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On the Pathology of Miner's Lung. By Wm. Osler M.D., Prof. Institutes of Medicine, McGill College.

(Read before the Medico-Chirurgical Society)

Situated as we are, at a considerable distance from mining centres, it is only occasionally that cases of disease resulting from the inhalation of coal dust are brought before our notice. Having lately had such a case, I take this opportunity of laying it before you, together with a hitherto undescribed specimen from the Museum of the College, and also, other specimens illustrating the pathology of lung pigmentation. The man from whom I obtained the lungs of the first case I am about to describe was a powerful, well built Scotchman, 36 years of age, who died under my care in the small-pox department of the General Hospital of Variola maligna, after an illness of five days. Throughout the attack there were no symptoms referable to disease of the lungs; the breathing, it is true, was greatly accelerated, but not more than is usual in cases of hæmorrhagi small-pox.

Post-mortem examination, four hours after death—On opening the thorax the lungs appeared very full in volume, and instead of collapsing, projected slightly forward. The lower lobe of the right lung was adherent to the pleura in front and laterally by thin, delicate bands, apparently not of old date. Left lung and upper part of right free. No fluid in the pleural cavities. On removal from the chest both lungs presented over their whole surface a uniform, deep blue-black colour; so general was it, that not a trace of the

natural hue of the organ remained. At the apices and in front the colouration was not as intense as in the posterior regions, but here it was exaggerated by the hypostatic congestion existing in these parts. Both lungs were crepitant throughout and floated in water. Cicatrices existed at the apices. Several patches of collapse were noticed along the anterior free margins. Pulmonary pleura somewhat opaque, and thickened to such a degree that even with a lens the air cells could not be seen through it, except at one border where they were much dilated and emphysematous. At spots, probably corresponding to the interlobular septa, the colour was darker than at others. On section the organs presented an intensely black colour, and the serum which flowed from the cut surface was of an inky hue. The posterior lobes were sodden and œdematous, but still crepitant, and floated in water. Here and there throughout the substance small patches of apoplexy—the largest the size of a walnut—could be seen. When squeezed a fluid like ink could be expressed, which left a dark stain upon the hands. Repeated washing of a portion of lung diminished considerably the intensity of the colouration. On the surface of a portion thus treated different shades of pigmentation can be seen. Round or linear patches, ranging in size from a pea to a hazel-nut, of an intensely black colour exist in large dark, slate grey areas. In many of these spots the air cells can still be detected, in others they appear to be obliterated, and the section in this case is uniform, not porous. On careful dissection I was able to demonstrate in nearly every instance that these spots had a small bronchiole penetrating them, and this can be seen in several of the specimens. These patches when excised and placed in water always sank, even when air cells could be seen in them. Many such existed just beneath the pleura and their situation was easily told, not only by the deeper colour at these localities, but, also, by the fact that a slight superficial puckering sometimes existed. To the feel they were also firmer, more solid, than the other parts of the lungs, not so much so,

however, as the apoplectic spots. The portions of lung tissue intervening between these intensely pigmented areas were of a uniform slate grey colour. studded with the hæmorrhages already mentioned. The fluid expressed from these pieces was very dark. The air-cells when examined with a lens appeared almost universally emphysematous, more especially those in the upper and anterior regions of the lungs, occupying a superficial position. Certain limited sections of the lungs, generally situated superficially, appear denser than others, the air cells are visible but very small, and the amount of alveolar tissue in proportion to the air space is abnormally great. This may be due, of course, either to collapse or to an increase of the fibrous elements in the walls of the air cells. I am inclined to think it due to the latter from examination of the air cells, and also after comparison of it with several genuine patches of collapse, which existed at the anterior free borders. Several small cavities, the largest about the size of a pea, containing air were met with, probably large emphysematous cells, as they were quite devoid of any definite wall, and the air vesicles opened directly into them. The tissues of the larger bronchi preserved their natural colouration, but as they reached their ultimate ramifications, when diminished to the size of a crow-quill, the mucous membrane became of a deep black colour, and the surrounding elements of the walls were very generally pigmented. The bronchi were filled with a frothy mucus, but the mucous membrane was not thickened, nor were there any evidences of chronic bronchitis. The *tunica adventitia* of the blood vessels—large and small—was impregnated with the dark particles and the transverse section of an artery presented three zones of colouration, a dark one corresponding to the *adventitia,* a white fibrous one to the *media,* while the red central zone occupying the lumen of the vessel is made up of the blood corpuscles. The bronchial glands were firm, not enlarged, and presented an excessively black surface on section.

