Dr Steel with
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*On the Healing of Wounds in Articular Cartilages, and on the Removal of these Structures after Amputations at the Joints, with Remarks on the Relation which exists between the Diseases of Cartilage and Ulceration and Inflammation in other Textures.* By P. Redfern, M.D., F.R.C.S.L., Lecturer on Anatomy and Physiology, and on Histology, at the University and King's College, Aberdeen.

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Having previously shown[1] by the result of about ninety observations made on the cartilages of the lower animals, that all changes which can be induced in them by experiments are precisely similar in their essential characters to those which are observed in the human body, I can with increased confidence refer to other actions observed to take place in the structures of the former, with a view to elucidate such as we have very rare opportunities of examining in the instance of the latter. I shall especially refer—1st, To the healing of wounds in articular cartilages, and show that this undoubtedly takes place, and that cut surfaces kept in apposition become firmly adherent by the formation of fibrous tissue out of the substance of the adjacent healthy cartilage, the union being so perfect that, after a short time, it is quite impossible to detect the injured spot with the unassisted eye; and, 2dly, To the process by means of which the removal of articular cartilages is effected after amputations at the joints, pointing out that the changes which cause this are such as are frequently observed in the cartilages of man and animals under other circumstances, and that the cartilage itself becomes converted into a layer of fibrous tissue, which constitutes a permanent covering for the end of the bone. I shall also endeavour to point out

[1] Anormal Nutrition in Articular Cartilages, with Experimental Researches, &c. Edinburgh, 1850.

the relation which exists between the diseases of articular cartilages and ulceration and inflammation in other textures.

*Healing of Wounds in Articular Cartilages.*—In my former observations, I found that from the 37th to the 49th day after incisions had been made into the articular cartilages of dogs, adhesion had taken place between the cut surfaces to such an extent as to render it easy to make thin sections through both and leave them attached. The uniting substance was composed of a granular mass, containing very imperfect fibres, and a number of corpuscles not to be distinguished from the nuclei of cartilage cells. The cartilage cells lying near the cut surfaces were very much enlarged, rounded or oblong in shape, and filled with corpuscles; in several places they projected into the mass between the cut surfaces, and were therefore in a position to discharge their contents into it whenever the cell-wall should offer too little resistance to their escape. The inter-cellular substance of the same part was somewhat softened and more transparent than ordinary, and presented indistinct traces of fibres. From these appearances, discovered on examination, and shown in Fig. 1, I concluded that the stimulus of the incision had produced

Fig. 1.

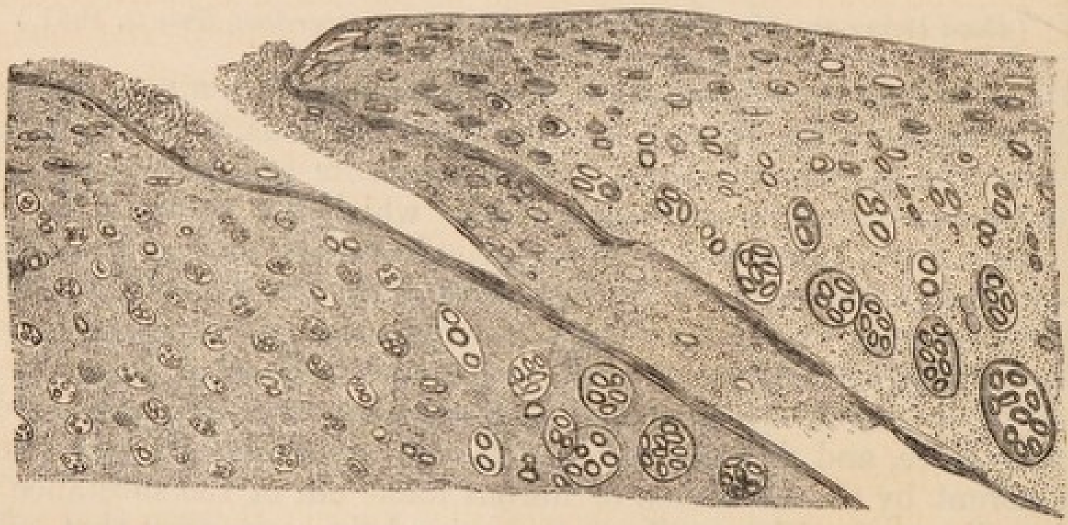


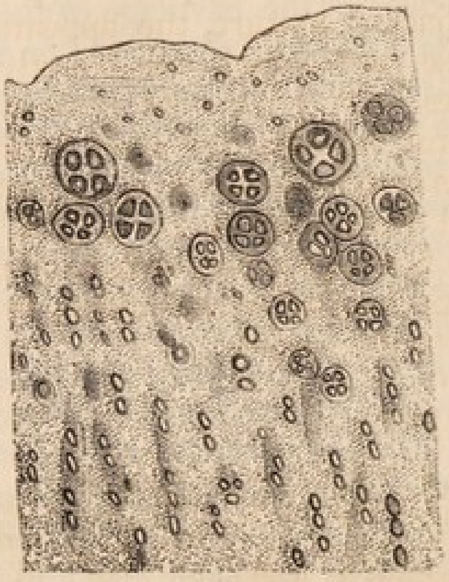
Fig 1.—Section of the cartilage of the patella of a dog passing through an incision made forty-nine days before death.

