OBSERVATIONS
ON THE
MORBID STRUCTURE
OF
BONES,
AND
ATTEMPT AT AN ARRANGEMENT
OF THEIR
DISEASES. 71

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THE object of my former inquiry * was to ascertain the particular instruments, by means of which the animal economy is enabled to produce the successive changes that take place in the texture and appearance of bones, during the period of growth; and also to determine precisely their minute structure in that stage of life, when, from having ceased to grow, they may be considered as being completely formed.

In my former experiments I endeavoured to de-

* See Med. Chir. Trans. Vol. VI. and VII.

monstrate several new facts, relating to the organization and economy of healthy bone ; which facts will, I trust, throw some additional light upon this very beautiful, although exceedingly intricate department of anatomy. I now propose to continue the investigation, by the examination of the appearances and structure of bone under the influence of disease.

It is, however, with extreme diffidence that I undertake this task, feeling as I do my inadequacy to so extended a research, and aware that however earnest may be my desire to promote the advancement of our knowledge in pathology, the exertions of a single individual can but rarely prove of any considerable value, unless they are happily assisted by many fortuitous circumstances.

With the exception of some few works, little information, as far as my reading extends, is to be met with in books upon the diseases of bones ; for most of those professedly written upon this subject are almost exclusively confined to the consideration of fractures and dislocations, which, strictly speaking, are the consequences of accident, and not of disease.

The only individual who seems to me to have studied this branch of surgery profoundly, was the late Mr. Hunter, who, with his characteristic penetration and singularly happy genius, has arranged

the affections of bones according to their appearances.

From Mr. Hunter's writings, and particularly from his lectures, it is evident that he was much more intimately acquainted with the principles of diseased action in bones, than any author who has yet attended to the subject. But even this great man frankly acknowledges himself at a loss how to explain some of those changes that bone undergoes in disease; although, had he applied the powers of which he was master to a more particular inquiry into the early stages of evolution and growth, there can be little doubt but that he would have been enabled to unravel with facility, most of those points which even to him remained inexplicable.

The imperfect state of our knowledge as to the diseases of the bones, has arisen partly from the subject, necessarily obscure, having been treated with neglect. The study of minute anatomy was never prosecuted with so much ardour as it is in the present day; neither were the advances of physiological improvement at any former period so rapid, as at the present moment. Independent of which considerations, it is most true, that in no department of anatomy is the assistance of the microscope so important and even indispensable, as in the unfolding the minute organization of bone; and the want of confidence that some have thought

proper to express with regard to investigations of this nature, must by every thinking person be attributed to a deficient knowledge of the most obvious principles of optics, rather than to any imperfection in the instrument employed.

In the attention hitherto devoted to this subject, I have enjoyed very considerable advantages in having recourse to one of the most valuable and most extensive collections of diseased bones, of any in this country; and it affords me singular pleasure to acknowledge upon this occasion, the kindness and friendship of Mr. Heaviside, who, with a spirit of liberality that always distinguishes the true friends of scientific research, has not only allowed me constant access to the above collection, but has also given me permission to remove, for more particular examination, such parts of any of the preparations as might appear to be essential to the success of the inquiry.

But notwithstanding these and other facilities, the endless diversity that occurs in the appearance of the same disease under different circumstances of age and constitution, as well as the occasional impossibility of making out the precise progress of symptoms, must still be regarded as unavoidable difficulties, which can be surmounted only by time and activity*.

* I shall feel myself particularly obliged to any gentlemen, who may have it in their power to assist me, by the favour of
any

The following observations are intended to be directed principally to the ascertaining the morbid anatomy, or structure, of the various diseases. This mode of procedure appears to be the most proper, because the most cautious, and least likely to lead astray ; and also because I am not without hope that my labours may thus prove useful, by affording at some future time a series of new data, for others more competent than myself to reason upon.

I shall not, however, bring forward merely the appearances of disease, but endeavour, as far as either our previous knowledge of the subject, or the results of my preceding inquiries may enable me, to point out the mode in which each particular disease takes place, noticing also the successive gradations of those processes set up by the constitution with a view to the preservation of life, or the restoration of health.

With regard to the diseases of bone, it will be readily admitted that there must be some certain and fixed principles, by which the operations of these parts of the machine are regulated, under disease as well as in health, similar to what we observe in affections of soft parts; but these principles have hitherto remained almost entirely un-

any such history or specimen of disease in bone, as may chance to fall under their observation, in the course of this inquiry.

known, a circumstance which has apparently arisen from the want of information with regard to the healthy structure and minute anatomy of bone.

Some anatomists, particularly Havers, pointed out the existence of a membranous expansion within the medullary cavities of the large bones; and from having occasionally perceived minute arteries perforating the substance of the bone, they concluded that the compact texture of bone must be in some degree vascular; farther examinations and subsequent inquiries also led to the opinion, that in some cases the minute canals through the bones might perhaps be furnished with membranous processes, extending outwards from the medullary cavity, and inwards from the periosteum.

I am not, however, aware that any series of experiments, previous to those which I have had the honour to lay before this Society, had demonstrated the existence, vascularity, and functions of membranous sheaths within even the smallest tube and canal contained in bone. The various facts brought forward with relation to this subject, appear to me to place the healthy economy of bone in a new point of view.

The small space occupied by the blood-vessels of the canals, compared with that which is found to be allotted to the secretions and membranes of these cavities, distinctly prove that the circulation

must, under all circumstances, enjoy as much freedom here as elsewhere; and the intimate connection formed by these canals between all parts of the bones and the surrounding soft parts, affords the strongest ground for believing, that the minute vascular and membranous organization of the bones is as susceptible of impressions from irritation, or sympathy, as the muscular, glandular, or other soft structures of the fabric.

I have elsewhere demonstrated the ease with which the continually varied operation of pressure is established in the animal machine during the successive stages of growth*; it is thence easy to transfer the idea to the same parts, when placed under the influence of disease, which will at once afford the true explanation of many appearances, that were not to be satisfactorily accounted for upon any other principle.