Microscopical examination : first, of the dark coloured

serum, which can be so readily expressed. A variety of cellular elements are here met with, and the colour is seen to depend upon black granules, partly free, and partly inclosed within the cells. A difference would seem to exist in this respect as to whether the drop examined was furnished by one of the darker spots, or from the intervening greyish portions; in the former case there are more free granules, in the latter they are generally inclosed within corpuscles. These carbonaceous particles range in size from almost imperceptible molecules up to portions the 1-12000 of an inch and over. The latter are, as a rule, angular and do not exhibit the Brownian movement. In addition, pieces are occasionally met with of an elongated form, and of a brownish red colour at the edges, or, if thin enough, over the whole mass. Some of these can be seen with the naked eye, and I measured several more than 1-250 of an inch in length (See fig. 1). Other very peculiar forms were noticed, which, from the regularity of their outlines, I believe to be structures connected in some way with the coal, but upon this point I lack the necessary knowledge to decide. The cellular elements found in the expressed serum may be arranged as follows :—

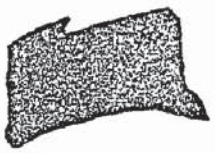

Fig. 1. x 100.

I. Groups of flat cells each with a distinct nucleus, the boundaries of the cells, in many instances, being ill-defined, or sometimes similar cells are grouped together upon a portion of membrane. Free in the field are others identical with the individual ones composing the above groups. They are about the 1-1200 of an inch in diameter, nucleus large and sharply marked, borders often indistinct, cell substance granular, friable, often broken away in part, leaving the nucleus exposed. The free nuclei of these cells also are present in numbers. Carbon granules are only occasionally met with in these corpuscles, and I think they must be regarded as the original cell elements of the alveoli, and perhaps, to a large extent deriviatives of them in a slight catarrhal process.

II. White blood corpuscles, distinguished from the former by their smaller size and less distinct nucleus. They only occasionally contain dark granules.

III. Corpuscles in which the bulk of the carbon is contained, and upon whose presence the black colour of the expressed juice in most instances depends. These are very variable in size, and may, on the one hand, approach the colourless blood corpuscles, and on the other, attain to five or six times their diameter. See figure 2 (*a*).

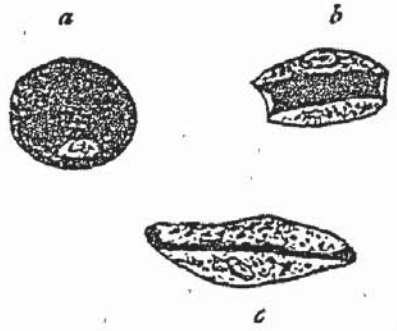

Fig. 2.

In shape they are usually round, sometimes oval, occasionally irregular, very rarely approaching the spindle form. Inside all of these the carbon particles exist in extraordinary numbers, filling the cells in different degrees. Some are so densely crowded that not a trace of cell substance can be detected, more commonly a rim of protoplasm remains free, or at a spot near the circumference, the nucleus, which in these cells is almost always eccentric, is seen uncovered. The contained carbon particles are, for the most part, angular, and when not too thickly massed together, a reddish brown colour can be observed in each. In a few of them comparatively coarse portions of coal are found imbedded, stretching the cells to their utmost limits. At fig. 2 (*b* and *c*) such cells are represented, and in the latter the corpuscle has evidently accommodated itself to the shape of the piece of coal. One most curious specimen was observed: on an elongated piece of carbon three cells were attached, one at either end, and a third in the middle; so that the whole had a striking resemblance to a dumb-bell. I could hardly credit this at first, until, by touching

the top-cover with a needle and causing the whole to roll over, I quite satisfied myself that the ends of the rod were completely imbedded in the corpuscles, and the middle portion entirely surrounded by another. So strong was the attachment that I failed to separate any of the corpuscles by pressure on the top-cover and other manipulations. Another corpuscle was seen entirely surrounding the end of a small rod, forming a miniature drum-stick, the handle of which was twice as long as the diameter of the corpuscle.

IV. Decolourized red blood corpuscles, which are very numerous in all the specimens examined. Many of them are aggregated together into masses, casts, probably, of the air cells pressed out of the apoplectic centres.

V. Amyloid corpuscles, of which a few well-marked specimens were observed.

We come now to the examination of the lung substance itself, and first of the small dark areas. On teasing portions of these, unless done very finely no structure can be made out, uniformly dark masses present themselves. If, however, the elements are more minutely separated a dense interpenetration by small dark granules of all the textures is observed. We have not here to deal with cellular bodies containing the pigment, for it is free in the interstices of the tissue, and few or no cells can be detected. So thickly is the pigment scattered over the structures, that even an isolated fibril of elastic tissue is with difficulty seen, on account of the granules attached to it. The air cells seem obliterated by the excessive accumulation of pigment and the great increase of the connective tissue, and hardly a trace of them is met with. As before mentioned, the fluid expressed from these parts contains only fine granules with an occasional cell. Thin sections show very well how intense the pigmentation is, but yield very little information as to its distribution, for a uniform black surface is presented, which only here and there in irregular spaces is penetrated by the light. To-

wards the borders, where the tissues are not so densely infiltrated, some of the carbon is seen to be contained within round corpuscles, and also confined in very irregular, somewhat spindle-shaped areas, but whether these latter are connective tissue corpuscles or not is difficult to decide. From their extreme irregularity and the number of their processes it is probable they are not, but only represent the arrangement of the carbon granules among the elements of the tissue. All the coats of both bronchioles and vessels in these areas are impregnated in the same way, but I have not found any of the latter obstructed by accumulations of coal dust.

