Inaugural Dissertation
On Necrosis
and the
Reproduction of Bore

By
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"Nec via mortis erat simplex; sed ubique venis
Omnibus acta eis omiseros adduceres artus.
Miles abundabat fluidus liquer, omnique
Ostia minutatio morto collapsa trahebat."

Virgilii Georgiis. Book I.
On Necrosis and the Reproduction of Bone

The osseous system that wonderful frame work upon which all the other tissues of the body are superimposed, constructed of numerous parts fittingly joined together and suitably adapted, possesses great stability. Combined with such freedom and elegance of motion as to excite the admiration of all; is no less peculiar for its power of reproduction, which in the affection of bone termed Necrosis forms a prominent feature.
The name of 'Necrosis' is derived from the Greek word *νεκρός*, signifying to destroy.

In former times this term was applied indefinitely, and often incorrectly, at present it is confined to partial or complete *amoebification of bones*.

Early in the 18th Century Levallois, a talented French surgeon, discriminated between caries and death of parts of bones, which conditions, prior to this time were not individually distinguished. They are, however, essentially different, and respectively resemble ulceration and inmorfication—especially gangrene, so like as they occur in the soft parts. "Although ulceration," writes M. Hunter, "arises from weakness, it is an action, a vital action, whilst inmorfication is the loss of all action."

And so it may be said of the corresponding conditions of bone, for while in
Carried the decay proceeds—at least in part—from deficiency of vital action or nourishment; in necrosis the part perishes from the cessation of vital action and nourishment.

Necrosis is confined to no climate, age, or sex, neither does it affect any condition of life, or habit of body; yet at the same time youth and puberty are the seasons of life most subject to its occurrence, and those individuals who are by their manner of life accustomed to severe labour and exposed to the vicissitudes of the weather and external injuries suffer most.

No part of the human skeleton is exempt from the liability of becoming necrosed, but the bones most frequently attacked are those situated superficially and entering into the construction of the articulations.

The tibia, femur, lower jaw bone.
* Belone an elegant and ancient author

in the third chapter of his eighth book thus writes, "Si quod diem od aduentum est a
parte sanitatis, subitque inter integram
atque mortuum spatia carcinula, quae, quod
aberravit, repellat." Medicina libri sed Celci.
Numerous, cranium, phalae radii and ilium; also the ribs, scapula and the bones of the pelvis, may be enumerated as the more or less common sites of Necrosis. With the exception of the inferior auricular bone and scapular regeneration seems only to have been observed in the Cylindrical (Cooper).

The physicians of ancient times were not unacquainted with Necrosis, since from the writings of Hippocrates, Celsius and others, we perceive that they were by no means ignorant of many important facts and peculiarities relating to this disease. Though certainly their opinions were varied and opposite when contrasted with each other, or with those which we now consider as established. The treatment adopted by the earlier practitioners, also differs importantly from that at present.
In eurous children destructively necrosis of the cancellated texture of bones is by no means of rare occurrence.
Employed in the treatment of Osteitis, for being led astray by an incorrect theory, they followed a more direct mode of management than the remedy even in its most exaggerated form ever warrants.

Necrosis commonly attacks the compact structure of bone, where the vascularity is least developed, and the vital principal consequently less energetic and therefore more readily extinguished. On this account slight injury of the shaft of the tibia, for example, will often occasion extensive inflation from the surface of its cylinder, while the passage of a musket ball through the cancellated structure, or its lodgment in the epiphysis of the same bone is often followed by but a minor amount of action not entailing death of the part involved.

For we find that when the cellular texture of the epiphysis is disturbed by the presence of a foreign body the
The irritation is more apt to induce inflammatory inflammation than death of the part.

When the body of a long bone or the middle portion of a flat bone is destroyed by necrosis, the cellular extremities of the formes, and the borders of the latter generally remain uninjured. (Bell) Thus in cylindrical bones after the cure of a necrosis which has destroyed a portion of the whole thickness of the shaft, upon examination the ends of the original bone will be found engrafted, as it were, in the new production. In some cases however even the articular extremities are not spared or it may hap the disease is confined to them, when this occurs in the head of the tibia the knee joint is often involved and disorganized.

Necrosis is termed simple when it is confined to one bone and the patient is in other respects healthy.
And compound when several different parts of the same bone, or several distinct bones are affected at the same time: then the patient's health is bad, and the parts of the body are also diseased.

When the cause is apparent as in the case of a wound it is called traumatic, but when it was its origin to an exciting cause of an indiscernible, or of a constitutional nature it is termed idiopathic necrosis.

Observation would seem to prove that a moist climate is a predisposing cause to necrosis.

The external causes producing necrosis are aptly enumerated by Wellmann in his valuable work "De Necrosis Osium," Frankfurt 1793. "Whatever he writes, by chance injuries or destroys the periosteum either of the bone or of its medulla they cause necrosis - as wounds, contusions, bruises, fractures,
The severe forms of paraphimia occurring the digital phalanges may be also mentioned.

Syphilis produces its effects chiefly upon the compact osseous texture, and in portions of bone which have thin soft coverings, as the cranial bones, the front surface of the tibia and the posterior border of the ulna near the olecranon.
Compound fractures, dislocations, the action of acids, poisons, fire, chill, frost, intense cold, by the action of any of which, if the bone or its periosteum is injured necrosis to a greater or less extent may result.

The necrosis is external when the exciting cause affects the outer surface of the bone. But when the lesion is internal, the necrosis is termed internal.

Those causes of a constitutional nature which are observed to induce necrosis, are, severe fevers, scarlet fever, rubella, also syphilis, syphilitic rheumatism, cancer, rickets, gout. And indeed mercury itself may produce such changes in the osseous tissue as to cause necrosis. In the latter case the lower jaw bone is the part most generally affected, but it seldom occurs in this situation.

According to Samuel Cooper, in patients
under thirty years of age.

Concerning necrosis.

As induced by mercury, Wildmann makes the following remark in his admirable work above named.

"Quaesitum istum est, hydrazium, que bi recte utamur, necrosim osium in lice venerea arce prosumus, vel natam totile, necroses osium, posterior in maxillis inferioribus, excipere, si eodem magna minus ephi, intrammis angustiam temporis spatium illitae."

