

lung and the consequent greater abundance of the pus-corpuseles, the sputum becomes less and less tough and adhesive, and is thus less confluent and more easily brought up; it begins rather to take on a more or less distinctly nummular or irregularly globular form.

Fibrinous clots, also, are found in the sputum, and constitute one of its most important elements; their presence indicates that the terminal bronchi are occupied by the same plastic exudation that fills the alveoli (see p. 180). They may be recognised while still in the expectoration-dish, on turning up the latter and examining the secretion which clings to its sides. On separating and washing these portions of the sputum with water the fine arborescent ramifications of the casts may be seen under a powerful magnifying glass.—Towards the end of the stage of hepatization the secretions become more fluid and less transparent, and the fibrinous coagula increase in numbers; the blood present in the sputum diminishes in quantity, its colour deepens into a dark reddish-brown, and in the event of there being no new exudation into any part of the lung all trace of bright-red, recent blood entirely disappears.

The various characters described so far do not always present themselves in the exact order mentioned, as it frequently occurs that after complete hepatization of one section of the lung another part, hitherto exempt from the inflammation, is attacked and goes through all the phases of the pneumonic process. Thus, whilst some of the sputa have the properties of those associated with the end of the stage of hepatization and the beginning of that of resolution, certain others, coming presumably from the portions of lung most recently affected, may be loaded with blood and be exceedingly viscid.

3. In the *stage of resolution* the *rust colour* fades, and the sputum becomes yellowish or of a darker, citron-yellow tint, from the metamorphosis of its hæmoglobin; it is expectorated with less difficulty, as it diminishes steadily in viscosity and no longer adheres to the sides of the vessel; it grows gradually more and more opaque, from augmentation of the number of pus-cells it contains, while the fibrinous bronchial casts disappear or break down in fatty degeneration. The secretions thus come to resemble closely those of simple bronchial catarrh. They are at first considerably more abundant than in the stage of hepatization, but

become by degrees scantier, more mucous, watery, transparent, and colourless; and finally, when the resolution of the pneumonia is complete, expectoration ceases entirely, or for a few days longer a scanty, mucous, bronchial secretion is discharged.

The features which have been enumerated as characteristic of the sputum in the various stages of pneumonia relate only to croupous pneumonia running an absolutely normal course. Should the disease, however, not end in resolution, but tend rather to fatal termination from exhaustion of the vital powers of the patient, or from pulmonary œdema, the ordinary pneumonic sputum is replaced by a secretion of more fluid consistence, containing numerous air-bubbles, extremely frothy, and often stained of a dark reddish-brown colour from the continued presence of blood (the *prune-juice sputum*).

In the rare cases in which the pneumonia results in *pulmonary abscess* a certain period usually elapses in which no sputum is expectorated; this is followed by a sudden and profuse discharge of greenish-yellow, perfectly purulent sputum, very fluid in consistence, and more or less offensive in odour, possessing all the properties of pus obtained from an abscess in any other situation.

This homogeneous sputum, when examined either with the naked eye or with the microscope, is found to contain numerous shreds of dead pulmonary tissue, consisting of elastic fibres, fat-crystals, crystals of hæmatoidin, and black pigmentary matter and micrococci.—Chronic pneumonia, also, occasionally terminates in the formation of abscess. In the purulent or muco-purulent sputa brought up at intervals from such an abscess, similar fragments of lung-tissue are seen, having a densely fibrous, cicatricial appearance, quite in keeping with the stony hardness of the diseased structure from which they come; elastic fibres, also, and plates of cholesterin (Leyden), are often present in this sputum.

When pneumonia runs into *gangrene of the lungs*, (not a common occurrence), the expectoration becomes excessively fetid and of a dirty greyish colour, and is loaded with shreds of necrosed tissue and acicular crystals of the fatty acids (see p. 202).

The sputum of catarrhal pneumonia shows many points of difference from that of croupous pneumonia, the former affection being one which attacks primarily the bronchi, and spreads

downwards so as eventually to involve the aveoli; of this nature is the broncho-pneumonia which occurs in children and the aged, and not unfrequently also in persons of middle age. As this form of pneumonia is not attended by any extravasation of blood the sputum presents the characters only of a catarrh, being simply muco-purulent, or containing at most, when the lungs are deeply congested, a few slight and transient traces of blood.

The Sputum in Tuberculosis and Phthisis of the Lungs.

Acute miliary tuberculosis of the lungs gives a sputum in no respect different from that of simple bronchial catarrh.

The sputum in *chronic* cheesy degeneration, before the process of excavation has begun, consists almost exclusively of the catarrhal secretion of the bronchial mucous membrane, and is consequently indistinguishable, with the naked eye at least, from that of ordinary catarrh. On microscopic examination, however, elastic fibres are sometimes seen, an observation which of itself is conclusive evidence that a destructive process is going on, even in the absence of the usual physical signs of such a condition. The presence of pulmonary epithelium in the sputum, on the other hand, at one time looked upon as an infallible indication of that form of phthisis which is essentially a desquamative pneumonia, is not entitled to be so regarded, as pulmonary epithelial scales similarly altered in structure are occasionally found in the sputum of simple catarrh.