In passing to the consideration of the histology of the less pigmented and by far the largest section of the lungs, it may be mentioned that a considerable part of the colouration in this is due to carbon granules retained within the cells already described. These exist in abundance throughout the whole substance, and are everywhere present, both in sections and in teased preparations. They are found chiefly in the interstices of the stroma and along the course of the alveolar septa, occasionally, also, lying free in the air cells. Nothing further need be added to the description previously given of them.

Fig. 3. (x 450.)

Secondly, isolated particles of carbon are tolerably numerous, even in situations which, under the microscope, look on superficial examination to be quite free. The membranous walls of the alveoli are constantly seen dotted over with black granules, though it is rare to see any occupying the cells upon it, and in the same way the interstices of the fibrous stroma contain them in abundance. The

manner in which these small particles gain entrance into the stroma may sometimes be observed, as sketched in figure 3, representing the margin of an air cell. Particles of various sizes are there seen, some attached to the free margin, others imbedded in its substance, while others again occupy positions a considerable distance in. A third situation is the point of junction of the fibrous septa, where, in many instances, quite a dense accumulation is met with in the form of fine granules, as is seen at fig. 4.

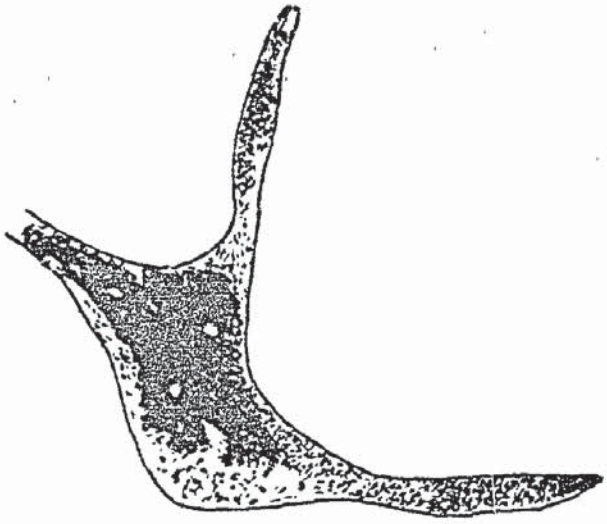

Fig. 4. (x 100.)

A fourth and most favourite locality is the interlobular connective tissue, which cannot be considered apart from that of the vessels and bronchi. Here, as can be seen with the naked eye, the deposit is excessive, and the blood vessels are readily followed as dark, irregular branching lines. The examination of sections of vessels show that in most instances the *adventitia* alone is effected, while the *media* and *intima* remain quite normal. Similarly it is only the loose fibrous coat of the bronchi in which the pigment occurs, though occasionally a transverse section of a bronchice is seen pigmented throughout.

With regard to the alveoli themselves no very great deviation from the normal structure was noticed, save that in many places an increase in cellular elements, the result of a catarrhal process, had taken place on the membranous wall. In some situations, also, a marked thickening of the

alveolar septa had occurred, which was perceptible to the naked eye and has been already referred to in the description of certain areas in which the air cells were much diminished in volume. This was rendered very evident by comparing specimens taken from these areas with others from a healthy lung, or even from more natural sections of the same one. In one or two localities isolated air cells, or small groups, were found filled with colourless tenacious plugs (very similar to those of croupous Pneumonia), consisting of an extremely delicate fibrillar network enclosing various cellular structures, among which those described under (1) and (3) of the elements found in the expressed serum of the lung were the most numerous. The large ones, filled with carbon granules, in some instances gave a dark tint to these small masses.

The most superficial layer of the pleura, composed of a fibrillar membrane upon which the pavement epithelium lies, can be stripped off as a clear transparent structure quite devoid of pigment. Immediately beneath this, however, there is a fibrous layer densely crowded with carbon granules, both free in the tissues and contained in the large round cells, which latter are very abundant in this situation. Oddly enough, just in teased portions from this sub-pleural region some of the coarsest particles of carbon were obtained.

