broncho-pneumonia. It is only, however, when complete fibroid transformation or calcification has occurred that we can really speak of healing. In many instances the colonies of miliary tubercles about these masses show that the virus is still active in them. Subsequently, in ulcerative processes, these calcareous bodies — lung-stones, as they are sometimes called—may be expectorated.

(*c*) *Pneumonia.*—An important though secondary place is occupied by inflammation of the alveoli surrounding the tubercles, which become filled with epithelioid cells. The consolidation may extend for some distance about the tuberculous foci and unite them into areas of uniform consolidation. Although in some instances this inflammatory process may be simple, in others it is undoubtedly specific. It is excited by the tubercle bacilli and is a manifestation of their action. It may present a very varied appearance; in some instances resembling closely ordinary red hepatization, in others more homogeneous and infiltrated, the so-called *infiltration tuberculeuse* of Laennec. In other cases the contents of the alveoli undergo fatty degeneration, and appear on the cut surface as opaque white or yellowish-white bodies. In early phthisis much of the consolidation is due to this pneumonic infiltration, which may surround for some distance the smaller tuberculous foci.

(*d*) *Cavities.*—A vomica is a cavity in the lung tissue, produced by necrosis and ulceration. It differs materially from the bronchiectatic form. The process usually begins in the wall of the bronchus in a tuberculous area. Dilatation is produced by retained secretion, and necrosis and ulceration of the wall occur with gradual destruction of the contiguous tissues. By extension of the necrosis and ulceration the cavity increases, contiguous ones unite, and in an affected region there may be a series of small excavations communicating with a bronchus. In nearly all instances the process extends from the bronchi, though it is possible for necrosis and softening to take place in the centre of a caseous area without primary involvement of the bronchial wall. Three forms of cavities may be recognized:

The *fresh ulcerative*, seen in acute phthisis, in which there is no limiting membrane, but the walls are made up of softened, necrotic, and caseous masses. Small vomicæ of this sort, situated just beneath the pleura, may rupture and cause pneumothorax. In cases of acute tuberculo-pneumonic phthisis they may be large, occupying the greater portion of the upper lobe. In the chronic ulcerative phthisis, cavities of this sort are invariably present in those portions of the lung in which the disease is advancing. At the apex there may be a large old cavity with well-defined walls, while at the anterior margin of the upper lobes, or in the apices of the lower lobe, there are recent ulcerating cavities communicating with the bronchi.

Cavities with well-defined walls.—A majority of the cavities in the chronic form of phthisis have a well-defined limiting membrane, the inner surface of which constantly produces pus. The walls are crossed by trabeculæ which represent remnants of bronchi and blood-vessels. Even the vomicæ with the well-defined walls extend gradually by a slow necrosis and destruction of the contiguous lung tissue. The contents are usually purulent, similar in character to the grayish nummular sputa coughed up by phthisical patients. Not infrequently the membrane is vascular or it may be hæmorrhagic. Occasionally, when gangrene has occurred in the wall, the contents are horribly fœtid. These cavities may occupy the greater portion of the apex, forming an irregular series which communicate with each other and with the bronchi, or the entire upper lobe except the anterior margin may be excavated, forming a thin-walled cavity. In rare instances the process has proceeded to total excavation of the lung, not a remnant of which remains, except perhaps a narrow strip at the anterior margin. In a case of this kind, in a young girl, the cavity held forty fluidounces.

Quiescent Cavities.—When quite small and surrounded by dense cicatricial tissue communicating with the bronchi they form the *cicatrices fistuleuses* of Laennec. Occasionally one apex may be represented by a series of these small cavities, surrounded by dense fibrous tissue. The lining membrane of these old cavities may be quite smooth, almost like a mucous membrane. Cavities of any size do not heal completely.

Cases are often seen in which it has been supposed that a cavity has healed; but the signs of excavation are notoriously uncertain, and there may be pectoriloquy and cavernous sounds with gurgling, resonant râles in an area of consolidation close to a large bronchus.