In the diseases of the soft parts of the human body, particularly in affections of membranous parts, either from irritation or inflammation, we are upon examination generally able to distinguish some one spot which may be regarded as the central point, round which, according to the distance, the lesser consequences of the impression graduate. If, for example, a central spot is ulcerated and sloughy, the first circle surrounding it shall

* See Med. Chir. Trans. Vol. VI.

be that of high inflammation, the next a more moderate degree of the same action, and beyond this again shall be perceived only those effects that arise from irritation alone. From all I have observed, or have been able to ascertain, I am convinced that the same observation will bear a more extensive application, the same law regulating and directing the sphere of irritation in the various diseases of the bones, hastening some actions, retarding others, but ever varying the balance so as to favour the accomplishment of the object held in view, the final restoration of health. It is this which Mr. Hunter has styled continuous sympathy; and if the name be objectionable, it nevertheless expresses very well a rule of action, by which most of the morbid changes incident to the living body appear to be materially influenced.

By reference to the various writers on the diseases of bones, it will be seen, that some authors have held that an effusion of purulent matter upon bone operates by dissolving the ossific structure; and even a late writer*, who certainly deserves very great credit for his application as well as ingenuity, says, "the dissolution of the sequestra is doubtless very much accelerated by the solvent power of the purulent matter by which it is surrounded." This opinion, however, I cannot help dissenting from entirely; for although I have looked

* Russell on Necrosis, p. 68.

over the diseased bones in the best collections in London, and have attended pretty closely to the question at the bedside also, I have never seen any appearance to support such a conjecture; on the contrary, I have even assumed, as a point upon which many of the following observations rest, that in every case in which bone is acted upon, the soft solids have been in close contact with it, that consequently the sections of all the minute cavities must give an accurate outline of the external figure of the contents, and that whenever bone is removed it happens through the immediate agency of absorption.

But I have discovered that in some affections of bone, the minute longitudinal canals become uniformly larger, retaining their smooth and polished surfaces, while in others they are less equally enlarged, the sides of the cavities exhibiting a rough and uneven appearance; and I have thence inferred, that under the influence of some diseases, the membranes of these canals become absorbing surfaces without losing their naturally smooth even texture, while in others they not only become thicker and more vascular, but take on a granulated structure externally, where the surface of absorption acts upon the surrounding bone; and although these facts are new, they are by no means singular, for they exhibit a parallel to what happens in other parts under excitement. That a smooth membranous surface may be rendered capable of ab-

absorbing bone is certainly a very curious circumstance; but it is nevertheless a fact established by occasional observation; one instance of which, where the surface of the dura mater was seen to perform this office, I have already mentioned in another place*; and as to the membranes within the canals taking on the form of granulations preparatory to their commencing the action of absorption, it is only what we see happen to the periosteum, wherever it is placed under circumstances fitting it for absorbing bone.

A very curious and interesting point of inquiry regards the actual existence of absorbent vessels within the minute structure of bone. It has been generally presumed, that wherever blood-vessels can be traced for laying down the various structures of the body, there must be absorbents also, to take them up again; but this is one of the many speculative points which has been taken for granted without being proved. We have not, it is true, been able either to disprove or to demonstrate their existence in these situations; but it appears reasonable to set some limits to our belief, and considering that the mean diameter of the longitudinal canals in bone has been shewn to be only equal to the $\frac{1}{200}$ th part of an inch, and that the vessels within them are proved to be much smaller†;

* See Practical Observations in Surgery and Morbid Anatomy.

† See Med. Chir. Trans. Vol. VII. page 401.

and reflecting at the same time upon the well-known axiom in all the operations of nature, that of preferring simplicity to complication, it becomes at least exceedingly probable, that the minute branches of the veins are in these minute canals appointed to perform the office, and conduct the function of absorption : and the opinion is supported by the experiments of some of the most celebrated physiologists; for Baron Haller, as well as Mr. Cruikshanks, have repeatedly proved the origin of absorbent vessels from the cavities of the veins, by having injected them from the veins; a circumstance which clearly implies, that the capillary branches of veins do contain matters not intended to be conveyed at once into the general mass of circulating fluids.

Now, with regard to the mode in which the condition of bone is changed previous to being taken up by absorption, there has been much diversity of opinion. Mr. Hunter admitted he did not know how absorption was performed, but he believed that the absorbents of surrounding living parts were capable of elongating themselves and of absorbing dead bone, which we see sometimes partially, sometimes wholly, removed. Mr. Cruikshanks says, " It is possible, that previous to the absorption of a solid, the parts immediately to be absorbed may be broken down, mixed with, or even converted into fluids*." One of our most deservedly eminent

* See Cruikshanks on the Absorbents, page 111.

teachers in medicine*, considers the affinity of aggregation as exhibiting the nearest approach to that species of cohesion, by which the particles of earth in bone are held together; and the experiments of Mr. Charles Hatchett, as well as those examinations I have myself instituted, prove that the particles of earth in bone certainly possess an animal medium, a reticulated gelatinous matter; and although it is only in the bones of young birds that I have hitherto been able distinctly to see the ultimate reticulated texture, the results of the operation by which I have been in the habit of removing the animal matter from the bones of various animals, demonstrate the equal distribution of that principle, as the constant basis of every ossific structure.

My own opinion is, that in every instance where bone is absorbed, the process is commenced by the agency of some power exerting itself in the blood circulated over the part, by which the state of the animal principle is changed, and the particles of earth let loose, so as to be ready for removal by absorption; and although we yet know very little upon the subject, I think I shall be able to demonstrate that the interstitial absorption of bone takes place by the different modifications of action of the same vessels, and the same membranous sheaths. There is the slow absorption incident to growth and

* Dr. Hooper.

health ; and that which occurs in connection with healthy inflammation of bone ; besides the absorption that takes place during the existence of venereal complaints, and the use of mercury ; and many others.