I have been fortunate enough to procure for examination several other specimens illustrating different degrees of pigmentation in the lungs. The first of these, comprising the lower lobe of one lung, was obtained from a Cornish miner who died under Dr. Howard's care some years ago in the General Hospital of Pneumonia. The notes of the case have unfortunately been mislaid so that I am unable to state the condition of the other parts of the organ. Superficially, the whole lobe is of an intense blue black colour, due to the accumulation of the carbon beneath the pleura, and this deposition varies in thickness in different parts, in some forming a very thin layer, while in others it has a

diameter of from two to four lines. At one or two places it is absent, one spot especially, near the root, and through these the light coloured portions of the lung can be seen. On section, irregular spots of an exceedingly black colour are seen scattered over a very pale lung substance. The relation between these two areas of colouration is not the same throughout; towards the root and in the portion of the lobe which rests on the diaphragm the dark exceed the light, while in the posterior and lateral regions the reverse holds good. Closer examination shows that the favourite localities for the pigment are about the vessels and bronchi, and the interlobular connective tissue, which can be seen as dark bands stretching from the pleura into the substance. Very many of the dark areas are firm and indurated, presenting a smooth hard surface on section, with occasionally the remains of a bronchus or vessel in the centre; while others of the same pitchy hue are made up of emphysematous air cells with thick hard walls. The portions of the lobe free from pigment look healthy, the air cells are however emphysematous at the margins and beneath the pleura. Many bronchi and vessels are wholly devoid of any pigmentation at their circumference, others of the former have somewhat thickened walls and from several tenacious plugs were extracted.

The bronchial glands, three in number, attached to the root, are firm and of an intensely dark colour.

In the microscopical examination it was found exceedingly difficult to tease up pieces from the dark indurated areas, on account of their extreme hardness and brittleness. They are composed entirely of fibrous and elastic elements, in the interstices of which the carbon granules are so densely arranged that it is only from the margins, where the fibrils project, that any idea of the structure can be obtained. Sometimes, near the borders, or in a less dense portion, a trace of an air cell is found, but as a rule, all remains of them are obliterated by the overgrowth of the fibrous tissue. Very few cellular elements are found in these localities,

and those present are small and do not contain many carbon granules. On the other hand, in and about many of the less indurated areas, the cellular elements are present in abundance, though not so large and more angular in shape than in the former case. This may be accounted for, however, by the fact that this specimen has been in spirit for over ten years, while the other was put while fresh into 1 per cent. solution of potassium bichromate. Cells, large and small, containing coarse particles of carbon or even distinct fragments are numerous. In some instances a process of atrophy, or shrivelling, appears to have gone on in these cells, for elongated portions of carbon were seen enclosed in a contracted mass which bore some resemblance to the remains of a cell; or again, others were imbedded in a yellowish coloured substance with irregular hard outlines as though a deposition of inorganic matter had taken place about them. Free in the field were many small angular black particles, also others much more minute. In this case coarse particles of silex were quite as common as those of carbon, and in one place an aggregation of 15–20 attached to a piece of lung tissue was noticed. None of these were observed within cells. The dark emphysematous localities, which usually have a small bronchus in immediate connection with them, are composed of a variable number of dilated air cells, all of a jet black colour, and with hard fibrous walls. I dissected out a small spot about the size of a cherry stone containing five emphysematous air cells and teased it up very finely, but was unable to find anything like an alveolar membrane, only fibrous tissue everywhere covered by dark granules. In other regions where the pigmentation was less profuse, a definite increase in the fibrous elements in the walls of the air cells can be seen. Instead of the isolated fibres of elastic tissue which in the healthy lung run across the alveolar wall and serve to strengthen it, we have here in many instances a perfect network. Nor are these to be mistaken with their sharp hard outlines for the collapsed capillary vessels, of which traces in the form

of irregular lines can be seen in normal alveoli. The infiltration of the pleura in this case, also, is limited to the deeper layers, the uppermost—basement membrane and epithelium—remaining free. The bronchial glands are unusually hard and fibrous, and microscopical examination shows an enormous overgrowth of the connective tissue with a corresponding diminution in the cellular elements. The few which are present contain numerous carbon granules.

The third and fourth cases do not properly come under the heading "Miner's lung," but they serve to illustrate several points in connection with the subject, and aid, also, in the understanding of the general pathology of lung pigmentation. The third specimen was obtained, like the second, from the Museum of the College, and of it I have unfortunately a still scantier history. All my information is confined to the brief record on the label, "Melanosis:" It is a piece about the size of the fist, representing, I take it, a portion near the apex, and is of a bluish black colour externally. The pleura covering it is thickened, in places white and fibrous, at others intensely dark and fully one-fourth of an inch in thickness. The colouration is very uniform, but on section is seen to be chiefly superficial, extending, however, into the interior in the form of bands, between which the lung tissue retains its natural hue. To the touch the whole mass is firm and indurated. The bronchi are thickened and in some cases surrounded by circles of pigment. Several small caseous masses encapsulated in fibrous tissue, deeply pigmented, occur at the apex. The microscopical examination shows that the pigment is chiefly interspersed as small granules among the fibrous elements of the thickened pleura, and in the bands that pass from it into the lung substance. In the former situation sections demonstrate that the pigment is distributed linearly, often in alternate layers, or interspersed between fasciculi of connective tissue. There is a marked absence of the small angular particles of carbon, and very few pigmented corpuscles were met with.

The fourth specimen is from a man, 65 years of age, who died of Bright's disease in the General Hospital under Dr. Ross, to whom I am indebted for the portions of lung. As far as could be ascertained this man had never been employed in mines, nor in situations where he would have been exposed to a sooty atmosphere. An interesting point in connection with this case is that the pigmentation of the skin was deranged; he presented several large patches of Leucosis.