The maxillary bones are occasionally necrosed in certain manufactories, especially those for lucifer matches, where the noxious vapours of phosphoric acid are generated and inhaled by the work people during many hours of the day. In certain match factories in the neighbourhood of Paris where necrosis of the lower jaw has been very frequent, it is advised that almost all employed
In cases of necrosis of the lower jaw-bone, when the new bone is forming and during its formation, the movements of the jaw are preserved, though the disease implicates one or both articulations, new bone being gradually avulded to the cartilages. — Smith.
suffer from chronic cough and bronchitis, but that few if any who have been in the woods less than two years are affected with necrosis of the lower joint.

Numerous authors during the last half century have treated of the teeth, and the diseases to which they are subject, yet few have described necrosis as occurring in them. Mr. D. Bell, however, in his work on the 'Diseases of the Teeth' 1829, devotes a chapter to this subject at page 164 of his interesting volume. 'The teeth he writes which are most subject to necrosis are the incisors - superior especially - and the canines. After a tooth has been dead for some time it assumes a balsamic appearance which increases gradually until it becomes almost black. In the mean time inflammation takes place in the sockets the gums become swollen, spongy, and tender, and a constant

Discharge of matter is established, either at the edge of the gum or through one or more openings opposite the ul.

For treatment, McCall recommends in the earlier stages free and repeated scarification of the gum, followed by the application of restorative solutions. In the after stage when the tooth and alveoli if it is involved, has become loose removal is plainly indicated.

Tomes in his published lectures, a standard work on Dental Physiologie and Surgery, (1848) writes in his eleventh lecture, "Dental necrosis may result from mechanical violence, or from inflammation of the alveoli. Severe salivation and fever are sometimes productive of this disease; absorption of the alveoli, with advancing age, may also lead to necrosis; but usually, the tooth in old age is connected with the dental periodontium, and the pulp lives till the tooth, having lost all natural support, is forced out."
another part of the same chapter he remarks. "The physiological changes in dental tissues indicate if complete necrosis commence with the death of the tooth, but from their slow progress some time elapses before they become discernible. The tooth gradually assumes a darker hue than natural, which increases in intensity till it is almost black. The dental periodontum gradually detaches itself from the gang, the tooth becomes loose, and unless held in by the crooked form of the root, drops out. The surface of the gang is generally rough, and near the teeth dotted over with nodules of hard green-coloured matter. While the ends of the looks often looks worm eaten as though absorption had commenced."

After commenting upon the danger of permitting dead teeth to remain.
in their sockets, a method of
treatment which Dr. For an
eminent dentist had advocated.
Mr. Jones, further remarks.
"The consequences upon the
neighbouring parts, when necrosis
occurs without previous absorp-
tion of the alveoli, and the tooth
as allowed to remain are often
more serious than those I have
at present noticed. The periodontal
of the alveoli becomes inflamed
together with the neighbouring parts.
And, if the case be still neglected
the adjoining teeth are set un-
frequently lost, and necrosis
of a considerable part of the
jaw may be the result."
The alveolar arch of either
jaw is often the subject of necrosis
which may affect a part or the
whole. A most common cause
inducing death of a small portion
of the jaw, is the unskillful attempt
of diseased teeth.

The inflammation excited by a carious tooth extending to the alveolar periosteum and thence to the jaw often occasioned abscesses. In very favorable cases where a portion of the alveoli has perished, a substitute has been formed embedding, and efficiently supporting the teeth. But it is to be feared that in too many instances the healthy teeth are improperly removed upon their becoming loose, thus precluding the possibility of their continuing to perform their functions.

When the periosteum has been wounded or torn by an injury, and violent inflammation extended so as to deprive it of vitality, either immediately or after the lapse of a short interval, the adjacent vessels of the bone are
The older surgeons during and preceding to the time of Helvius, invariably treated some strips of its peritoneum with actual cantharides or some stimulating dressings, believing that in every case its death and exfoliation was inevitable and that this treatment expedited the cure.
Destroyed, and thus of necessity it follows that the portion of bone from which the periosteum has been removed, dies. Still, cases are still wanting in which, when the denuded portion was of limited extent, the circumstances of the patient's health and age favorable, and a proper management of the suitable remedies and treatment practiced (without death of any portion of the bone) early resolution has occurred by healthy granulations rising from the surface of the bone and forming a firm, dense, white and depressed cicatrix, with the surrounding soft parts. Weismann was amongst the first in establishing this last and important fact, which so materially influences the treatment of wounds. *
Proceeding and entailing necrosis may be either acute or chronic. It is acute when it occurs in the interior of a bone in an irritable patient of the pellagra type, for in such a case the symptoms which quickly succeed are considerable symptoms: fever, severe pain and restlessness or even delirium. It is chronic when it progresses tardily, and when the symptoms are neither so violent nor so well marked. Of this description it is chiefly present in patients of a debilitated constitution, originating from what may be termed a chronic cause, and only affecting the external portions of the bone or bones.

Having thus promised, I will now treat of some of the pathological phenomena accompanying this disease. The limb or part in which a necrosis is situated, is affected with a swelling or tumefaction which in some cases grows slowly, in others with great rapidity. This swelling...
is formed chiefly, in some instances entirely, by interstitial effusion, and is so diffuse that its limits can with difficulty be distinguished. The more deeply the bone is embedded in the soft tissues, the more extensive is the tumour. Of the tumour Weismann remarks, The tumour of necrosis is so accustomed to point as to common with other abscesses. And it may be observed that from the depth at which in many cases the pus is situated in necrosis fluctuation is indifferently or not at all appreciable. When accompanied with oedema the swelling may extend over the whole limb. The inflammation when acute quickly reaches at the suppurative stage and tenable pus rapidly collects in the vicinity of the necrotic bone or portion of bone: but in most chronic cases pus forms slowly and is thinner and less healthy. When the abscess which accompanies a necrosis arises from violent inflammation
Actin, and is situated near the skin which is itself inflamed, it bursts spontaneously. But when the bone is surrounded by a great thickness of soft parts, and the inflammation is chronic, the quantity of matter daily increases, the cavity which it occupies becomes more and more spacious, and the abscess extends mechanically by pressure upon the surrounding structures. The bones and tendons resist the progress of the pus, but the cellular tissue yields and numerous sinuses form, which, when the abscess is situated beneath a fascia, often undermine and burrow to a great distance from the main collection of matter, but finally become subcutaneous, and exit by ulceration and maintain a more or less abundant discharge.