It is presumable that the extremely minute circulation which has been demonstrated to exist in the interstitial parts of bone, may, like the other systems connected with the machine, be capable of varying and modifying the actions of its vessels in a manner peculiar to itself ; and that dependent on the variations of action in the blood-vessels, will be the particular affinities, at one time favoured and at another retarded. It also seems to me extremely probable that the galvanic influence, which in some late experiments has been found to exert a power as curious as unexpected, in arranging and separating the elementary constituents of animal fluids, is evolved in the blood, by the action of the vessels upon their contents ; and that the particular arrangement of the vessels regulates the resistance and motion of the blood in such manner as may best insure the evolution of the precise measure of animal electricity that is required for the production and disposition of the new combinations.

Having premised the above general remarks, I shall now proceed to the consideration of the diseases of bone.

The intention of making a series of examinations necessarily supposes some plan, or arrangement of the subject; but the reducing the diseases of the bones into any kind of arrangement, is by no means an easy undertaking. Indeed, from the present imperfect state of our knowledge, the very attempt may to some appear an idle occupation of time; but as it seems to me indispensable that they be taken up in some sort of order, I have preferred that which I trust will appear least objectionable, placing them according to the more obvious characters of each affection, under the following heads or divisions.

ARRANGEMENT

OF THE

DISEASES OF BONES.

I.

Alteration of external figure, not arising from general swelling, but most commonly from a deposit of newly formed ossific matter, upon the surface of the bone.

Including all nodous formations, and those accumulations of ossific matter, constituting exostoses. These affections are in general the result of irritation or excitement of the circulation in the perios-

teum, in consequence of which the texture of the membrane itself undergoes certain progressive changes, while the capillary arteries deposit the ossific matter, the quantity and appearance of which will be regulated by the peculiar nature of the excitement in which it has originated; occasionally, the appearances of exostosis are the consequence of the external part of the affected bone being separated, and raised above the general surface.

The appearances produced by the formation of new joints, and those resulting from the ossification taking place in the periosteum subsequent to necrosis, as well as the irregularities of surface consequent to the union of fractured bone, will be included under this division.

II.

Enlargement, from swelling of the original substance of the bone.

Under this head will rank the various appearances produced by spina ventosa; an affection in which the natural secretions, for the most part, form the contents of the tumor.

to

The apparent readiness with which the bone gives way upon these occasions, is partly explained by the circumstance of the excitement pervading the membranes lining the canals that are within the

solid substance of the bone, as well as the membranous expansions contained in the medullary cavity ; in consequence of which the pressure by which the bone is expanded operates in the most diffused manner, for while the general mass of contents within is keeping up a degree of pressure outwards, the parietes of the bone are still further induced to unfold themselves, by the influence of the same principle being extended throughout the whole of the innumerable canals, that pervade the more solid parts of the ossific structure.

These affections appear to be produced by a peculiar modification of scrophulous action.

III.

Enlargement of bone, connected with an increased interstitial deposit of ossific matter, producing a more dense and compact texture than natural, as happens in healthy ossific inflammation.

Comprehending all those affections connected with healthy, or phlegmonous inflammation of bone. As the establishment of this kind of inflammation requires a considerable degree of constitutional strength, it more commonly occurs subsequent to the completion of growth ; whereas scrophulous enlargement most frequently takes place at an earlier period. The appearances produced are regulated by the degree of energy in the living powers,

combined with the peculiar nature of the local irritation.

The active agents in these cases are the membranous sheaths lining the longitudinal canals of the bone ; and I trust I shall be able to demonstrate that upon these occasions they exert a power of absorbing, as well as secreting, ossific matter. The particular preponderance, either of the one, or the other, of these actions, is productive of endless variety in the appearance of the parts when examined minutely. In one instance there shall be considerable enlargement of the canals, with little absorption, and still less interstitial deposit of ossific matter ; in a second, there shall be less disposition to enlargement of the canals, with a more considerable deposit of ossific matter ; while in a third, the inflammatory action shall be found to have been confined entirely to one side of the cylinder of the bone, producing thickening and consolidation, while the opposite side remains unaffected. In some cases of the latter description a most curious process may be observed to have taken place, for where the excitement has continued a long time without exceeding certain limits, the medullary cavity, with its natural contents, has been slowly transferred away from the central part of the bone, to that side furthest removed from the seat of the inflammatory action.

IV.

Enlargement more or less perceptible, with a disposition to absorption and disorganization of bone, either operating from the internal or medullary cavity, when the parts of the bone are progressively separated and absorbed ; or acting upon the external surface, when a succession of superficial exfoliations are thrown off.

When from the establishment of this process the internal parts of bones are removed, the irritation would appear to spring from within the medullary cavity, operating outwards, as from a central point. This irritation, and the consequent increased secretion, first affects the membranous linings of that circle of longitudinal canals situated next to the medullary cavity, in the solid sides of the bone. As the quantity of secreted medullary matter within the longitudinal canals increases, the degree of pressure increasing also, the space is soon enlarged ; and as the resistance is least towards the medullary cavity, the thin mass of ossific matter interposed between the canal and the general cavity, is by degrees projected inwards ; and as this process advances, the sphere of irritation extends itself to the next circle of canals, and the parietes of these also are made to give way, becoming thinner in proportion to their expansion ; and as these successive courses continue to be thrown off, the laminæ first displaced, being rendered extremely

thin, are eventually removed by absorption. Where this process has been carried on to a certain extent, the bones are reduced to the appearance of mere shells, and are rendered in some instances as thin as paper.

Where, on the other hand, the external part of a bone has been subjected to this action, it generally arises from an abscess, or other tumor taking place in the soft parts covering it. The sphere of the irritation in this case extends itself, until, through the medium of the periosteum, the external part of the bone becomes affected. Under these circumstances an exfoliation is usually separated, and makes its appearance at the bottom of the abscess, and the exfoliating process will continue to go on, or not, according to circumstances.

These affections most commonly occur while scrophulous action is going on elsewhere, and there are strong reasons for believing them to be necessarily connected with a scrophulous state of constitution.

V.

Absorption, without enlargement ; a consequence of peculiar excitement, more or less diffused through the general structure of the large bones, tending to weaken their sides, and render them liable to fracture from slight causes.