In the portions of lung given to me for examination, the pleura certainly is abnormally pigmented for a man of his age. In parts the dark colour is almost uniform, but the general arrangement is in round, often irregular shaped spots, which are tolerably closely set over the surface and do not correspond to the interlobular septa. On section they are seen to be quite superficial, in most instances confined to the pleura, though sometimes dipping into the lung substance in the form of bands, or else involving the air cells immediately beneath, in which case, these are invariably emphysematous. The lung substance itself is but little affected, only here and there presenting a dark appearance, due to the accumulation of pigment about the vessels and in the interlobular connective tissue. The dark subpleural areas contain a tolerable number of the large cellular elements, but most of the pigment is free among the fibrous tissue. Where the pigmentation extends into the subjacent air cells the septa are dark in colour, and occasionally the alveolar wall was seen to have irregular patches of pigment upon it. Cells containing carbon are also very common in the alveoli, which have been involved in a pneumonic process, and are filled with cellular elements. Sections made parallel to the pleura in these situations show very well how the alveolar septa are covered with pigment, partly free and partly intra-cellular; while the air vesicles are filled with a fine granular substance and cells, many of which contain carbon and are identical with those in the alveolar septa. Small angular particles of carbon are com-

mon in the field, but no coarse ones, like those in cases 1 and 2, were met with. An interesting fact, which will be referred to hereafter with reference to the probable origin of the pigment in this case, is that extravasations of blood were seen in the sub-pleural region, and usually in the vicinity of the dark areas. On several occasions I saw at the edges of small teased portions of an intensely black colour the reddish brown remains of an extravasation. The small pigmented areas in the lungs presented nothing remarkable, they were chiefly in connection with blood vessels.

From the description of the two first cases it is evident that we have here to deal with the early stage of the disease known as Miner's Lung, or, to give it the scientific appellation, Anthracosis. I say the early stage, meaning that the degenerative process can hardly be said to have commenced, and had not these men died of intercurrent affections, they might have lived for years under favorable hygienic conditions. No doubt, however, the point had been reached where further exposure to the impure air of the mines could only have resulted in bringing about serious lung trouble. Ultimately, as the records of *post mortems* show, there arise extensive areas of consolidation—carbonaceous Pneumonia, as it is called,—with numerous cavities containing an inky coloured fluid, and at last death takes place with many of the symptoms of chronic Phthisis, a peculiarity in some cases being the expectoration of a dark colored mucus. In the cases under consideration the intensely black consolidated spots may be regarded as the first step in a series of degenerative changes. Such general infiltration of the tissues by a foreign matter cannot be without a strongly irritating action, the final effect of which would be a proliferation of the epithelial and connective tissue elements, with the result of obliterating the air cells and the formation of firm indurated areas. The larger these become, the more the cellular elements participate in the process, so much the more likely will they be to soften at the centres, and finally form cavities. The indurated spots

in our specimens were remarkable by the absence of corpuscular elements, and the same would probably hold good in larger areas; still, even in these, as occurs in Cirrhosis of the lungs, a molecular degeneration goes on in the centre, with the formation of a cavity. In the lungs of all individuals who die of this disease these cavities, which are no doubt often bronchiectatic, are described, surrounded by indurated areas, while the comparatively healthy sections are intensely black and emphysematous. Several cases I find recorded of miners having died of intercurrent affections, in whom the lungs presented an appearance similar to what has been described, viz: uniformly dark in color, but with patches of variable size of a much more intense hue, the lung texture itself being healthy, or a little emphysematous. In some instances the continual inhalation of the dust in mines would appear to produce very little effect, for cases are mentioned of miners exposed for years to the same influences to which others succumb, and yet who were but slightly affected. Predisposition to lung disease is an important factor here, and it has been found that where this exists, they die at a much earlier age than those without this hereditary weakness, which need not, however, necessarily be a true tubercular diathesis. Indeed, in reading over the records of the *post mortems* in this disease, one is struck by the absence of any mention either of true tubercles or caseous masses, and in neither of the cases before us do these elements occur. It was suggested by Dr. Wilson Fox, at a discussion on this subject at the Pathological Society a few years ago, that exposure to the irritating substances in the air of the mines might directly induce the production of tubercles, and that the fibroid masses represented the final change which these had undergone. Against any such view the cases here speak strongly. There is nothing in these lungs which would be called a tubercle by a follower of Lænnec or of Virchow, and yet, if the process was one in any way connected with tuberculosis, we should expect just in this early stage to find traces of it;

but instead, we find at the outset of the disease what is spoken of as occurring at the close, fibroid consolidation; the difference consisting in the extent to which it has gone, and in the absence in the former of secondary changes. In its essence the whole disease would appear to consist in an overgrowth—a hyperplasia—of the fibrous tissue of the lungs, induced by the chronic irritation to which they are subjected by the inspired particles of coal dust, a veritable Cirrhosis, or, as it might appropriately be called, the black Cirrhosis of miners. This certainly is the most natural view to be taken of these two cases, and accords best with their general and histological characters. From the fact that in many instances small bronchioles are seen in connection with the fibroid masses we may infer that about them the process begins, and spreads to the surrounding alveoli. In other places the *adventitia* of the blood vessels, and the interlobular connective tissue furnish starting points. We are still in the dark as to how all this takes place, how the air cells become converted into firm, hard areas—fibroid substitution as Dr. Bastian calls it, or why, again, in the same lung, some of the intensely dark spots are solid, while others are emphysematous.