The discharge from a seceded limb was at one time supposed to be invariably infectious, acid, and what is termed unhealthy, but these conditions
are not constant, and when present do not depend upon the state in which the bone is, but are to be ascribed to the influence which the patient's condition of health exercises on this and all similar discharges.

Whilst resident in the ward of the St. George's Hospital during the summer of 1859, having numerous cases of necropsy under my charge, I carefully observed the disease in its different stages, and was impressed with the varied character which the discharge presented. In the healthy and robust it remained thick and comparatively laudable, in the debilitated and wasted it often assumed an unhealthy taint and odour, or sometimes acid and flatly appearance; affording a very true diagnostic symptom of the patient's health.

The sinuses or ulcerated openings, commonly situated
over the most projecting line of bone, are termed fistulae when they are considerable, continue patent and maintain a discharge, on account of their edges assuming a callous appearance and throwing off fungoid granulations. The granulations lining the fistulae and seething gaye are continuous with the lines of pyogenic membrane of the sequential capsule, in the case of internal exfoliation. The ulcerated excrescences just alluded to are admirably described by Weitmann in his valuable treatise, "Uleera quibus ossium necroses subeunt, purulampan Cupiam fundunt, labii incurvis longus. Non tamen remediaverunt, quae sequens, quandoque hanc vehementer, dolens, excrecit, quo se tangatur, tanguinum facile uiminit." The more severe and extensive the necrosis the more numerous are the fistulae, and when ulcerous is
* Stanley mentions a singular case in which the inner lamella of a long bone perished and became detached from the living bone, without the formation of a single fistulous passage in the walls of the latter. (Op. cit.)
affected on every side, as in general fissures, the fistulae commonly appear on the corresponding aspects of the limb.*

Besides these characteristics and manifestations, chemical analysis of the discharge from the increased limb is of singular interest. If it we are indebted to Mr. Bamby Cooper, who says: The discharge arising from diseased bone contains a larger quantity of solid constituents of bone in solution, which consequently pass off in these fluids. — The discharge from a case of diseased bone was found to yield after incineration from 72 lbs. of pus.

Phosphate of Lime — 1.75 lbs. or 2.15 percent.
Carbonate of Lime + Soda — 1.5 pounds or 2.46 lbs. or.

Thus continues Mr. Cooper, in pus from parts around diseased bone phosphate of lime was found to the amount of nearly two and a half per cent, whilst in pus elsewhere obtained only traces of the phosphate
of bone were discovered.

When a portion of bone dies with or without the intervention of inflammation, the process of separation is immediately instituted. The separation of the dead from the living bone is often termed ephelisation, and the sequestrum is the detached portion, whether that be external or internal.

According to Mr. Hunter, who was the first to investigate the exploitation of bone as a vital action, the groove of separation is formed by the absorption of the living bone adjacent to the dead bone; the bulging part of the viable bone at its line of apposition with the dead portion disappearing, causing a softening there before the calculus is formed.

The sequestrum presents an appearance similar to that produced by protracted emanation, but exposure to the air, conjoined with the action of the discharge, affects its colour and
generally changes it from white to black. Of the change in colour, Professor Stanley writes in his excellent work on "The Diseases of the Bones." "The colour of the dead bone changes in the following manner. First dark spots appear in it, these increase in number and coalesce, rendering the whole surface brown or black; but the change of colour does not extend below the surface of the bone, except in the instance of its texture being porous."

The circumstances which attend the process of separation and reparation vary much, according as they affect the external surface, internal surface, or whole thickness of the bone concerned. The internal surface of bones being more obnoxious to these impressions, either of a direct or indirect character, which produce decrass and its accompanying phenomena, suffer most frequently
from it. Of the individual bones these most superficial are consequently more especially liable.

Separation of the dead portion of whatever size it may be, from the living, is effected through the agency of ulcerative absorption, and is therefore a vital process, not permitting of surgical interference. But whilst the changes consequent on the formation of the ulcer are taking place, the pus which is abundantly secreted ought to be afforded with, by suitable incision.

The condition of the ulceration must also be occasionally examined, and when discovered to be loose it must be removed by the forceps through some of the natural openings, or an enlargement of the same. The remaining surface of the ulcer, if healthy, then granulates, and osseous matter is formed forth to partially to occupy the cavity or space.
Internal exfoliation or necrosis occurring only in the cylindrical bones, is most common in those of the largest size.

The case may be generally traced to an inflammation of the medullary surface of bones and in most cases free from those injuries which induce arthritis.

The connection between the internal exfoliation is a sequestrum of a cylindrical bone, and the surrounding end-bone is dissolved by a similar absorption to that which occurs in the case of external exfoliation. The sequestrum consisting commonly of a part of the cancellous texture, when separated from the healthy bone is imprisoned within the walls of the shaft, form which cavity it has no way of escape.

Mr Schor has stated in his
work "De inflammatione accidit," that the sequestrum gradually disappears, by the detachment of very minute thin scales from its margin. This species of disintegration if occurring to any extent must be very gradual indeed. But Benj. Bell in his treatise on "The Diseases of the Bones," writes at page 45, "The abscesses in the interior of a bone being also excited the up a considerable quantity of the dead portion or sequestrum."

These statements are evidently at variance with both experience and experiments so numerous to enumerate.

The sequestrum enclosed within the defendre, being now an extraneous body, remains a permanent source of irritation, inducing enlargement of the living bone, with a pressure and very often irregular effusion of osseous matter. Chieflly from its
outer surface beneath the periosteum, while that membrane becomes closely adherent to the inflamed soft parts around.

At this stage, if a section were made of the parts, the bony case would be found to consist of, from without inwards, a stratum of newly formed osseous substance, a layer of the old bone (more or less thick, according to the size of the dead portion) the inner aspect of which is lined with numerous granulations.

The pus enclosed in the cavity at this stage of the disease, by its pressure on the periosteum, induces absorption and the formation of cylindrical apertures or cloacas; the foramina grandia of Tunique and others, in the laminated portion of the bone. The cloacas are usually of an oval or roundish form, with smooth edges bevelled externally.