Affections of this kind, although not unfre-

quently to be met with, have, I believe, hitherto been exceedingly misunderstood. The appearances to which they give rise, and occasionally the accidents that have resulted from them, have in some instances been attributed to caries, and in others to a preternatural fragility of the bones; but caries implies death in the affected bone, and fragility can arise only from the bone having suffered some change in its constituent principles, while in the present case there is no appearance of the bone having either lost its vitality, or its healthy constitution.

✓ This absorption of bone is the slow result of excitement upon the membranous sheaths of the longitudinal canals, and while these membranes deposit from their internal surface an increased quantity of medullary matter, they become absorbing surfaces externally, in consequence of which the canals are enlarged, and as this enlargement is progressive, the smooth surfaces of many of these canals are at last formed into one space, within which may still be perceived, very distinctly, the traces of those instruments by which the cavity has been produced.

From the above process taking place in conjunction with the formation of nodes, and other appearances of diseased bone, while the patient laboured under venereal symptoms, it has been considered as one of the consequences of the disease.

VI.

Change in the figure of adult bone, from absorption removing in succession the more internal parts of the structure, weakening the general fabric, and rendering it by degrees incapable of supporting the weight of the body, or the action of the muscles.

This division includes the appearances produced by mollities ossium, an affection which varies in its effects in different cases, and in the same case in different parts of the body. In some instances, from the colour, appearance, and smell of these bones, and particularly from their having occasionally shrunk very much in drying, it is presumable that the proportion of animal matter is too great; in most cases the preternatural curvature of the bones forms the only external character of disease; in all, however, the particular kind of absorption described (under division IV), appears to have been the principal agent in reducing the bone to a state of weakness, this process having, in every instance I have yet examined, rendered the cylinder of the femur nearly as thin as paste-board.

VII.

Partial death, or necrosis of bone ; sometimes the result of inflammation and abscess within the bone, but most frequently the consequence of disease in the soft parts covering it.

Necrosis is generally the result of disease in the soft parts, and where the necrosed portion is of considerable extent, especially where the affection takes place in a cylindrical bone, it gives rise to a curious action in the periosteum, referred to division I. A degree of excitement arises, producing a secretion of ossific matter which is deposited in the cellular tissue of the membrane, and as the quantity of ossific matter increases, the cellular texture in which it was laid is progressively removed by absorption, so that after some time there is the appearance of a strong and compact framework of new bone, more or less completely enveloping the old one.

This new fabric must necessarily be connected with the living extremities of the original bone, for as the ossific matter is secreted into the texture of the periosteum, it will follow the course and disposition of that membrane, so that provided the powers of the constitution are adequate, it will be eventually carried beyond the limits of the part to be separated, however extensive this may be.

VIII.

Change in the figure of growing bone ; dependent upon the more or less perfect removal of the phosphate of lime from the ossific texture, the organization of the bone in other respects being unaltered.

The affection here alluded to, is that which is generally described under the name of rachitis, in which the bones become preternaturally soft, losing more or less of their opacity and firmness, so that they may be in some cases bent in any direction.

IX.

Loss of firmness, with absorption and disorganization of bone ; induced by a depraved state of constitution, in some instances nearly allied to scurvy, and connected with decomposition of the gelatin of the ossific structure.

Of this diseased state of bone few instances have been recorded ; those that are known appear to be exceedingly curious, and are almost inexplicable. In its progress, however, it has occasionally been found to follow the same course with the mode of absorption described in division IV., and in such cases fragments of the external shells of the bones have been found here and there attached to the periosteum.

From the appearances upon dissection, as well as from symptoms during life, there is reason to believe this disease allied to scurvy.

OBSERVATIONS
ON THE
DISEASES OF BONES.

DIVISION I.

ON THE ALTERATIONS OF EXTERNAL FIGURE, CONSEQUENT EITHER TO PARTIAL SWELLING, OR TO A DEPOSIT OF NEWLY FORMED OSSIFIC MATTER, UPON THE SURFACE OF THE BONE.

In the consideration of the affections of bone included under this head, the appearances to be enumerated are exceedingly various, both as regards the causes, and the changes induced. Some result from a specific disease, dependent apparently upon the existence of the venereal poison in the system; others appear to be the purely local consequence of external violence, without indicating any tendency in the constitution to take up unhealthy action; although we occasionally see instances of a contrary description, where the slightest accidental cause, producing a disturbed circu-

lation in the periosteum, gives rise to some affection of that membrane connected with extensive secretion of ossific matter, and eventually fatal disease.

Under this head, I propose also to examine the appearances and structure of ossific matter, deposited, not as the consequence of disease, but as the natural means for repairing injuries of various kinds. This association may seem objectionable, as it connects the appearances of disease with the consequences of health and strength ; but the various actions here alluded to must be allowed to possess certain features of resemblance to each other, which has determined me to include them all under the same general head.

On partial swelling of the external surface of bone.

Mr. Hunter says in his Lectures, "In some cases the bones themselves are swelled, and the parts evidently pushed out : how this should be, is very difficult to conceive." Now the appearance here described, is exactly that which occurs in many cases that are considered exostoses. The principle upon which the change in the figure of the bone takes place, I have endeavoured already to explain ; and as to the degree of alteration and extent of the affection, these will be as various as the varying circumstances which regulate the ex-

tension of the sphere of irritation in the vascular membranous expansions connected with the periosteum, and passing thence into the solid structure of the bone.

All practical writers have agreed that the structure of exostoses is exceedingly various, in some being comparatively soft, light, and cancellated; in others, as dense as the ordinary solid texture of bone; and in others again, exceedingly difficult to remove, being as hard and compact as ivory. But I am not aware that any of those authors who have yet treated on this subject, have pointed out with sufficient clearness, the distinctions between the various modes of action, by which the different appearances are brought about. There are some which, notwithstanding the conspicuous results that attend them, are only very slight deviations indeed from the natural and healthy actions; there are others which mark a depraved turn in the whole constitution, although the local change may be much less obvious to a superficial observer.

The specimens which I have particularly examined of partial swellings, have been selected from the collection in Mr. Heaviside's Museum; and I have preferred those, where the swelling is situated upon some part of the body of the various bones, because most, if not all such appearances connected immediately with joints, may be rather

considered as the result of affection of the ligaments of the joints, and consequently not, strictly speaking, attributable to change of action either in the substance of the bone, or in the periosteum investing it.