Before referring to the other specimens, which do not, I believe, come in the same class, a few words must be said upon the general subject of lung pigmentation. Briefly, two sources must be admitted, an internal and an external; in the former, the pigment is transformed hæmatin, and the affection is termed *Melanosis;* in the latter it is inhaled carbon, and the resulting disease is *Anthracosis*. It is only within the last ten or fifteen years that unanimity has been reached on this point. Up to this time many of the leading German and French pathologists refused to recognize the latter source. Even Virchow as late as 1859, basing his observations on portions of miner's lung sent him from Edinburgh, came to the conclusion, though he describes angular particles of carbon from the same cases, that a transformation of the colouring matter of the blood

in repeated small hæmorrhages would account for the whole pigment. The English observers (and with them several French), one and all, as far as my reading goes, from Pearson, who in 1813 first described the affection, took a more practical and common sense view, and attributed to it solely an extraneous origin. Having many more opportunities of observing the conditions under which miners worked, and knowing the foul, sooty atmosphere of the mines, they were led to connect cause and effect, the dust with the disease, and so arrived at the truth years before the Germans, to whom, however, the credit is due of having placed the fact upon an histological and experimental basis. They demonstrated the presence of dotted cells and other structures characteristic of vegetable tissue in the coarser particles obtained from the lungs, and, also, proved that the lungs of animals might be made of a dark color by exposing them for a length of time to a sooty atmosphere. I have been fortunate, also, in these cases to obtain positive evidence of the external origin of the pigment. At fig. 5 a portion of coal is represented which

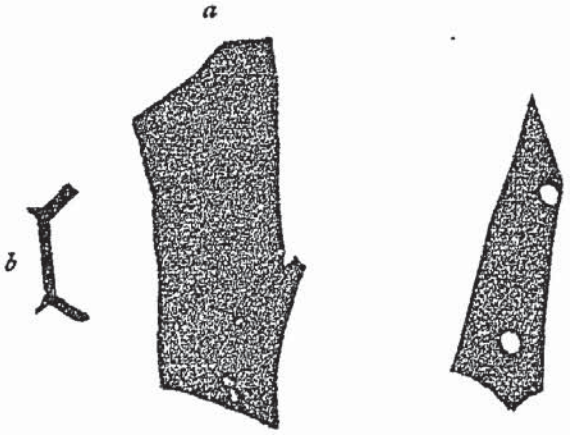

Fig. 5. (x 300.) Fig 6.

exhibits the characteristic appearance of scalariform tissue. This was a very thin flake with distinct cross bars, three of which occupied the whole breadth of the piece, while one other is less evident. The thin spots between the bars were of a brownish red colour. By manipulating I managed to break it across just below the third bar, and was then able to obtain the transverse section, which is given at

fig. 5 (*b*), and makes it more than probable that this was a portion of a scalariform duct rendered prismatic by pressure, a common structure in ferns, and also plentiful in cannel-coal. Another piece, seen at fig. 6, with two round holes, represents a portion of a dotted cell of fir wood.

To consider now this subject of Anthracosis more closely, and endeavour to obtain an insight into its rationale. A comparison of the lungs of a child with those of an adult, or, better still, of an old man, shows that the natural colouration of these organs undergoes a change as age advances, the rosy tint of childhood giving way to a marbled slate-grey, interspersed with patches or lines of an intensely dark colour. Similarly the lungs of an animal present a marked contrast to those of an adult man ; and there can be no doubt whatever that in great measure this change in colouration depends upon the inhalation by him of the products of imperfect combustion of fuel of various sorts, gas, &c. This has been called physiological Anthracosis, in contradistinction to the more extreme condition met with among those who work in mines, and other situations in which the air is charged with soot and coal dust. Against the entrance of these noxious matters into the lungs the nasal orifices are furnished with numerous hairs, which, together with the mucus of these passages, retain a considerable quantity of the dust and coarser particles met with in the air. After a lengthened sojourn in a smoky atmosphere how common it is to see the nasal secretion quite black upon the handkerchief. Still, even if the particles escape retention at the orifice, as they all do when the breathing is carried on *per orem*, a further provision is made for their expulsion when they reach the bronchial membrane, the cilia of which are in constant motion, producing currents which set externally, and slowly and surely convey the mucus with the contained granules towards the larynx, whence they are readily coughed up. In ordinary inspiration the volume of tidal air does not probably reach further than the larger bronchi, and the coarser particles in this