Extrusion of the sequestrum, whether effected by the efforts of Nature, or the assistance of art through an enlarged cloaca, is followed
by the growth of a plentiful crop
of granulations from the inner surface
of the cavity, which quickly expand
and fill it. The mass then
gradually ossifies and instead of
the medullary cavity there is produced
a solid lenticular lamina more dense than normal. At a
later period, however, a gradual
enlargement that takes place in the
Haversian canals, changes its structure
into cellular, and incompletely supplies
the place of a medullary cavity, so
that when examination is made at
an advanced stage of the case, the
internal cellular surface is found
lined with a membrane containing
medulla. (Rokitansky)

Kochler was the first to observe the
regeneration of the medulla.

The abscess being formed, as above
described, the confined pus escaping
through them presents itself as a sub-
cutananeous abscess, which if not opened
Artificially, after a more or less prolonged interval, discharges its contents by ulceration.

After evacuation of the matter, the patient, who until now was harassed by the pain and swelling, experiences grateful alleviation, and relief, especially if the dead portion of bone has escaped, is much relieved, as in some cases to make even considerable use of the affected limb.

When as well, unfrequently happens, Nature is insufficient to the extrusion of the sequestrum, at least within a moderate time, then it is that active surgical assistance is demanded.

The causes inducing death and disjunction of the whole thickness of parts of bones, are similar to—though perhaps aggravated or longer continued than—those which produce partial accroix in their external or internal surfaces, and the same action of absorption separates the living from the dead portions.
in every form of necrosis. It is
however best observed, in account of the
extent to, and the direction in which it
occurs in the description of necrosis at
present under consideration.

The process of separation at the
line of demarcation is thus ably
described by Professor Miller. But
around this unchanging dead portion,
and more especially in the parts
immediately continuous with it,
there is great activity. The color is
red or dark brown, evidently from
increased and increasing vascularity.
The slightest touch is painful, and
followed by blood of a florid arterial
hue; a clear fibrinous exudation is slowly
condensing; and the gentlest touch of the
probe or finger plainly indicates a soft-
ening of that part. By removal of a
large proportion of its earthly matter.
In short, while the dead portion is
undergoing an change, unless perhaps
a tumor in it, the living parts
Principals of Surgery, Edin. 1851. Art. 446.
all around are soft, swollen, and increased in vascularity; they in carrying on an inflammatory process of a truly phlegmonic kind. This quickly terminates in suppuration and ulceration. And so a ulcer is begun, which by gradual deepening ultimately—but not it may be till after a long time—detaches the dead from the living, re-solving the former into the condition of a loose sequestrum.”

In necrosis of the whole thickness, after completion of the separation, the condition of the part requires particular consideration as the space formerly occupied by the dead part may be vacant, or very imperfectly supplied; though at other times the shape and size of the bone remains but very slightly affected.

After amputation of an extremity, as that of the upper arm or thigh, the stump often takes on an unhealthy motion and assumes a gangrenous character.
The soft parts remain disunited and no granulations appear on the surface of the bone is exposed to the baneeful influence of the atmosphere, and in a short time is deprived of its vitality. The internal lamina, for some distance above the point where it projects from the soft parts, also perishes, leaving a portion of the internal lamina and medullary tissue uninjured, so that the vascular conical portion thus formed, throws out granulations. Granulations are also generated from the flesh portion of the stump, after the ungranulated parts have been detached, and these granulations amalgamating, in fortunate cases, with those of the bone, form a continuous cicatrized surface.

The power and function of reducing the Deputytown by absorption has been assigned by Trendy to the granulations. Amongst the supporters of this view, some distinguished
* We sometimes hear of empty wedges which had been driven into bones adjacent to a false joint or ununited fracture, presenting on their removal an appearance similar to that which absorption effects in the living bone: but from what I have observed I would attribute such waste or disintegration to decay of the ivory.
authors appear. "It is right" says
Sir Ashley Cooper, in his lectures on Surgery,
Page 632, "if we wish to diminish the
size of the excision, to build it upon the
granulations which will absorb a part of
it, according to the experiments made by
Sir W. Blizard, on this subject."
Here, Sir Ashley is at fault, for it is an
ascertained fact that lead bone when
placed in a granulating sore and retained
there for long periods - as has been done
by Collider, and others - remains unchanged.
And that under circumstances cannot
possibly be absorbed. *
When a portion of the shaft of a long bone
has died throughout its whole diameter.
The sequestrum production begun by the
living bone at the surface of separation
is seemingly continued by the periosteum
which lies loosely upon the exterior of
the inanimate portion. The sequestrum
when it becomes loose, changes its
position with relation to the shaft and
directed by a well known law of nature,
Seeks the surface, thus supplying space for the reproductive formations, which quickly expand, in whole or in part, from either end of the original bone. The external or cortical shell of the new bone, upon the extraction or ejection of the acceptrum, inclining towards the centre, and uniting with the growth sent out by the old bone, forms when the case has progressed favourably a solid and efficient column of support.

Professor Goodson's researches have presented us with a very interesting account of the minute changes which take place at the line of junction of the living and the dead portions. During the processes of separation, he informs us that the osseous canals which immediately bound the dead or dying bone, are enlarged temporarily with the filling of their cavities with a cellular growth. As the process continues, canals are thrown into one another. At last the dead or dying bone is connected
to the living by the Cellular mass alone. It is now Locke and has become so in consequence of the Cellular layer which surrounds it, presenting a free surface and a free surface of it. In this, Mr. Goodsell observes, the veins and absorbers act on the osseous tunic of the walls of the Haversian Canals, in no other way than in the most natural state of the part. They are immediate and immediate instruments of absorption. It is the cells of the newly formed Cellular mass contained in the Haversian which are the immediate cause of the removal of the bone, either by taking it up as nourishment and substituting themselves in its stead, (the bone being prepared for this absorption in a manner analogous to that which occurs during the digestion of food prior to its absorption by the cells of the villi,) or by the active formation of the cells of the new substance inmortizing the resources of the part, and as inducing the disappearance of
* Anatomical and pathological observations.
E.N. 1845.
The symptoms of necrosis are at first those of acute osteitis, there is dull, deep-seated, and often extremely severe pain owing to the inflammation of the part and the unyielding nature of the periosteum.