In the formation of vomicæ the blood-vessels gradually become closed by an obliterating inflammation. They are the last structures to yield and may be completely exposed in a cavity, even when the circulation is still going on in them. Unfortunately, the erosion of a large vessel which has not yet been obliterated is by no means infrequent, and causes profuse and often fatal hæmorrhage. Another common event is the development of aneurisms on the arteries running in the walls of cavities. These may be small, bunch-like dilatations, or they may form cavities the size of a walnut or even larger. Rasmussen, Douglas Powell and others have called attention to their importance in hæmoptysis, under which section they are dealt with more fully.

And finally, about cavities of all sorts, the connective tissue develops and tends to limit the extent. The thickening is particularly marked beneath the pleura, and in chronic cases an entire apex may be converted into a mass of fibrous tissue, enclosing a few small cavities.

(*e*) *Pleura.*—Practically, in all cases of chronic phthisis the pleura is involved. Adhesions take place which may be thin and readily torn, or dense and firm, uniting layers of from two to five millimetres in thickness. This pleurisy may be simple, but in many cases it is tuberculous, and miliary tubercles or caseous masses are seen in the thickened pleural mem-

brane. Pleural effusion is not at all infrequent, either serous, purulent, or hæmorrhagic. Pneumothorax is a common accident.

(*f*) Changes in the *smaller bronchi* control the situation in the early stages of tuberculous phthisis, and play an important *rôle* throughout the disease. The process very often begins in the walls of the smaller tubes and leads to caseation, distention with products of inflammation, and broncho-pneumonia of the lobules. In many cases the visible implication of the bronchus is an extension upward of a process which has begun in the smallest bronchiole. This involvement weakens the wall, leading to bronchiectasis, not an uncommon event in phthisis. The mucous membrane of the larger bronchi, which is usually involved in a chronic catarrh, is more or less swollen, and in some instances ulcerated.

(*g*) The *bronchial glands*, in the more acute cases, are swollen and œdematous. Miliary tubercles and caseous foci are usually present. In cases of chronic phthisis the caseous areas are common, calcification may occur, and not infrequently purulent softening.

(*h*) *Changes in the other Organs.*—Of these, tuberculosis is the most common. In my series of autopsies the brain presented tuberculous lesions in 31, the spleen in 33, the liver in 12, the kidneys in 32, the intestines in 65, and the pericardium in 7. Other groups of lymphatic glands besides the bronchial may be affected—the cervical, the mediastinal, and the retro-peritoneal.

Certain degenerations are common. *Amyloid change* is frequent in the liver, spleen, kidneys, and mucous membrane of the intestines. The *liver* is often the seat of extensive fatty infiltration, which may cause marked enlargement. The *intestinal tuberculosis* occurs in advanced cases and is responsible in great part for the troublesome diarrhœa.

Endocarditis is not very uncommon, and was present in 12 of my post-mortems and in 27 of Percy Kidd's 500 cases. Tubercles may be present on the endocardium, particularly of the right ventricle. As pointed out by Norman Chevers and confirmed by subsequent writers, the subjects of congenital stenosis of the pulmonary orifice very frequently have phthisis.

The *larynx* is frequently involved, and ulceration of the vocal cords and destruction of the epiglottis are not at all uncommon.