case, if they reach the alveoli at all do so by the force of gravity; but in the stronger respiratory efforts, just such as miners by the very nature of their work must constantly make, many attain this situation, and, as here no provision is found for their expulsion, nature provides that they shall at any rate be placed in less injurious localities. In what way this is effected, how the small angular particles which can be seen on the alveolar walls penetrate into the interior, has not yet I believe received a satisfactory explanation. Sharp, angular bodies are said to have a habit of working into soft textures, especially if there is any impelling force, however slight, behind; but what of the infinitesimal particles that we find throughout these lungs, can the same apply to them? Certain it is, however, that once fixed in the alveolar wall they resist all attempts at removal, and they may be seen, as at Fig. 2, in all stages of progress towards the interior. In their further distribution they follow exactly the course of the lymphatics, and the tissues in their immediate vicinity; where these are most abundant there the pigment is in the greatest quantity, as about the connective tissue of the vessels and bronchi, the interlobular septa, and, above all, just beneath the pleura. Once inside the lymphatic vessels a large proportion of the granules is carried on to the glands at the root of the lung, and is there permanently fixed in the cellular elements, hence the intensely dark colour of these in most persons over fifty. This fixation of the carbon granules in cellular bodies is very remarkable, and must be regarded as an effort of the economy to render harmless what might otherwise be very irritating substances. In the greater part of the lungs in the first case the pigment was contained within large cellular elements, belonging to the amœboid class of connective tissue corpuscles, and in the other cases they were by no means uncommon. These were unusually large, twice or three times the size of the colourless blood corpuscles, and very abundant, as if the supply had been equal to the demand. This pathological infiltration of corpuscles

with carbon appears to interfere just as little with the performance of their functions as does the physiological, so common to many connective tissue corpuscles of man and the lower animals ; for in the air cells which had been involved in a pneumonic process, and among the epithelial elements with which they were filled, these same large corpuscles occurred, evidently having migrated from the surrounding tissues, in which sections demonstrate them to be plentiful. To show the remarkable aptitude of cells to take up granules of various sorts, and, also, to demonstrate the rapidity with which the lymphatic glands are affected, I performed several simple experiments, of which I shall mention two :—

Experiment I.—Into the axilla of a two days' old kitten m iii. of a strong solution of Indian ink were injected, and into the right lung of the same animal a similar quantity was injected through the pleura. The kitten was killed twenty hours after and the parts carefully examined. In the axilla there was a spot the size of a marble of a dark black colour, composed chiefly of connective tissue and fat. On examination of teased portions it was seen that the particles of Indian ink were either free in the interstices of the tissue, or else contained within the numerous leucocytes, white blood corpuscles, with which the tissue was inundated These were specially abundant along the course of the puncture, and in this situation all the leucocytes were loaded with the dark granules. The spindle shaped connective tissue corpuscles did not contain any.

On removing the sternum a dark lymphatic gland was seen, and close to it a much smaller one. Nearer the manubrium was another black spot, apparently only an aggregation of dark granules. Where the point of the syringe had penetrated the thorax the layers of the pleura were united by a dark round band about two lines in diameter. Under the dark spot on the pulmonary pleura was a portion of inflamed lung substance the size of a large pea of a dark red colour. Examination of the dark spots on the pleura

and the intervening band showed tissues everywhere infiltrated with small and large cellular elements, in which the bulk of the pigment was held. The small corpuscles in appearance and size correspond to colourless blood corpuscles, which modern pathology has demonstrated leave the vessels in large numbers in the early stage of inflammation. Among these some were sparsely, others densely, crowded with dark granules. The larger cells were more than twice the size of the ones just described, and belong to the group of connective tissue corpuscles. Many were rounded or oval in outline, and these contained the greatest number of granules, while elongated, spindle shaped ones rarely contained any. Changes in outline, amœboid movements, were seen in most of these corpuscles. In a portion of the pulmonary pleura which was under the microscope a small net work of lymphatic vessels was rendered beautifully clear by the number of dark granules inside them. Unfortunately I was unable to sketch it, as on changing the object-glass for the purpose I accidentally let it fall upon the slide and damaged it for any further use. The curious phenomenon was seen in teased portions of the inflamed lung of cells containing red blood corpuscles. A considerable number of these were met having from six to ten corpuscles in their interior, others presented only a diffuse colouration.

Experiment V.—Into the right thorax of a four weeks' old kitten m x of a solution of Indian ink were injected, and the animal killed thirty-six hours after. A dark spot on the costal pleura corresponded to the point of entrance of the needle, but the layers of the pleura were not adherent. The lower lobe of the right lung presented a dark firm mass, about the size of a walnut, occupying its interior, and scattered round it were several other small dark spots involving both pleura and lung substance. The sub-sternal glands were slightly coloured, and those at the bifurcation of the trachea were dark superficially. Examination of the dark mass in the lung showed the air cells in a condition of inflammation, and everywhere crowded with leucocytes, in-

side which almost all the Indian ink granules were contained. So numerous were these cells that even in very thin sections hardly anything could be seen. At the margins of the healthy and inflamed portions larger corpuscles occurred, which were also filled with the dark granules, and a few were noticed containing red blood corpuscles. The lymph corpuscles of the glands, sub-sternal and bronchial, especially in the superficial region, contained numerous pigment granules.