The pain, at first, is seldom aggravated by pressure. As the inflammatory action advances, it causes swelling of the soft parts in the neighbourhood, which in a short time become the seat of plastic exudation. The integument is tense, red, and tender to the touch, and if the case is severe, high sympathetic fever prevails.

Upon the accession of suppuration, these several symptoms are aggravated, and no relief follows the suppurrative crisis.

At this stage the pain is very severe, and its intensity does not diminish until the matter gains exit; when
This occurs, the distention of the periostum is removed, and with it a great amount of the pain. Several apertures are usually formed when the evacuation of the pus is left to nature. When once these openings are formed, pus continues to be discharged by them until after the extraction of the sequestrum. From the nature of the cavity, pressure applied externally does not increase the flow of the matter. The number of apertures always bear a relation to the extent and severity of the disease, and while they communicate internally with the cloaca, they open externally in a papilla.

Examination by the finger of the condition of the cone is the most satisfactory, but if the cloaca will not admit the finger a probe can be used, and often by introducing probes at two different cloacae, at the same time, knowledge as to the size and condition of the dead part will be more readily obtained.
When the bone thus examined, is felt to be extensively uncered by the periosteum, we may conclude that all such portion of bone has perished; but if this we may be still more certain if the edges of the striped bone are found to be unequal and rough.

In proportion to the decline of health, so does the discharged pus degenerate, but if this I have treated in a former portion of the essay.

"The discharge which continues during the stages of separation and separation is in every case," says Mr. Miller, "invariably phlegm, and in consequence of such discharge, the constitutional symptoms which during the ostitis with simple and subservative had shown characters of acute inflamatory fever, often intense, may now change into hectic." (Sp. cit.)

In most cases when the sequestrum has become detached from the living bone, it is more or less composite.
* Sometimes, the sequestrum—when unassisted by art—in escaping wounds an artery and causes hemorrhage, this not infrequently happens in the passage of the sequestrum from the lower end of the femur, the popliteal artery being much exposed.
and at this time it should be removed, but if not interfered with it may after a time make its appearance at the surface and projecting there become black, apparently by the action of the atmosphere.*

The common appearance which is often to be seen on the surface of the sepulchrum is to be ascribed to the action of the ulcerative process, and not as has been so frequently and so obstinately asserted, to the action of agents of absorption by the granulations.

A slight inflammatory attack, it must be remembered, may disturb the substance, its vital power of resistance being by no means great.

Necrosis is a subject though not properly a chronic disease, and its duration even in similar cases, admits of considerable latitude. In the young and stout the process is, as might be expected, more rapid than in the aged and infirm. The quick set separation of a seared tissue, unless
* Russell asserts at page 98 of his Essay, that he has seen necrosis of the lower jaw long gone through all its stages to the cure in less than three months.
Sir Astley Cooper, "such I have ever known, was accomplished in three months." * 

The average duration of Cases of Necrosis may be stated as lasting from twelve months to two years (Smith). In old age from the diminished activity of the constitution and its powers of reproduction, restoration is apt to be imperfect.

After the cure is effected, the limb is reduced in its circumference by absorption, but only approaches its pristine form, remaining larger and less shapely than its fellow. The process is more rapid in spongy bones than in those of greater density.

The treatment of necrosis now demands attention, and although I have discussed some of its points, others of importance remain to be considered.

"The old surgeons" says W. Samuel Cooper, "were in the habit of amputating necrosed limbs, though instances are all wanting in their days to prove
the possibility of relieving the Disease without Amputation. And this blameable custom of removing every limb affected is quietly exploded from modern surgery.

Alhacuis, an Arabian surgeon, who flourished in the twelfth century, appears to have been the first who attempted the cure of Accreas by the judicious employment of the knife and saw. After him, Sollicitus, following the same course, met with equal success; notwithstanding which, the habit of amputating again became general: and it was not until late in the last century that the treatment of this very common affection was performed through the advocacy of Mr. Davil, a Parisian surgeon.

Yet, though amputation, as the ordinary treatment of Accreas, was thus thrown into disrepute before the dawn of the present century, we cannot but imagine that with it all the other unnecessarily cruel measures disappeared.
we find Mr. Wilson, an intelligent London surgeon and lecturer, writing in 1829. "In the treatment of diseased bones we are still obliged to use canthiers to produce exploration. Sometimes more than one canthier may be necessary, and therefore should be prepared. As it would be desirable, if possible, to remove the whole of the diseased bone at once, the potential canthier like the actual should if possible be applied to the whole of the diseased surface. When the death of a bone is perfect, mild dressings should be employed, but when it is not so, the nitric, mercuric, or sulphuric acids diluted may be applied."

The treatment of osteitis should always be preventative, but when suppuration has taken place we must employ the palliative. When the indications that suppuration has occurred are sufficiently evident, one or more free incisions dividing the periostium
are demanded. On this subject writes Mr. Stanley, reasoning from the fact of partial absence of reproduction at parts deficient in periosteen. Accordingly in all cases of necrosis the same practical importance should be attached to the preservation of the periosteen, as if it were proved to be the sole and exclusive regenerative power (p. 47). Local depletion may in some of the more violent cases be indicated. During the period of suppulsive inflammation the patient's health must be supported by a nourishing diet, tonics, cod liver oil and a pure atmosphere. The sea air is much recommended. Local excoriation must at the same time be avoided and should violent inflammatory action threaten, leeches, warm injections and other antiphlogistic measures are at once to be employed. It is necessary for the patient's health that he should not be entirely
benefit of exercise, but this should be of such a kind as will interfere as little as possible with the affected part. In the cases of some delicate individuals, especially those who by long confinement have their naturally feeble systems still further reduced, death by excrescences of the liver, ischi, or of the trochanters major, in whole or in part, with destruction of their soft coverings, often ensues from inability to sustain the pressure to which these parts are subjected.

In such cases during the after-treatment the water-bed may be advantageously employed; and if daily after having the sores dressed, the patient continues to lie, or long as convenient on his breast, the parts will have a much better opportunity of healing, and the sufferer will undoubtedly experience grateful ease.