Modes of Onset.—We have already seen that tuberculosis of the lungs may occur as the chief part of a general infection, or may set in with symptoms which closely simulate acute pneumonia. In the ordinary type of pulmonary tuberculosis the invasion is gradual and less striking, but presents an extraordinarily diverse picture, so that the practitioner is often led into error. Among the most characteristic of these types of onset are the following: (*a*) *With dyspeptic and anæmic symptoms*, forming a large and important group. The patients may naturally have had feeble digestion. They begin to show marked signs of dyspepsia and become pale, lose flesh, and look chlorotic before any pulmonary symptoms are manifest. (*b*) *With chills and fever.* This mode of onset is particularly important in malarial regions, as the diagnosis of ordinary intermittent fever is often made, and the nature of the disease entirely overlooked. In Philadelphia it was very common to have patients sent to hospital supposed to be suffering with malaria, who had well-developed signs of pulmonary tuberculosis. (*c*) *Bronchitic onset.* These are the instances which arise in what the patient calls a neglected cold. The patient has perhaps been subject to naso-pharyngeal catarrh, and has been liable to take cold readily; then a bronchial cough develops, which proves intractable. Sometimes the bronchitic symptoms are associated with wheezing, like mild asthma. The development in these instances may be extremely insidious and, without any special aggravation of the general symptoms or increase in the fever, the tuberculous nature of the trouble may be discovered accidentally by the examination of the sputum. (*d*) *Onset with hæmoptysis.* The relation of hæmoptysis to pulmonary tuberculosis will be discussed elsewhere. The hæmoptysis may come on in a condition of robust health, and it occasionally, though rarely, happens that the pulmonary symptoms follow rapidly. In other cases a long interval elapses. Undoubtedly these are cases in which there has been a small localized lesion in the lung which has not produced constitutional disturbance. (*e*) *Pleuritic onset.* This may be a dry pleurisy, developing at the apex or in a scapular region, or in some instances extending generally. It may be acute pleurisy with effusion, or the effusion may have come on insidiously without any acute manifestations. Phthisis developed in a third of ninety cases of pleurisy with effusion, the subsequent history of which was followed by Bowditch. (*f*) *With laryngeal symptoms.* In rare instances huskiness and loss of voice are the symptoms for which the patient seeks advice, and the epiglottis or cords may be involved in a well-characterized tuberculosis before the physical signs in the lungs are at all clear. It is in these instances that the examination of the sputa is of the greatest value.

These represent the usual modes of onset of the ordinary chronic phthisis. It occasionally happens that in an instance with an acute pneumonic onset the severity of the symptoms subsides, and, instead of terminating as a majority of these cases do within ten or twelve weeks, the case drags on and becomes chronic.

Symptoms.—In discussing the symptoms it is usual to divide the disease into three periods: the first embracing the time of the growth and development of the tubercles; the second, in which they soften; and the third, in which there is a formation of cavities. Unfortunately, these anatomical stages can not be satisfactorily correlated with corresponding clinical periods, and we often find that a patient in the third stage with well-marked cavity is in a far better condition and has greater prospects of recovery than a patient in the first stage with diffuse consolidation. It is therefore better perhaps to disregard them altogether.

1. **Local Symptoms.**—*Pain* in the chest may be early and troublesome or absent throughout. It is usually associated with pleurisy, and may be sharp and stabbing in character, and either constant or felt only during coughing. Perhaps the commonest situation is in the lower thoracic zone, though in some instances it is beneath the scapula or referred to the apex. The attacks may recur at long intervals. Intercostal neuralgia occasionally develops in the course of ordinary phthisis.

Cough is one of the earliest symptoms, and is present in the majority of cases from beginning to end. There is nothing peculiar or distinctive about it. At first dry and hacking, and perhaps scarcely exciting the attention of the patient, it subsequently becomes looser, more constant, and associated with a glairy, muco-purulent expectoration. In the early stages of the disease the cough is bronchial in its origin. When cavities have formed it becomes more paroxysmal, and is most marked in the morning or after a sleep. Cough is not a constant symptom, however, and a patient may present himself with well-marked excavation at one apex who will declare that he has had little or no cough. So, too, there may be well-marked physical signs, dulness and moist sounds, without either expectoration or cough. In well-established cases the nocturnal paroxysms are most distressing and prevent sleep. The cough may be of such persistence and severity as to cause vomiting, and the patient becomes rapidly emaciated from loss of food.

Sputum.—This varies greatly in amount and character at the different stages of ordinary phthisis. There are cases with well-marked local signs at one apex, with slight cough and moderately high fever, without from day to day a trace of expectoration. So, also, there are instances with the most extensive consolidation (caseous pneumonia), with high fever, and, as in a recent instance under observation for several months, without enough expectoration to enable an examination for bacilli to be made. In the early stage of pulmonary tuberculosis the sputum is chiefly catarrhal and has a glairy, sago-like appearance, due to the presence of alveolar cells which have undergone the myelin degeneration. There is nothing distinctive or peculiar in this form of expectoration, which may persist for months without indicating serious trouble. The earliest trace of characteristic sputum is seen in the presence of small grayish or greenish-gray purulent masses. These, when coughed up, are always suggestive and should be the portions picked out for microscopical examination. As softening comes on, the expectoration becomes more profuse and purulent, but may still contain a considerable quantity of alveolar epithelium. Finally, when cavities exist, the sputa assume the so-called nummular form; each mass is isolated, flattened, greenish-gray in color, quite airless, and sinks to the bottom when spat into water.

