

Sterilization may be done in the male by vasectomy, a small incision, after the application of cocaine, being made in the scrotum in the situation of the epididymis, the vas deferens isolated, a loop drawn out and divided, and about one quarter of an inch cut from it. The distal end is tied, and the end nearer the testicle left open, so that the secretion from it may be absorbed into the blood, preventing any disorder of metabolism; the contents of the scrotal sac are returned, and the small wound closed. In the female, the Fallopian tubes are divided, and the ends nearest to the uterus tied. The ovarian end of the tube is left open, thus permitting the absorption of the ovarian secretion. Dr. Van Meter makes a small slit through the peritoneal covering of the tube at its proximal end. The oviduct is hooked up and severed at its uterine junction, the severed end reflected on the distal side out through the incision in the peritoneal covering, and the small incision closed with continuous stitches of fine catgut. If there should be the least suspicion of the uterus being unhealthy, the oviduct should be ligatured.¹⁹ Sterilization may also be brought about in both sexes by x rays, but it must be remembered that whereas vasectomy and salpingectomy do not in any way interfere with the functions of the interstitial cells, either in the testicle or ovary, yet the x rays may possibly do so.

I have pointed out the influence of the gonococcus in producing inflammatory affections in women, and the enormous number of infant deaths which are due to syphilis. These two conditions alone, quite apart from the mental and physical sufferings entailed on the parent, are, in my opinion, amply sufficient reasons why the antecedent and present condition of anyone about to be married should be inquired into before granting a certificate of marriage. Sir Frederick Mott says:

"For twenty years I was endeavouring to awaken the authorities to the necessity of combating venereal disease, for it was overwhelmingly proved that syphilis, besides being the sole cause of general paralysis of the insane, which accounts for 15 per cent. of admissions, is also a very frequent and sole cause of mental deficiency and organic dementia. Yet nothing was done until the Royal Commission on Venereal Diseases in 1914."

I have been particular to emphasize syphilis in my appeal for a State certificate, for it is a preventable disease. Everything which can be done to prevent the spread of syphilis will diminish enormously the proportion of cases admitted to hospitals, asylums, institutions for the blind, the deaf, and the dumb, and for mental deficiency due to congenital syphilis.

The authorities who can best give an opinion of real value are those who are superintendents of institutions for the feeble-minded. They assure us that, in spite of all we can do for these mentally defective children, they can never be really cured. As examples of what a man of defective mental type can do, I may quote family histories:

The first was carefully investigated by A. H. Estabrook.²⁰ The two sons of a mentally defective man married degenerate sisters, from whom six generations, numbering 1,200 persons, were born, of every grade of idleness, viciousness, pauperism, disease, idiocy, insanity, and criminality, and of the total more than half the women fell into prostitution. By the year 1915 the clan had reached the ninth generation, and increased its evil record. It had then numbered 2,820 individuals, half of whom were alive. Although the family was scattered widely over the country change of environment produced no benefit. They still showed "the same

feeble-mindedness, indolence, licentiousness, and dishonesty." The cost to the State had risen to 2,500,000 dollars. The one who investigated this family history most justly remarked that this evil might have been averted by preventing the reproduction of the first degenerate.

The second was the striking example of superiority and degeneracy in the well known case of the Kallikak family, published by H. H. Goddard.²¹ A young soldier of good stock had a son by a feeble-minded girl, from whom there have descended in a direct line 480 individuals, of whom only 46 are known to have been normal. Of the rest, some are unknown or doubtful, and the others turned out to be feeble-minded, alcoholic, some of the women grossly immoral (mostly prostitutes), epileptics, and criminals. Years later he married a woman of good family, who bore several children, and the descendants turned out well, many of them being distinguished. The two families lived in the same environment.

These two families show what evil can be done from the feeble-minded scattered all over the empire.

In conclusion, I need hardly say that I am fully aware of the opposition my suggestion will meet with in this country, not only on sentimental grounds but on those of State interference with the liberty of the subject, and the possibility of evasions, which would certainly be attempted. Nevertheless, those who seriously consider what is best for the future of our race, in view of the facts I have mentioned, cannot but agree that it ought to be of the highest importance; we should at least endeavour to secure the advent of only healthy children, and as we have the means at our hand we ought to avail ourselves of them and prevent the propagation of the mentally defective.

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MINERS' NYSTAGMUS.

BY

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In the first report of the Miners' Nystagmus Committee, published last year, we read:

"The Committee have unanimously reached the following conclusions:

"1. The essential factor in the production of miners' nystagmus is deficient illumination.

"2. The deficient illumination is due to the low illuminating power of the safety lamps generally used by miners.

"3. Workers at the coal-face are more affected than other underground workers, and this appears to be due to the unrelieved blackness of the coal and the greater need for accurate vision.