The quantity of the sputum generally depends on the intensity and extent of the bronchial catarrh accompanying the phthisis; it is therefore scanty at the outset of the disease, and becomes more abundant in its later stages. The expectoration may also be completely suppressed, at least for a time, particularly in case of remission or definite arrest of the progress of the disease.—Occasionally there is blood mingled with the secretion, in reddish specks or streaks, seldom in the form of a generally diffused coloration; if the admixture be of long duration or of frequent recurrence we may infer, with almost absolute certainty, the existence of chronic caseous infiltration of the lungs, even when the physical signs which mark this affection cannot be distinctly elicited.

On the formation of cavities in the lung-substance the sputa at once take on more specific characters; they are of firmer consistence, assume a rounded or nummular form, become more or less ragged at the edges, opaque, of a yellowish-green or dirty grey colour, contain little or no air, and sink in water (the *sputa rotunda, fundum petentia* of the early physicians).

Now and then the cavernous sputum contains blood, recently effused or of older date, disposed either in a thin layer on its surface or intimately mixed up in its substance; the secretion then presents a more or less intense coloration, varying from light red to reddish brown. The blood in this case has evidently leaked from the smaller vessels, whose walls are disorganised and broken down by the extension of the morbid process. In this sputum is usually also included a variable quantity of catarrhal bronchial and buccal secretion, which, being very thin and full of air-bubbles, floats on the surface of the fluid in the expectoration-glass. The larger the quantity of this catarrhal exudation and the more crowded it is with air-bubbles, particularly if it be brought up with considerable pain and effort, the greater difficulty is there in distinguishing between it and the proper cavernous sputum. Very frequently the latter, in these circumstances, does not sink to the bottom of the vessel, but is suspended in the general mass of expectorated matters, in the frothy, mucous layer near the top.

On microscopic examination of the cavernous sputum there are found multitudes of pus-cells (hence its opacity), free nuclei, detritus, and occasionally elastic fibres.

The cavernous sputum, fluctuating in quantity from time to time according as the morbid process is aggravated or arrested, retains for a considerable period the physical properties above described; but if the excavation be occupied by a profuse fluid secretion which stagnates there for some time, the sputa become of a dull muddy colour, acquire a somewhat offensive odour, diminish in consistence, lose all appearance of having any definite shape, and tend to coalesce in the crachoir.

In the species of consolidation of the lungs which do not lead to phthisis,—for example, in atelectasis of the lungs, due most commonly to prolonged compression by pleuritic exudation, or more rarely (when it is usually only partial) to compression

arising from some other cause, and, further, in the forms of collapse dependent on the blocking-up of large bronchi, and in condensation from hypostasis,—no characteristic sputum is discharged, but only such as owes its existence to the catarrh which accompanies these affections.

The Sputum in putrid Bronchitis and in Gangrene of the Lungs.

These two diseases have at least one feature in common,—there is associated with them a certain destruction of pulmonary tissue, the result of a putrefactive process, which, again, is probably set up in consequence of the introduction of bacteria or spores into the air-passages; as might be expected, therefore, the sputa also present some characters which are common to both. These, enumerated by Traube, are as follows: the sputa are very abundant, have a somewhat fluid consistence and a dirty greenish yellow colour, and separate into three strata on standing; the uppermost layer is greenish yellow, opaque, and frothy; the middle layer is strikingly transparent, albuminous, and almost serous in consistence; the undermost layer is yellow and opaque, and is composed almost exclusively of swollen pus-corpuscles and a detritus which contains a number of dull yellowish-white, soft *cores*,* whose size varies from that of a grain of millet or oats to the bulk of a bean; these cores have also an excessively *fetid* odour, and contain the *needle-shaped crystals of the fatty acids* described on p. 182.

The chief condition which seems to be necessary to the formation of these crystals is that the sputum should be retained for some time in the ulcerated gangrenous bronchi or cavities; this occurs particularly in sinuous excavations not in communication with any of the larger bronchi. Fatty crystals are therefore wanting in the secretions of a large cavity opening freely into a bronchus of considerable calibre, as in such a case the sputum is always at once ejected. In the same way also may be explained the fact

* Traube recognises four different stages in the development of these cores. In the beginning of the affection, when they are first discovered, they for the most part consist of pus-corpuscles and detritus; at a later period they become dirty grey, a colour which they always afterwards retain, while the débris enclosed in the purulent mass shows globules of fat. In the third stage they are composed chiefly of débris, within which not only the fatty globules but acicular crystals of fat are observed. In the fourth stage they are greatly increased in number and gathered together into bundles.

that putrefaction takes place so readily in bronchiectatic cavities while it is so exceedingly rare in those of phthisical origin; bronchiectatic cavities are situated in the *lower* lobes of the lung, and their secretions are brought up and expelled with greater difficulty, and therefore remain stagnant for a much longer period than those of phthisical cavities, which are generally situated in the *upper* lobes.