By the microscopical examination of the sputum we determine whether the process is tuberculous, and whether softening has occurred. For *tubercle bacilli* the Ehrlich-Weigert method is the best. Eleven centimetres

of a saturated solution of fuchsin in absolute alcohol is added to one hundred centimetres of the saturated solution of commercial aniline oil (made by shaking up the oil in water and then filtering). This should be made fresh every third or fourth day. A small bit of the sputum is picked out on a needle or platinum wire and spread thin on the top-cover so as to make a uniformly thin layer. The top-cover is slowly dried about a foot above a Bunsen burner. Sufficient of the staining fluid is then dropped upon the top-cover, which is held at a little distance above the flame until the fluid boils. The staining fluid is then washed off in distilled water or put under the tap, decolorized in thirty per cent nitric-acid fluid, again washed off in water, and mounted on the slide. In doubtful cases the long process is used, the cover-slips remaining twenty-four hours in the stain. The bacilli are seen as elongated, slightly curved, red rods, sometimes presenting a beaded appearance. They are frequently in groups of three or four, but the number varies considerably. Only one or two may be found in a preparation, or, in some instances, they are so abundant that the entire field is occupied.

The presence of these bacilli in the sputum is an infallible indication of the existence of tuberculosis.

Sometimes they are found only after repeated examination. They may be abundant early in the disease and are usually numerous in the nummular sputum of the later stages.

Elastic tissue may be derived from the bronchi, the alveoli, or from the arterial coats; and naturally the appearance of the tissue will vary with the locality from which it comes. In the examination for this it is not necessary to boil the sputum with caustic potash. For years I have used a simple plan which was shown to me at the London Hospital by Sir Andrew Clark. This method depends upon the fact that in almost all instances if the sputum is spread in a sufficiently thin layer the fragments of elastic tissue can be seen with the naked eye. The thick, purulent portions are placed upon a glass plate fifteen by fifteen centimetres and flattened into a thin layer by a second glass plate ten by ten centimetres. In this compressed grayish layer between the glass slips any fragments of elastic tissue show on a black background as grayish-yellow spots and can either be examined at once under a low power or the uppermost piece of glass is slid along until the fragment is exposed, when it is picked out and placed upon the ordinary microscopic slide. Fragments of bread and collections of milk-globules may also present an opaque white appearance, but with a little practice they can readily be recognized. Fragments of epithelium from the tongue, infiltrated with micrococci, are still more deceptive, but the microscope at once shows the difference.

The bronchial elastic tissue forms an elongated network, or two or three long, narrow fibres are found close together. From the blood-vessels a somewhat similar form may be seen and occasionally a distinct

sheeting is found as if it had come from the intima of a good-sized artery. The elastic tissue of the alveolar wall is quite distinctive; the fibres are branched and often show the outline of the arrangement of the air-cells. The elastic tissue from bronchus or alveoli indicates extensive erosion of a tube and softening of the lung-tissue.

Another occasional constituent of the sputum is blood, which may be present as the chief constituent of the expectoration in hæmoptysis or may simply tinge the sputum. In chronic cases with large cavities, in addition to bacteria, various forms of fungi may develop, of which the aspergillus is the most important. Sarcinæ may also occur.

The daily amount of expectoration varies. In rapidly advancing cases, with much cough, it may reach as high as five hundred cubic centimetres in the day. In cases with large cavities the chief amount is brought up in the morning. The expectoration of tuberculous patients usually has a heavy, sweetish odor, and occasionally it is fetid, owing to decomposition in the cavities.