These experiments serve to show how quickly irritating materials are taken up by cellular elements; and it is in precisely the same way that the carbon granules which reach the parenchyma of the lungs are fixed in the connective tissue corpuscles and so rendered harmless. In experiments 2, 3, and 4 the substernal glands were also more affected than the bronchial, as in these cases the pigment was chiefly about the pleura, and adhesions having taken place between the layers, the lymph bearing the Indian ink granules was conveyed in the vessels of the parietal layer to the glands under the sternum.

In cases three and four the pigmentation is not so extensive, and there is not the same certainty as to its source. In the absence of any history it is hard to say whether in the former case we have to deal with a condition produced by the inhalation of dust, or whether it is an excessively pigmented piece from an old man with chronic lung affection. The general firmness of the piece, the thickened pleura, the existence of caseous masses, and the absence on microscopical examination of large particles of carbon favour the the latter view; and if so, the pigment is to a large extent melanotic, i.e., proceeds from the hæmatin of the blood. Of course in all these cases a double origin may usually be attributed, for the process of physiological Anthracosis goes on constantly, whether there be disease in the lungs or not; but we have learned to regard the pigmentations occurring in the indurated areas about cavities or caseous masses as specially of blood origin, in as much as they are met with

in young children, in whom an Anthracosis is out of the question, and, also, because the extravasations are found in all stages of transformation from yellow up to a jet black. In the last case I think there is still less room for doubt. Here the irregular distribution of the pigment in circular patches, not following the interlobular septa beneath the pleura, to which situation it was in great part confined, a situation, moreover, shown by Virchow to be specially prone to extravasations, but, above all, the detection of extravasations in and about some of the pigmented areas, make it tolerably certain that this is a melanotic process. Whether this had any connection or not with the derangement of pigmentation in the skin, as was suggested, may be questioned. Melanosis as it ordinarily occurs is a very different thing from the physiological process of pigmentation. For the former to take place there must be either long continued congestion, amounting almost to stagnation, or else extravasation, under which circumstances the colouring matter of the corpuscles infiltrates the tissues, and there gradually undergoes a granular precipitation, forming the little particles known as melanin. If in a tissue containing cellular elements the bulk of the hæmatin finds its way into them, it may occur in them only; but if the extravasation takes place in the region of a fibrous tissue, like these indurated areas in the lungs, the colouring matter passes by imbibition among the various elements, and we find it there as a granular precipitate.

In the normal process, as it goes on for example in the *rete mucosum*, the cells obtain colouring matter from the nutritive plasma, without any stagnation or rupture of vessels. One pathological condition, met with in the pigmented Sarcomas, adheres to the physiological method, for the cells of these derive their pigment, in great part, from the plasma irrigating the tissue, but according to some observers, also from small capillary hæmorrhages.

It is interesting in this connection to refer to the corpuscles containing red blood corpuscles which were found

in the lungs of several of the kittens experimented upon. Here we have to do with an intravasation, or rather an ingestion of the coloured corpuscles within others. Many deny this, but as far as my observation goes there can be no doubt of the fact. In these corpuscles as many as six to ten were seen, in others again the outlines of the red corpuscles could not be detected, as if the cells had absorbed only the colouring matter. Nuclei and granular protoplasm were also seen—strange constituents, if, as some suppose, the appearance of a cell is caused by the separation of the fibrin round a group of red corpuscles. I have sketches in my possession of amœboid cells from newt's blood crowded with blood corpuscles of the guinea-pig, which were abundant in the serum with which the newt's blood was mixed for examination; and it is not at all unlikely that other amœboid cells, even in the tissues, should do the same thing. This is not a common way for cells to become pigmented, but there can be no doubt that these would rapidly have become so, and would then have been undistinguishable from many of the larger corpuscles containing Indian ink granules. To sum up—

I. The histological examination of these two specimens of miner's lung favours the view that in the early stage the process is confined to an increase in the fibrous elements about the bronchioles and vessels, and in certain emphysematous areas—a genuine Cirrhosis, or, as some would prefer to call it, an interstitial Pneumonia.

II. A considerable proportion of the carbon is contained in large cellular elements, which are specially abundant in the less pigmented, healthy portions, and in these it probably remains without much injury to the lung parenchyma. Another large part of the pigment lies free among the elements of the tissues, this being specially the case in the indurated spots, in the thickened pleura, and at the junction of the alveolar septa.

III. The extraneous origin of the carbon is proved by the detection in the lung of portions of fossilized vegetable tissue in the form of scalariform and dotted ducts.