If the surgeon interferes as soon as the exanthem becomes more
for its detachment it Nature's exclusive operation. He will find in most cases the new bone to be soft, the natural openings being seldom sufficient, that he can make the necessary enlargement of the cloaca with a knife, a circumstance which materially simplified an otherwise difficult and oftentimes very tedious operation.

Although Nature is so fully adequate to the task of separation, she effects the extraction of the sequestrum in a very indifferent manner, to assist in this process it is the especial duty of the surgeon.

If the Explication is external and of no great size, a simple incision will often free it. When the sequestrum of an internal Explication is diminutive and favourably situated for escaping by a cloaca, the source of irritation will thus be readily expelled and the patient restored to health; but if the sequestra do not pass out spontaneously, the surgeon, having ascertained their presence by careful examination, must enlarge the
Opening leading into the cavity contain-ning them, so as to obtain a sufficient space for their extraction. "In order to effect this," says Professor Syme, "make a simple or if the parts admit of it a crucial incision through the integuments, having the cloaca for its centre, dissect back the flaps, and apply the trephine over the opening, when there is sufficient room, or when that is deficient employ the Cutting pliers to increase its capacity."

When necessary the sequestrum may be divided or broken up to facilitate its extraction. This latter maneuver, often effected by Nature, changes the sequestrum into more or less numerous sequestra.

After the removal of the sequestrum or sequestra, the wound is to be gently filled from the bottom upwards with dry lint, and rigid antiphlogistic treatment must be adhered to for some days, as the operation always excites considerable irritation and inflammation in the parts. Until the new osseous
Structure is properly consolidated, the patient must preserve perfect rest and quiet, and if the bone is weak and has a tendency to bend, splints and other appropriate means must be employed to preserve the correct form. Although the limb should be kept rigid, especially where a portion of its whole thickness has separated and been removed, passive motion of the articulations must be occasionally used, lest stiffness of the limb be induced. When necrosis has arisen from syphilis and the separation of the part proceeds tardily, the exhibition of mercurial must be considered a "Sine quia non," for in most of these cases the preparations of iodine, especially the hydrate of potash will be found to stimulate the action of the absorbents and thus expeditiously the case. When action is deficient, moderate and often serviceable excitement is readily produced by stimulant applications. A mercurial ointment mixed with borax...
but in no case ought a too powerful stimulant to be selected since the use of such might only increase the evil by extending the disease.

Amputation is happily but seldom necessary, although undoubtedly in some cases of great value, as where the patient's health is failing more rapidly than the process of separation is progressing or where the knee joint has become involved, and a destructive and dangerous inflammation thus occasioned.

"Remorse to amputation may be advisable" says Dr. Miller, "in the case of extensive death of a bone throughout its whole thickness, when the reproduction has failed. The limb then bends, shrivels, and is worse than useless; its removal becoming a matter of expediency, in the eyes of both patient and practitioner."
The Reproduction of Bone.

It now devolves upon me to discuss that most important section of the subject under observation, namely, "The reproduction of bone." This enquiry has at all times been a fertile source of controversy and upon reflection I have deemed it proper for the elucidation of this matter, to enumerate in an abridged form, the different theories of the more conspicuous disputants, and writers on necrosis, as well as some of their arguments in support of the same.

Amongst the authors on necrosis and the reparative process, we find many of the most illustrious
Professors, as, Dupamare, Waller, Trotta, Weidmann, Hunter, Russell, Bayer, Stanley, Syme, Latus, Meicker, Müller, Bell, Scarpa, Gooden and Jones. Physiologists.

As far as I am aware, coincide with each other regarding the existence of an organized lymph at an early period in this disease. It has been well described by Professor Russell, in his important practical essay upon Accurate, 1794. I shall insert the passage. "At an early stage the affected bone is surrounded by an effusion, apparently of a gelatinous nature; which some authors have described as more dense towards the surface of the old bone, and more rare as it recedes from it. This effused stratum gradually gains an increased degree of consistency, nuclei appear, which are at first distinct, but afterwards increase in number, enlarge and finally coalesce,
so that the effusion is converted into a mass of bone, which is subsequently augmented by additional osseous granules.

It may be further remarked that in the effusion bloodvessels are gradually developed, and that the glutinous exudation of Russell, and others, becoming organized and vascularized, assumes the appearance of cartilage previous to its transition into perfect bone. This is the Callous of the older writers, and it bears a close analogy to the Callous which surrounds and connects the extremities of a fractured bone. The newly-formed bone is more vascular than the old with which it is in contact, and contains a larger number of Haversian canals. The lamella are not so distinctly seen as in the old bone, and the new structure contains a smaller amount of bony tissues but a greater proportion of animal matter.
Some writers describe the reproduction of bone as the bony tissue itself; but it would seem that the majority assert that the periosteum is the agent of reproduction.

Pilhamelet, who wrote in 1743, founded his theory upon a false analogy, inasmuch as he considered that the periosteum resembled the bark of a tree, and that the bone was deposited by it, in the same manner as the layers of an exogenous tree are deposited by the internal layer of the bark. He arrived at this opinion from the fact of finding a silver wire he had placed round the middle of the shaft of the femur in a pigeon, occupying at a subsequent period a situation in the medullary cavity, surrounded by bone, instead of embracing the shaft externally as he had placed it.
Trogis, the celebrated Italian pathologist, who published the result of his experiments in 1775, devoted particular attention to the formation of new bone subsequent to the destruction of the old. He experimented on pigeons and detailed the results of numerous cases with very great accuracy. His experiments indeed, have been repeated by almost every inquirer on the subject. The following case is the result of an experiment instituted by him. "Having bored through the shank bone of a pigeon and destroyed the medullary structure with a probe, I found that several days afterwards the bone was enormously thickened and fresh new bone deposited around the old. On separatimg the periosteum bloodvessels were seen to enter the substance of the new bone. The
Pernostium was very where a little swollen, and at the lower end it was raised up by a semi-cartilaginous jelly.

He then continues, upon dividing the new shell longitudinally the old bone dropped out, the Calcar was separated from the new deposit by a very juicy and thickish membrane which I considered an internal layer of the peristium.

Thus I imagined that the shred of new bone was deposited between the layers of the peristium.