Hæmoptysis.—Hæmoptysis is met with either early in the disease, before there are physical signs, or during the course of the affection when there is softening or excavation. A majority of the hæmorrhages believed to be precursory are really due to already existing disease of the lung, and there is no ground whatever for the opinion, so long held, that phthisis can originate directly from hæmoptysis. The blood may be either pure or mixed with sputum. A distinction should be made between these two forms. When the sputa are simply tinged or the blood is admixed, it comes, in all probability, from hyperæmic bronchial mucosa or locally congested areas of lung-tissue; but the brisk hæmorrhage in which the blood comes up in mouthfuls is always due to erosion of vessels, small or large, in the process of softening, or, in the later stages of the disease, comes from the erosion of a branch of the pulmonary artery or from a ruptured aneurism of the pulmonary artery in a cavity. This latter is the most frequent cause of the fatal hæmorrhage in consumption.

Dyspnœa is not a common accompaniment of ordinary phthisis. The greater part of one lung may be diseased and local trouble exist at the other apex without any shortness of breath. Even in the paroxysms of very high fever the respirations may not be much increased. Rapid advance, as of a broncho-pneumonic process, or the development of miliary tubercles throughout the lung, causes great increase in the number of respirations. A degree of dyspnœa leading to cyanosis is almost unknown, apart from extensive invasion of the sound portions by miliary tubercles. One reason why there is so little shortness of breath in phthisis is that there is always a moderate grade of anæmia, and the diminished lung-space is sufficient to supply oxygen to the reduced number of blood-corpuscles.

2. **General Symptoms.**—*Fever.*—To get a correct idea of the temperature range in pulmonary tuberculosis it is necessary, as Ringer pointed

out, to make tolerably frequent observations. The usual 8 A. M. and 8 P. M. record is, in a majority of the cases, very deceptive, giving neither the minimum nor maximum. The former usually occurs between 2 and 6 A. M. and the latter between 2 and 6 P. M.

A recognition of various forms of fever, viz., of tuberculization, of ulceration, and of absorption, emphasizes the anatomical stages of growth, softening and cavity formation; but practically such a division is of little use, as in a majority of cases these processes are going on together.

Fever is the most important initial symptom and throughout the entire course the thermometer is the most trustworthy guide as to the progress of the affection. With pyrexia a patient loses in weight and strength, and the local disease usually progresses. The periods of apyrexia are those of gain in weight and strength and in limitation of the local lesion. It by no means necessarily follows that a patient with tuberculosis has pyrexia. There may be quite extensive disease without coexisting fever. At the moment of writing, I have eighteen instances of chronic phthisis under observation, of whom ten are practically free from fever; but in the early stage, when tubercles are developing and caseous areas are in process of formation and when softening is in progress, fever is a constant symptom. It was present in one hundred consecutive cases at my dispensary service.

Two types of fever are seen—the remittent and the intermittent. These may occur indifferently in the early or in the late stages of the disease or may alternate with each other, a variability which depends upon the fact that phthisis is a progressive disease and that all stages of lesions may be found in a single lung. Special stress should be laid upon the fact, particularly in malarial regions, that tuberculosis may set in with a fever typically intermittent in character—a daily chill, with subsequent fever and sweat. In Montreal, where malaria is practically unknown, this was always regarded as a suggestive symptom; but in Philadelphia and Baltimore, where ague prevails, it is no exaggeration to say that yearly scores of cases of early tuberculosis are treated for ague. These are often cases that pursue a rapid course. The fever of onset—tuberculization—may be almost continuous, with slight daily exacerbations; and at any time during the course of chronic phthisis, if there is rapid extension, the remissions become less marked.

A remittent fever, in which the temperature is constantly above normal but drops two or three degrees toward morning, is not uncommon in the middle and later stages and is usually associated with softening or extension of the disease. Here, too, a simple morning and evening register may give an entirely erroneous idea as to the range of the fever. With breaking down of the lung-tissue and formation of cavities, associated as these processes always are with suppuration and with more or less systemic contamination, the fever assumes a characteristically intermittent or hectic type. For a large part of the day the patient is not only afebrile,