These affections of bone seem to me the result of some external cause, applied either in the form of pressure or bruise. They appear to be the consequence of some state of periosteum of the part, and of the membranes of the canals within the bone, certainly different from that of exact health, and yet falling short of any material deviation; not at all disturbing the healthy functions of these membranes, in many cases, beyond the first or second series of the longitudinal canals; and even in these operating only to a small and defined extent, producing no appearances whatever, except merely such as are now known to arise from an increased activity in the healthy actions of the vascular system within the bone.

In some instances, however, the impression is found to extend itself through the whole substance of one side of the cylinder of a bone, producing a tumor outwards, the structure of which differs in no respect from that of healthy bone, although the general figure of the mass is changed.

In some cases the alteration can only be consi-

dered as the result of a gradually increased secretion of medullary matter into the longitudinal canals, while in others it is evidently the consequence of an increased secretion of ossific matter, which, however, is still deposited in the same manner as in health ; for the only circumstance in which the affected part of the bone is altered, is the enlargement, or rather elongation, of that portion of the cylinder.

The preparations to which I have been most attentive, are a series of exostoses formed upon the larger cylindrical bones, principally the femur ; from these will be selected such specimens as will most clearly illustrate the general structure of these tumors. Upon the anterior surface of the middle of the femur, I found in one instance a smooth equal tumor of an oval figure ; its elevation above the general surface, was one-fourth of an inch, and its greatest extent, which was parallel to the axis of the bone, was about an inch. With a view to its more particular examination, I removed a part of this tumor, with the assistance of Hey's saw ; making two transverse sections, one through the middle of the tumor, the other beyond its extremity, and two parallel longitudinal sections, meeting the first so as to separate the included part of the tumor, together with that portion of the cylinder upon which it was formed*.

* See Plate II. Fig. I.

The specimen was then calcined and prepared in the manner pointed out in former communications*, and was subsequently placed in the solar microscope. From the attentive examination of successive sections of this specimen†, it was manifest that the swelling had not been produced by any new deposit of ossific matter, as might have been supposed from its external appearance. The healthy action of the secreting membranes within the two more external series of longitudinal canals had by some means been disturbed, and the quantity of medullary matter deposited had been thereby increased; and this increase in the volume of contents had ultimately operated by raising up the external surface of the bone, without producing any other appearance of deviation from the natural structure of the parts, except in the enlargement of the canals.

Another preparation to which I have particularly attended, is that of a femur having upon its anterior part, about the middle of the cylinder, a considerable tumor. From the external figure of this tumor, there would appear to be little reason to doubt its being a deposit of ossific matter upon the external surface of the bone; for a considerable part of its circumference not only rises ab-

* See Med. Chir. Trans. Vol. VI. and VII.

† See Plate II. Fig. 2.

raptly above the general surface of the femur, but extends in some points beyond what appears to be the basis of the tumor ; the greatest breadth of which is one inch, its length four inches, and its elevation near half an inch above the natural surface of the bone.

Sandifort, in his *Museum Anatomicum*, has given two views of an exostosis exactly resembling the specimen now under consideration, except that it was near two inches longer, and half an inch broader. But forming his opinion of its origin entirely from its external appearance, he seems to have been led into an error. He describes it as "*fracturæ squamosæ exemplum ;*" and says, "*De latere exteriore ossis femoris sinistri secessit lamella, quatuor pollices longa, quæ ab anteriore et superiore non nisi pro parte cum osse rursus concretit, sed ab inferiore ad longitudinem duorum pollicum cum dimidio ab eo distat.*" Now it appears to me that in the healthy state of the bone, the shaft of the femur is of too compact a texture to admit of its being fractured by any external violence in the manner here supposed, for any force sufficient to splinter a part of the cylinder, could hardly fail to break it transversely also ; which very evidently was not the case in any of the specimens exhibited by Sandifort, nor in any one of the numerous and interesting examples contained in the Museum of Mr. Heaviside. In order, how-

ever, to clear up this point satisfactorily, I carefully divided the above-mentioned specimen, considering that in all probability its internal structure would demonstrate the manner of its production. In this expectation I was not disappointed. The tumor was found to have arisen from the superficial part of the bone having been raised up; and as in the former example, so in this also, it appeared that the disturbance in the healthy functions of the circulation within the bone, had been confined to the more external series of the longitudinal canals for a given extent, beneath which the natural structure of the cylinder remained undisturbed*.

There is in Mr. Heaviside's Museum another very remarkable exostosis, situated upon the anterior part of the femur; and from the seat of the tumor as well as from the disposition of the masses of ossific matter of which it is made up, it appears as if the vastus externus muscle had suffered a partial conversion into bone. The extent of the tumor is equal to the extent of the insertion of that muscle; and the irregularities upon its surface correspond very much with the appearance of the packets or fasciculi of the muscular fibres. The greatest elevation of this tumor above the general surface of the bone is one inch and a quarter.

* See Plate II. Fig. 3.

To determine the mode in which this swelling had arisen, I divided the tumor longitudinally, and found that this also resembled precisely in its mode of production the specimens I had formerly examined; although in the present instance the affection had extended itself more deeply into the structure of the femur. About two-thirds of the compact substance of that side of the cylinder upon which the tumor lay, was reduced to an equal, light, cancellated texture.

A very fine specimen of exostosis is exhibited by Sandifort in a tumor, the size and figure of which resembles very much the kidney of a sheep, supposing the flattened side to be laid against the inside of the femur, opposite to that part of the bone usually pressed by the saddle in riding. A section carried round the basis of the tumor, and exposing the medullary cavity of the femur, is shewn, and demonstrates that in this instance the affection had extended itself to the membranes lining the whole of the longitudinal canals contained within that side of the cylinder, and that consequently the affected portion of the bone had spread itself in every direction. It had increased in length and breadth, and as the contents of the general medullary cavity, together with the natural figure of the bone, tended to prevent its intrusion, the swelling had by slow degrees taken place outwardly. In this instance, therefore, the gene-

ral medullary cavity of the cylinder of the femur was continued into that within the tumor. The growth of this swelling was not confined to the formation of an increased extent of bone, for the average thickness of the parts of the tumor is near an inch; the compactness of its texture being apparently rather less than that of the original bone.