Granting this we might conclude that for the reproduction of osseous tissue, bone is not necessary, but this would be contrary to the general law of Nature, which is, that every tissue has the power of originating its own kind: but, Faja, declares that the peristium, a tissue so widely different from the osseous, reproduces and forms bone.
The substance of the new bone Troja, correctly remarks, seems spongy and tinged everywhere with the color of the blood; this red tinging depends upon numerous Haversian canals, which the microscope demonstrates as existing in far larger numbers in the new bone than in the old. For new bone when first formed appears spongy and afterwards becomes consolidated by the impregnation of earthy materials, and this fact is a strong proof of the powers which the living tissue has of reproduction if fully nourished; for the blood contains all the necessary constituents or elements required by bone for its acquisition and development, as is evident, independently of chemical analysis, from the circumstance that new bone is first deposited in the form of a lymphatic effusion in which vessels
are developed, and which is converted into true bone.

But it must be remembered that the blood supplied to the coxal bone, cannot enter the canals of Havers, until the diameter of the vessels is sufficiently reduced by the ramifications which they are observed to make in the periosteum and endosteam.

Weidmann, in his work, so often alluded to in this essay, seems to coincide with Virchow and remarks, "However, from the experiments of those illustrious men, Virchow, Blumenbach, Desault and Boehler, it is shown that the periosteum is the chief organ of regeneration. If, indeed, in these experiments new bone was always reproduced, from what of the old bone except the periosteum - if that remained, could regeneration succeed." At another part he says, "Haller, Calvé, Tournier, Herreme
And many others have been a part of a new bone evidently to grow from the very texture of the bone, and hence it may be inferred, that the whole cylinder of a long bone having died, the sound and untouched epiphyses grow together and become consolidated with the new tube if the intermediate peristium be repaired.

That the new bone grows from the epiphyses is incorrect.

Mr. Goodric observes that he has never seen an instance in which the epiphyses supplied the new bone; that in those cases in which the whole shaft has been imagined to have perished, there has been a ring or small portion of the diaphysis at each end, and that from these the new bone shoots in calcareous masses in the longitudinal direction.

Mr. Goodric also remarks the epiphysis...
is a distinct part and has no greater tendency to supply the losses of the principal mass of the bone to which it belongs, than the femur, tibula, or astragalus to supply the loss of the tibia." He considers that the death of the entire shaft of a long bone, is a very rare occurrence, but when it does occur that no regeneration will supply its place.

The Hunterian theory expresses an action or process, the details of which have not been recognised.

According to John Hunter, the arteries bring the supply to the bone for its increase, while the absorbents are at the same time employed in removing portions of the old bone, so as to give to the bone the proper form, and thus the new bone becomes larger, without having any material change produced in its internal configuration. Here Mr. Hunter describes the reproduction to the bone
when properly supplied with
nourishment, but he attributes
to the absorbents a work almost
of not entirely theoretical.

Bayer in his work published early in the present
century considers the periosteum
the regenerative organ; for whilst
speaking of the shell of bone
which encloses the diaphysium, he
says in his lectures upon the diseases
of the bones, "This new bone which
is in fact the periosteum ossified is
rough on its surface." Thus Bayer,
while he altogether neglected the
subjacent layers of new bone, con-
sidered the superficial or cortical
one, to be truly ossified periosteum.

Dr. Knox, an
anatomist of high merit, in a paper
on necrosis published in the Edinburgh
Medical and Surgical Journal, 1822,
writes, "A portion of the bone this,
say of the tibia, the internal layer of
The old bone becomes vascular, spongy, and full of holes for the transmission of vessels. The whole bone becomes much thickened, and occasionally heavy and compact. In fact, the process of regeneration is merely a thickening of the old bone, and if examined in a recent state the periosteum will be found very vascular and pulpy but neither thickened nor ossified. And, when the disease has ceased, or the cause of irritation been removed, the membrane recovers entirely its natural texture. Thus continues this author when the shaft of the femur perishes, a formation of new bone arising from the extremities of the old, first downwards and upwards, to form a case, which, in very favourable instances may form a sufficient substitute.

Dr. Black thus declares himself a supporter of the least popular
Theory that which ascribes the reproductive power to the bone, Mr. Stanley in his late excellent work on the "Diseases of the Bones," 1847, writes "Under certain circumstances, the soft tissues surrounding the dead bone, independently of the periosteum, may take an active part in the reproduction of the new bone, and these circumstances favorable to this mode of regeneration are, that around the dead part there should be a thick stratum of soft parts, and that the inflammation in them, consequent on the death of the bone, should have been so mild as to terminate in the effusion of serum or fibrin rather than in suppuration."

"Thus," continues Mr. Stanley, "in a case where Mr. Travers removed the clavicle with its periosteum, on account of a tumor originating..."
in it; the production of new bone was of a cylindrical figure, and extended from the truncated extremity of the Clavicle, at least two inches, terminating beneath the Centre of the Cartilage in a firm ligamentous bond, adherent to the skin. Here, therefore, the new bone was produced only from that portion of the Clavicle which had been left in the operation, and accordingly in this case it was seen to what extent the reparative forces would ensue, unaided by the periosteum, and eliciting but little aid from the surrounding soft parts.

From the above it is evident that Mr. Stanley deems the assertion that the periosteum is essential to reproduction, but favours the opinion that the extremities of the shaft and the surrounding soft parts are gifted with that function.

Professor Syne
States it as his opinion that the peristenum is the only agent employed in reproduction and that the process is conducted independently of the old bone. He adds that to prove his position, one experiment consisted in excising the radius of a dog and removing an inch and three quarters of it along with the periosteum, and in the other leg removing a corresponding portion without the periosteum. In six weeks the cut extremities of the radius, from which a portion had been taken, together with the periosteum, had only extended towards one another in a conical form with a great deficiency of bone between them, and in its place merely a small band of tough ligamentous tissue. In the other where the periosteum had been allowed to remain, there was a compact mass of bone, not only occupying the space left by the
* For it seems nearly ascertained, that neither blood, itself, nor any other effusion from uninflamed vessels, nor purulent matter nor the effusions from certain varieties of inflammation are capable of thus becoming vascular and organized and the useful purposes which inflammation serves in the animal economy depends essentially on this that is in the process by which portions of blood are thus prepared for the vital changes by which they are to close wounds and repair breaches of texture. — Alison.
protein removed, but rather proceeding it. The objection to this experiment, says Mr. Bailey, is that it cannot be accurately performed since it is impossible to separate the periosteum from a dog's radius without removing along with it minute longitudinal filamentary, or ribbon shaped portions of the surface of the bone, more particularly, as may be conceived, when performed in the manner which under the circumstances would be adopted, by leaving it up in front and detaching it transversely before separating the periosteum of bone. And it remains to be proved, that it is not from these minute shreds of bone that the regenerated portion of the shaft has derived its origin.