"4. Distinct signs of nystagmus are present in a large proportion of coal miners, though only in a small proportion do the symptoms ever become so severe as to cause even temporary incapacity for work underground."

With these conclusions I think no one who has practical experience of the disease in the counties of Northumberland and Durham will agree, but of course unsupported assertions are absolutely useless in contesting the point. I have therefore, owing to the courtesy of the Coal Trade Office and of the officials at thirty-two pits in these two counties, obtained some details of 36,232 underground workers during the year 1922, with notes of the character of the illumination and of the average thickness of seams worked at each pit during that year. The numbers are sufficiently large for reliable statistical conclusions to be drawn from them.

The first point we wish to determine from the facts presented is whether in these pits deficiency of light or something connected with coal hewing is the more important cause.

Here what are technically called two attributes are to be investigated, and therefore four independent class frequencies

must be given in order that a valid conclusion may be drawn. (If n attributes are under consideration, no conclusion can be drawn unless 2^n class frequencies are given, which must be independent of each other.) Of these 36,232 underground workers, 11,383 were hewers and 24,849 were non-hewers; 103 of the hewers and 59 of the non-hewers acquired nystagmus. It is only necessary to compare the proportion or the percentage of the nystagmus cases among the hewers with that of the nystagmus cases among the non-hewers—that is:

$$\frac{103}{11,383} : \frac{59}{24,849} \text{ or } 0.904858\% : 0.237434\%$$

Clearly, if the percentages were equal, nystagmus would be quite independent of hewing; if they were even nearly equal, deficiency of light might be the essential cause of the disease, but we see that the percentage amongst hewers is nearly four times greater than that amongst non-hewers, so we are driven to the conclusion that hewing, or something connected with hewing, is of far greater importance than mere deficiency of light. I have given the percentages to six decimal places when three figures would be quite enough, but I wished to guard against any ambiguity in using less exact figures. If hewing were the only cause of the disease, of course there would be no cases of nystagmus amongst the non-hewers. If both percentages be multiplied by the reciprocal of the greater ($\frac{1}{0.904858}$) we get the ratio 1 : 0.2624.

The difference ($1 - 0.2624 = 0.7376$) gives a sort of measure of the degree of association, where 1 indicates complete association, and 0 indicates that the percentages are equal or that there is complete independence.

There are four other pits, employing altogether 7,452 underground workers; as the details about these are not so complete, for the period is not limited to the year 1922, they are here considered separately. On comparing the proportion of the nystagmus cases amongst the hewers with that amongst the non-hewers we have:

$$\frac{34}{2324} : \frac{20}{5128} = 1.463\% : 0.4179\% = 1 : 0.2856,$$

which gives the degree of association of hewing with nystagmus as 0.7144. When all the cases are added together, making a total of 43,684 underground workers, the degree of association becomes 0.7363.

It is true that the prevalence of nystagmus amongst hewers is noticed in the conclusion (3) of the report, but the explanation given is more than doubtful.

All underground workers are exposed to "the unrelieved blackness of the coal," and "the accurate vision" required by a hewer with a pick does not involve macular vision, but a keen sense of projection from extramacular parts of the retina, as has been so well insisted upon by Dr. Freeland Fergus under the name of alignment. I have examined several miners with macular vision less than 6/24 who have been admitted by their comrades as more efficient coal getters than themselves. In a very dim light macular vision is almost useless, for the fovea is a blind spot, as anyone can prove for himself.

I hold that nystagmus is excited by the long-continued strained position of the eyes in an unusual position. This view is no longer fashionable—chiefly, I believe, because it was found that the incidence of nystagmus was rather less in thin than in thick seams. But in undercutting a thin seam the miner lies on his side while the position of his eyes is rather downwards; whereas in top-holing a thick seam the gaze is directed obliquely upwards, a far more uncomfortable position for the eyes to maintain. Consequently, the greater frequency of nystagmus in thick seams supports the view that the constrained position of the eyes is the important factor in exciting the disease.

Unfortunately, in most cases only the average thickness of the seams worked at each pit has been given me—for example, St. Hilda, 3 ft. to 5 ft. 6 in.—so that it is impossible to draw any conclusions as to the incidence of the disease at 2 ft. and under, at 3 ft., 4 ft., 5 ft., as would have been desirable. In the few cases in which more precise data have been given the numbers are too small for any reliable conclusion to be drawn.

The same difficulty of insufficient data occurs with regard to the character of the illumination. Most of the pits use both oil lamps and electric lamps; in no pit are electric lamps used solely. I have been told that in the Dean and Chapter pit, where Messrs. Bolckow, Vaughan, and Co. had gone to the expense of providing excellent electric lamps to