Sandifort has also given several more engravings of considerable tumors of this kind. In one, the swelling has arisen from the inside of the upper end of the humerus, just at that part where the bone would be pressed upon by the habitual use of crutches. In another, the tumor had sprung from the anterior surface of the tibia, two inches above the ankle. In both these examples the sections indicate an affection of all the solid substance of the bone, which is reduced to a state much resembling the cancellated texture within the extremities of the cylindrical bones.

In the exostosis upon the humerus, the section exhibits a disposition to form new bone, the appearance of which is that of a light cancellated structure, thrown across the general medullary cavity of the bone opposite the seat of the affection; and in the section of the specimen upon the tibia the same disposition has gone further, and the whole of the medullary cavity opposite the external swelling is filled with cancelli.

In some few instances the latter affection (that within the medullary space) appears to take the lead; a very beautiful illustration of which is preserved in Mr. Heaviside's Museum. The specimen alluded to exhibits a part of the cranium of a man who had been insane for many years. The left parietal bone is raised up into an unequal tumor externally, consequent to an increased secretion of ossific matter into the medullary space, or diploe, between the two tables of the skull. The distance between the separated tables of the cranium, at the thickest part of the tumor, is about an inch; the basis covering an extent equal to about four inches. The natural figure of the cavity of the cranium remains unaltered.

On the ossific action of the vessels of the periosteum, producing nodes, or exostoses.

The secretion of ossific matter by the vessels of the periosteum assumes so many different forms, and takes place under so many various circumstances, that it seems almost impossible to define those appearances that belong to specific action, so as to distinguish them in all cases from such as may arise from common or accidental causes.

On the present occasion I propose the examination of two kinds of structure. The one, the result of the ossific action having deposited a circum-

scribed scale, or lamina of bone, upon the natural surface; this action being often connected with a degree of obvious thickening; a tender, painful, and probably inflamed state of the periosteum; and sometimes appearing to result from an affection of a specific nature. The other, arising in connection with great thickening of the periosteum, and most probably the consequence of a more or less perfectly diseased state of that membrane, which, continuing to increase in volume during the progress of the disorder, assumes new characters, determining the kind and quantity of the ossific secretion, conformably to the age and constitution of the patient.

The appearances of bone connected with the formation of nodes, I ascertained in the summer of 1814, at which period also I made most of the drawings that accompany the present paper. I cannot however avoid noticing, from its particular accuracy, a description of this appearance of bone as given in a valuable work just published. The author, speaking of superficial exostoses, says, " Dans la seconde forme que les exostoses affectent, un os sain et naturel sous tout autre rapport, presente une tumefaction circonscrite et plus ou moins volumineuse, dont la structure est différente de celle du tissu de l'os primitif, et qui parait surajouté. Les pieces anatomiques sur lesquelles on peut étudier cet dernier espece, tandis que l'affec-

tion est encore peu avancée, présentent en effet une lame osseuse plus ou moins épaisse, fixée sur la surface extérieure de l'os primitif, que la macération et une longue exposition au contact de l'air peuvent en détacher, et au-dessous de laquelle on retrouve l'organe sous-jacente exempt de tout altération*." It is impossible that any description can be more accurate than this, with the exception of the last circumstance in the statement, which might readily be overlooked, because the exact state of the subjacent bone cannot be seen without the aid of a microscope, and even with the assistance of this instrument the change in its organization might not be detected, unless the eye was previously familiar with the natural appearance of the compact structure of bone.

The deposit of ossific matter which I have found on various parts of the tibiæ and other bones, in a man whom I had attended till his death, whose early history I was well acquainted with, and in whom the painful swelling and other symptoms produced by the nodes were at once relieved, and presently removed, upon the establishment of the mercurial excitement in the system, exactly resembled that which has been just described. The section of the affected part of the tibia, subsequent to calcination, exhibited very distinctly the

* Précis Élémentaire des Maladies Chirurgicales. Par J. Delpech. Tom. III. p. 572.

even line of the natural surface of the bone, upon which was laid a thin deposit of ossific matter, about one-fortieth part of an inch in thickness. The peculiar disposition of the spaces that existed between the recent deposit and the original bone, leads me to believe that the ossific matter was not deposited immediately upon the original surface, but that the secretion took place into the texture of the periosteum, but yet so near the surface of the bone, as to leave only the finest lamina of the membrane forming the separation. It is also pretty evident to me, that while some parts of this intermediate membranous texture were progressively removed, so as to allow the new and the old ossific matter to be brought into contact and close union, other parts had actually assumed to themselves a new function, in having furnished secretions, in sensible properties, resembling, and in effect equivalent to, the medullary contents of the longitudinal canals*. The surface of the newly deposited bone was exceedingly beautiful, and exhibited a great variety of foramina for the passage of vessels, and the transmission of secretions, of which it would have been absolutely impossible to have procured a perfect representation by any other means than by the solar microscope†.

The deposit of ossific matter upon the undisturbed surface of originally formed bone, may

* See Plate II. Fig. 4.

† See Plate II. Fig. 5.

take place upon every occasion in which the healthy economy of the circulation through the periosteum is deranged, as is proved by an almost infinite variety of specimens preserved in Mr. Heaviside's Museum. In one very extensive series, the various shades of this process are exemplified as having taken place in consequence of the mere division of the periosteum in amputation; in another, as having been excited by the additional irritation of some part of the divided end of the bone having died and separated; and in a third, by very numerous instances in which, from various causes, a considerable part of a bone has perished, and has been subjected to the changes produced by necrosis. In the first of these three descriptions of case, the excitement appears to have been usually confined to a small extent of surface, and the thickness as well as extent of the deposit has been inconsiderable. In the second, the extent of the separating portion of bone, appears to have regulated the violence of the excitement and consequent deposit in the periosteum. In the third, the quantity and extent of the ossific deposit is in many instances considerable, the process of secretion in this case approaching very near to that in which the constitution forms new bone, with the specific view of preventing the ill consequences that would otherwise follow in extensive necrosis.