The sputum of pulmonary gangrene and that of the putrid stage of bronchiectasis are distinguished from those of other affections involving destruction of tissue (caseous pneumonia, pulmonary abscess) by containing *few or no elastic fibres*. The latter seem to be completely destroyed by the action of the putrefactive material, the chemical properties of which, however, are still unknown; the connective tissue of the lung, on the other hand, is not in any way affected by this material.

The element which effects the decomposition of the elastic fibres is evidently present in the sputum, as the filtrate of gangrenous sputa, while alkaline in reaction, completely dissolves elastic tissue (taken, for example, from the ligamentum nuchæ of the calf) and boiled white of egg in 1—4 days, but has no influence whatever on gelatin-yielding tissues; this process is therefore exactly analogous to that which goes on within the lungs. The material on the presence of which this action depends appears to be of the nature of a ferment. It, too, is subject to disorganization, as the filtered gangrenous sputa no longer have the power of dissolving elastic fibres when, at the end of a few days, they become cloudy and undergo further decomposition. The contents of gangrenous cavities also, after removal from the dead body, and indeed all other putrid fluids whatsoever, proved equally powerless to effect the solution of elastic tissue (Filehne).

Chemical examination (by Jaffe) has shown that ammonia, sulphuretted hydrogen, leucin and tyrosin, volatile fatty acids (butyric acid), enter into the composition of the sputum in pulmonary gangrene and putrid bronchitis.—On being introduced into the trachea of animals, the gangrenous cores described above convey infection to the healthy tissues, if not at once expelled by coughing. This is usually followed by the occurrence of local, circumscribed pneumonic inflammations (particularly in the case of rabbits), or even by gangrene of the lungs (Leyden and Jaffe). The inflammation seems to be really due to the presence of vegetable parasites, which have been discovered by Fürbringer in great numbers in the gangrenous masses; the fungi consisted chiefly of the *aspergillus niger* and *muçor*.—These same fungous growths and, under certain circumstances, even acicular fatty crystals, like those of the sputum in pulmonary gangrene, may be developed in a simple catarrhal sputum which has been exposed some time to the air.

The Sputum in Bronchiectasis.

It has the characters of the muco-purulent sputum, is generally yellowish-green or dirty greenish-white in colour, homogeneous and confluent. In colour and consistence, as in its microscopic elements, it thus differs in no respect from the expectoration in chronic bronchial catarrh; in both cases it is the result of hypersecretion from the bronchial mucous membrane. Since, however, the bronchial secretion stagnates for a longer or shorter period in the dilated bronchi, not only when the latter are cylindrical in shape but also when they are sacculated, both of which conditions are generally present together, it acquires an *offensive odour*, which frequently has a certain resemblance to that which pervades a soap manufactory; the smell is most penetrating when the sputum is recently expectorated, and becomes less intense when the secretion has stood some time in the vessel.—The bronchiectatic sputum is, further, brought up only at long intervals, and then in large quantity. As the sensibility of the walls of the bronchiectatic cavity is greatly diminished the fluid accumulates till it reaches the orifice of the communicating bronchus; violent coughing is now excited and the sputum is ejected, when the patient has rest again for a period usually of several hours, expectorating at most only a little catarrhal sputum, till the cavity is filled anew, and the same process is repeated.

The quantity of sputum discharged in the twenty-four hours may amount to several hundreds of grammes; it is usually somewhat greater in the morning, as the secretion gathers in the cavity during the night. The fetid odour and the periodical evacuation of a large quantity of sputum, serve to distinguish the bronchiectatic secretion from that proceeding from phthisical excavations.

In the expectoration-dish the bronchiectatic sputum usually separates into two or three layers, the upper of which is transparent and very fluid, the lower opaque, almost exclusively purulent, and resting on the bottom of the glass; the middle stratum consists chiefly of a quantity of flocculent mucus.

On the subsidence of the bronchial catarrh which attends every case of bronchiectasis, considerably less fluid is secreted, and as expectoration becomes more easy the sputum loses its fœtor, and is then almost identical in character with the muco-purulent

sputum of bronchial catarrh. If, on the other hand, simple bronchiectasis is followed by ulceration of the dilated bronchi, and if, further, under the influence of minute vegetable or animal organisms, which find their way into the air-passages and there multiply and develop, a putrefactive decomposition of the secretions sets in (particularly in summer), the needle-shaped crystals of the fatty acids, mentioned on p. 202 when discussing putrid bronchitis and pulmonary gangrene, are found in the sputum.