As in other tissues of the animal system we have a fibrinous effusion becoming organized and assuming the function and appearance of the tissue from whence
for the most part it has been bended, and with which it is in contact, so is
the reproductive stage of necrosis, or in the separation of a fracture
we have an effusion; but this effusion
would never take on the characters
of vital tissue from which it had
its origin unless it were in actual
contact with it; and by the same law
the exudation in the reproduction of
bone would never become osseous
unless in contact with vital and
healthy bone. Or in other words, if
bone were entirely removed from
a part that influence or impression
which seems necessary for the ossification
of the plasma would I believe be
found deficient, and that plasma
which is bereft of what we may term
osseous influence (though in experiments
itward the establishing of this point,
the difficulty of continuing all the bone
must ever present a considerable obstacle
to this inquiry) will, I am satisfied, neve
be the seat of true resorption. In those instances of a shell of bone prevented from being in contact with the sound bone by the presence of an intervening substance it may perhaps be said, that the communication between the effusion and the bone is cut off; this, however, is incorrect as there are always adhering to the periosteum minute particles of the bony tissue. The intervening substance just mentioned, is considered by some as an internal layer of the periosteum; but W. Goodall, considers it to be a separating medium formed by the vascular contents of the inflamed Resorptive Canals being allowed to combine with the granulations by the gradual enlargement and subsequent thickening of the Canals.

Meischer in his work before quoted, writes with respect to the intervening substance: "That part of the
Granulations near the bone are converted into living substance, while the exterior layer is not so changed, but like the granulations of the soft parts has a cellular structure, and, this as it were forms a new periosteum." At another part of his treatise he writes, "The fluid is first changed into cartilage and becomes substance on the surface of the old bone."

Müller viewed this simulation as poured out from the sound bone independently of the periosteum.

Benjamin Bell, in his work upon "The Diseases of Bones, 1826, says "I coincide with those authors who are of the opinion that bone is regenerated by means of the vessels of its proper tissue, and that the periosteum performs nearly the same offices to it which fascia does to muscle, and neurilema to nerve."

But do not mean to deny that...
Some seem, and perhaps not erroneously, to view deposits of earthly matter occurring in certain tissues, as in the cellular and fibrous, as abnormal secretions. In these earthly deposits or secretions the carbonate of lime usually preponderates while the phosphate is present in an inconsiderable quantity.
the periosteum may be opacified in its texture, at least impregnated with earthy matter: but this im-
pregnation I think should rather be classed with those de-
positionts which occur in many
other tissues of the human body.

Thus Mr. Bell far from
ascribing to the periosteum the
function of reproducing bone, in a
very evident manner discloses
his doubts of that membranes ever
becoming really ossified.*

M. Rohitansky of
Vienna, in his pathological Anatomy,
adies with three authors who view
the bone as the regenerator: he is
however less definite and more
liberal (if I may use the expression)
than experience would seem to
indicate, in pronouncing the
source of the exudation. He writes
that regeneration is ac-
complished by that part of the
old bone which remains healthy. But there can be no question that the periosteum and other surrounding soft parts, and even newly formed vascular tissue, are capable of furnishing an exudation which will become bone.

In partial necrosis of the whole thickness the process of repair originates by the old bone at the living margin of the sulcus, consists of two distinct parts, deep and superficial, which occurring after the discharge of the suparetum from the new bone or substitute.

The deep consists of recoil production from the living bone beneath the exfoliation and follows closely the back of the ulceration.

The superficial in the language of Dr. Miller, "is begun by the bone but apparently carried on by the periosteum, invaginating the dead part in its interior; gradually
The expansion of the resorbed
structure within the new case
after a time occupies its whole
cavity and fills up the closed
so that scarcely any vestige of
them — after the elapse of a
few years — can be discovered
on the surface of the substitute.
Shelving once and encrusting it, as bush does a tree, and hence the term "cortical portion of the substance of new formation."

When the periculum is not continuous but perforated by apertures, the osseous deposition occurring and constituting the cortical portion; passing round the margins of these openings forms corresponding spicula or cones, in the newly constructed core; and these are serviceable, as before stated, in sealing the vascular discharge of the secreted fluid and permitting easy examination of the dead portion. The absence at these centres of a medium in which the minute vessels carrying the blood can find their exit evidently explains the corresponding deficiencies in the enveloping cortical formation.

The reproduction of the
outer lamella of a bone can perhaps be that imperfectly affected without the aid of the periosteum. It is not, I think, essential that the bone shall
constitute in every case both
the reproduction of the organiz-
able material and the manage-
ment of the organizing process.
This is especially important
in the development of the trophic
formation and it seems probable
that in some cases a more or
less healthy condition of the
periosteum is indispensable
towards the diffusion of that excitation
which is to be the field of future
change.

From what I have already
stated, it would appear that
the new bone in substitute will
be formed once commenced by
the edge of the living bone at
The odens, wherever there is peristomium, tend to surround the soft part which have been in the junction of the former.

Upon careful consideration of the different arguments and evidence adduced in favor of the two theories: namely, that in which the bone itself is considered its own regenerator, and that in which the peristomium is viewed as the reproducer of bone. I would state, as I have in a manner already done, that bone is its own reproducer, and that inasmuch as the pressure of peristomium, through the agency of which bone derives its nourishment, is necessary,
the health and existence of long
so far is it subervient to the
process of regeneration.

Therefore persistem
is indispensable to the development
of the reproductive power of new bone,
and there must exist wellconditioned
bone from which to germinate and
persistem whence to derive a supply
of blood.

In conclusion
it may be remarked that the
reproductive power exists alone
in bone, and that regeneration
is carried on by it be induced
by its presence.

Finis