I shall now pass on to the consideration of those cases in which a diseased and thickened state of

the periosteum takes place, in connection with a very extensive secretion of ossific matter, giving rise to an affection which has by some writers been termed exostosis, and by others osteo-sarcoma.

One of the most striking circumstances to be noticed in this disease, at least as it appears to me one of the most curious if any, is, that in one case the tumor shall commence and go on increasing until it becomes necessary to amputate the limb, without any material complaint having been made of pain, or even inconvenience, beyond that which resulted from its weight and magnitude; while in another, the patient is, from the first, distressed, harassed, and at last exhausted by continual pain and irritation in the seat of the disease; although after death, the general structure of the tumor, as well as the actual seat of the disease, are found to be in both cases precisely the same. In the first case, the patient may be induced to propose the removal of the limb with a view to get rid of an unwieldy incumbrance; but in the second, he is glad to submit to amputation in order, if possible, to preserve his life, by the performance of an operation which may relieve him from the consequences of the irritative fever, produced by the disease.

The seat of this disease being the same in all cases, the only mode that appears to me capable of explaining the wide diversity that is occasionally observed in its effects, is to admit that the

periosteum, in common with all membranous and other soft parts, may possess a variable measure of irritability, dependent on the prevailing turn, or particular state of the constitution; and that although in some instances a chronic increase of action may continue to go on for a long time without exciting any material local irritation or constitutional sympathy, yet in other cases, where the affection is seated in the same parts, the whole train of symptoms and consequences may be completely different; the morbid irritability hurrying on the progress of the disease, while the irritation of the diseased mass already formed appears to operate by increasing every hour the rapidity of its growth, until at length the unhappy sufferer sinks, completely exhausted. It must however be confessed, that supposing this reasoning to be perfectly just, we ought in opium to possess a specific; while we are obliged to admit, that in fact it is here useful as a palliative only*.

The idea, that the measure of irritability in the system, regulates in a very principal manner the consequences of the disease, is at least supported

* The early stages and present progress of this inquiry, closely connected as it is with the introduction of the laws of irritability, as not only influencing but regulating all the operations, both of health and disease in bone, frequently brings to my recollection how much I owe in gratitude to my early teachers, and particularly to Dr. A. Crichton, and Dr. R. Hooper, whose luminous and eloquent expositions of the laws of irritability, were always listened to with interest and pleasure.

by all that I have been able to learn in the attentive examination of many preparations of these tumors, as well as by what I have myself seen of the complaint, during its progress.

I have already stated, that I conceive disease in general to be propagated in bone, by the formation and extension of a sphere of irritation; and upon this principle I shall now endeavour to explain the progress of the disease at present under consideration, as well as the appearances met with upon dissection.

In several preparations of this disease, preserved in the Collection at Saint Bartholomew's Hospital, the appearances of the ossific structure are admirably displayed. In one instance a section including a large mass of the disease is preserved in spirits, and gives an adequate idea of the enormous bulk of the thigh, in a case in which I was informed the progress of the disease occupied several years, without being attended with any material severity of pain or irritation. In another preparation*, the astonishing magnitude of the ossific mass is such as would almost exceed belief. The extent of it nearly conceals the whole length of the femur, and the circumference can scarcely be less than three feet. In this instance the correct relative position

* Of this preparation Mr. Abernethy has kindly permitted me not only to make an outline, but also to bring it forward upon the present occasion. See Plate III. Fig. 2.

of the two extremities of the bone affords a strong argument that the femur remained entire very late in the progress of the disease, or more probably till the patient's death; because otherwise the weight of the leg, added to the unavoidable slight motions of the limb, must have loosened the ends of the bone from each other, seeing that the texture of the disease by which the femur is surrounded is too weak to have afforded the least support. Upon this ground it may be inferred, that the disease in this instance was not connected with an excess of irritability; although the same point is more distinctly proved by the patient's having lived till the tumor had attained its present magnitude.

In Mr. Heaviside's Museum there is a very beautiful specimen, similar to those just described. The tumor has formed round the inferior part of the thigh-bone. The mass of ossific matter is in volume equal to a large melon, but the cylindrical part of the bone, nevertheless, remains undivided, although the external parts have experienced some disturbance, as may be seen upon the preparation, where the superficial series of the longitudinal canals have by the usual consequences of irritation been laid open; at some points the external surface of the femur is entirely removed, still more clearly demonstrating the principle upon which absorption takes place in these cases*.

* See Plate III. Fig. 1.

The last instance I shall mention, is one in which the ossific tumor formed upon the upper part of the tibia. This is one of those cases the history of which I have related in my Practical Observations in Surgery. It is also one, in which I had the best opportunity of studying the minute structure, as well in the processes of preparing the disease, as in the examination of it by the solar microscope.

The maceration of the disease, and the subsequent task of separating and clearing away the surrounding soft matter from the ossific structure, proved that this was a disease of the periosteum. The putrefactive process had rendered the whole mass light, loose, and easily separable; and the foul thick water poured off, and clear pure water substituted, most of the disease floated up to the surface, loosely involved in the remaining membranous parts. In the endeavour to raise it from the water it all fell asunder. The spongy head of the tibia remained nearly entire, as did the lower portion of the bone, but the two parts were disunited; as, however, the present confused state had been anticipated, I had previous to maceration made a rough outline of the preparation, which outline now proved useful, as it demonstrated not only the exact extent of bone removed by absorption at the point of separation, but also assisted materially in enabling me to recognise and replace the various parts of the disease.

In unfolding the structure of this tumor, the disjoined masses of ossific matter when drawn asunder, exhibited the remains of the membranous fibres drawn out so as to resemble very much the fine filaments of the silk-worm's cone. These membranous filaments were exceedingly numerous, and in every part equally subtile and tender.

In those parts of the tumor situated anteriorly, where the vascularity was most considerable, the maceration had produced a perfect decomposition, so that the soft matter was readily washed away, and all the masses of the ossific structure were seen beautifully distinct and clear in the pure water. Towards the back part of the tumor, next the calf of the leg, the disease, as stated in my account of the dissection of the limb, had in some measure the appearance of fungus hæmatodes. In these parts the soft secretion, which much resembled sebaceous matter, was less susceptible of the putrefactive fermentation, and consequently remained unaltered in the interstitial spaces of the fine ossific fabric.

All the parts of the disease being laid out and allowed to dry, were ultimately built up, and replaced in their original relative position, as represented upon the engraving that is given with the history of the case.

The structure of the various ossific masses, when

observed with attention, appeared to be finely laminated, or fibrous, proceeding in a divergent course from the central part of the disease, which appearance was confirmed by the subsequent examinations with the solar microscope.

One small mass of an oval figure, the minute structure of which was particularly well cleared by the macerating process, was selected from the rest, and as it had formed an external part of the tumor, it was carefully divided with a very sharp knife, to exhibit a smooth section of its structure, including that of its external or growing surface.

The appearance of this specimen was then examined particularly, magnified to different degrees in the solar microscope, and a drawing of the whole piece made upon a moderate scale. The longest diameter of the specimen was four and a half eighths of an inch; and upon this extent of surface I enumerated between forty and fifty lamina of ossific matter, as they appeared when the piece was magnified to the length of five and a half inches. On this scale, however, very few openings for the transmission of vessels were perceptible, nor was it apparent whether the surfaces of the foliated structure were smooth or not. Upon these accounts the screen of the instrument was moved until a part of the specimen, which, upon the first figure, measured half an inch, was in-

creased to four inches, when the texture was rendered much more evident. The openings of communication between the various spaces in the ossific fabric were perfectly distinct, and very numerous. It now appeared that the first deposition of the ossific matter took place in the form of small irregularly granular masses, and that by the subsequent operation of the soft parts of the disease, these were rendered laminar, or foliated.

Upon the engraving which is published of this disease, the progressive manner in which the body of the tibia has been absorbed may be perceived distinctly. Where the bone is immediately contiguous to the diseased mass, the deficiency of the whole of the compact part of the spine of the tibia is apparent, and to some distance beyond this point, the external series of the longitudinal canals may be observed to be enlarged and laid open, from the progressive extension of the sphere of irritation.

The minute structure just described, as belonging to the last-mentioned specimen of the disease, agrees in appearance with that of all the other preparations I have yet seen; and as to the composition of the ossific matter, it appears to me from its sensible qualities to resemble, in general, healthy bone, or perhaps there is a trifling excess in the proportion of the gelatinous principle.

In one specimen, however*, the colour is a light grey, instead of a yellowish white; and from the superior fragility of this, compared with other specimens of the disease, it is pretty manifest that the earthy matter predominates.

I have in one instance known the capillary arteries dispersed through the cellular membrane of a whole limb, assume to themselves the power of secreting ossific matter; it occurred in a very extensive disease of the lower extremity, the history of which has been related by Mr. Chevalier†.

The following is the note which I preserved of the dissection at the time. “On bringing home some pieces of the diseased adipose mass, Mr. Heaviside observed, that in precisely the same state of parts he had repeatedly found a deposition of ossific or calcareous matter. This induced me to examine it again with more attention, when to my surprise I found that numerous little bits of hard matter were plainly to be felt with the finger, and some of these brought away with the finger nail, and subsequently examined with a glass, had the appearance of a crystallized substance; although the largest of the pieces did not exceed in size a grain of mustard seed.

* See Plate III. Fig. 1.

† See Med. Chir. Trans. Vol. II.

“ In some parts these little earthy masses were more thinly dispersed than in others. Where they were thickly scattered, the feel of the disease, when the finger was pressed into it, was as if small particles of broken stones had been crushed in among the adipose matter.”

EXPLANATION OF THE PLATES.

PLATE II.

Fig. 1. Shews the appearance of a longitudinal section of the femur, upon the external part of which a swelling had taken place.

- a.* The external margin of the section.
- b.* The internal margin of the section.

Fig. 2. Exhibits the appearance of a part of the above section, considerably magnified in the solar microscope.

- a.* One of the external series of the longitudinal canals passing into the seat of the affection.
- b.* The continuation of the same series of canals, much enlarged, and entirely altered in form, by the operation of continued pressure from accumulation of contents within the canals.
- c.* The external surface of the bone, or that covered by the periosteum.
- d.* The internal surface of the bone, or that towards the medullary cavity.

Fig. 3. A longitudinal section of the femur, exhibiting the structure of an exostosis.

- a.* The compact and healthy cylindrical part of the bone.
- b.* The appearance of the enlarged part upon the external surface.
- c.* The surface towards the medullary cavity of the bone.

Fig. 4. A longitudinal section of the tibia, magnified; to shew the mode of attachment between a superficial deposit of ossific matter, and the natural surface of the bone.

- a.* The natural surface of the tibia.
- b.* The super-imposed lamina of ossific matter.

Fig. 5. The surface of the superficial deposit, magnified to the same degree as the last figure. Upon this figure the numerous foramina passing through the new structure are accurately seen, and the peculiar characters of the surface also are sufficiently apparent.

PLATE III.

Fig. 1. Shews on a reduced scale the appearance of a very fine specimen of foliated ossific tumor upon the femur.

- a.* The healthy part of the femur.
- b.* The condyles of the femur.
- c.* The ossific tumor.

- d.* The part of the bone, where, from the immediate vicinity of the irritation of the disease, the external surface has been not only disturbed, but entirely removed.
- c.* The part immediately beyond, where the diminished effect of irritation, instead of inducing absorption, has been the means of exciting a new ossific secretion upon the natural surface of the bone.

Fig. 2. Exhibits on a reduced scale the appearance of a tumor of the same description with the above. The minute structure of the disease is similar to that of the former preparation, but the general character of the disease was all that it appeared essential to represent.

- a.* The healthy part of the cylinder of the femur.
- b.* The condyles of the femur.
- c.* The ossific tumor.

L. Henshaw del.

T. Milner sculp.