an anormal development of the cells of the part through which it had passed, whilst the inter-cellular substance having become softened, received the contents of the cells after the destruction of their walls; and that this process, so similar in every respect to that by which a fibrous membrane is formed from diseased human articular cartilage, would terminate in a similar way, by forming a dense fibrous mass, with its fibres leading into the substance of the cartilage, and therefore attaching the opposed surfaces firmly to each other. This, however, was not proved, for the fibres observed were very imperfect, and the uniting medium was too soft to remain as a permanent structure; I therefore instituted other experiments, which were as follow:—Three incisions were made across the cartilage of the patella and obliquely from below upwards, in a young dog, and two others were made vertically and from the centre towards the circumference in the cartilage of the trochlear surface of the femur. The patella became dislocated on the inner condyle of the femur, and the dislocation returned instantly after reduction, so that it was allowed to remain. The dog suffered considerably, and could not put his leg to the ground for a fortnight, after which, slight lameness continued for some time, and then almost altogether disappeared, except when any unusual movement was produced. The joint was examined at the end of twenty-four weeks and five days, and presented the following appearances:—A slightly increased quantity of synovia exists in the joint; the patella rests by the external half of its articular surface on the inner side of the internal condyle of the femur, and the part of the fibrous capsule of the joint which lies upon the trochlear surface of the femur and glides over it, presents a dense, white, and smooth spot, similar in appearance to fibro-cartilage, and of exactly the same size and shape as the trochlea. The edges of the trochlear surface of the femur, and the vertical ridge on the cartilage of the patella, are less prominent than usual, and rounded. The cartilage of the femur appears perfectly healthy, that of the tibia somewhat softer than natural, and the cartilage of the patella is more transparent, and has a small perforation in its centre leading down to the bone. The position of the incisions is difficult to see on the patella, and is only marked by the slightest curvilinear depressions; on the femur, one incision is recognised with the greatest difficulty, and the position of the other cannot be seen with the naked eye.

On microscopical examination, the superficial cells over a considerable extent of the surface of the cartilage of the patella, and especially in the neighbourhood of the central depression, have become much enlarged, many measuring $\frac{1}{1000}$th of an inch in diameter; they are nearly spherical, and their contents appear to have divided into three or four masses like nuclei; they are lodged in hyaline substance of greater transparency, and much greater softness than ordinary, so that the cells can be pressed out of it. The appearance of the surface is in fact very similar to that shown in Fig. 2, and formerly described as showing the structure of the superficial layers of the cartilage of the tibia of a dog at a spot in which increased pressure had been made.

In the neighbourhood of the incisions into the cartilage of the patella, and upon the trochlear surface of the femur, though not extending upon the condyloid surfaces, the substance of the superficial layers of the cartilage has become converted into a membrane composed of granules, nuclei, and fibres. The formation of this membrane may readily be traced by an examination of it at the line of junction of the trochlear and condyloid surfaces, where it becomes thin before it ceases to be observed. The contents of the cells first become granular, and the hyaline substance soft and more trans-

Fig 2.



parent; the walls of the cells disappear gradually, and scarcely anything but cell-membranes, granules, and molecules lying in a hyaline mass, can be seen; fibres are then formed between the nuclei, and the latter either disappear altogether or elongate into nuclear fibres, and thus a dense fibrous mass is produced. If, during this process, the cells have become larger than natural, they give to the junction of the cartilage and membrane a notched appearance, by bursting and discharging their contents into the latter; but if no enlargement has taken place, the textures run into each other so insensibly that no distinct line of demarcation can be drawn between them.

The portions of the texture through which incisions were made present similar appearances in every instance. Not the slightest difficulty is experienced in making sections through both the cut surfaces and the substance by which they are firmly united. Such sections show the cut surfaces to be very uneven and hollowed into small pits of the size of the cartilage cells of these parts. The pits are obviously produced by the half-destroyed cells, the former contents of which are now seen lying on the surface. No evident change has taken place in the texture of the cartilage at a little distance from the cut surfaces, except that here and there the inter-cellular substance presents a fibrous appearance. There is no obvious enlargement of the cells, or crowding of their interior with corpuscles, as is frequently seen to occur under similar circumstances. The substance uniting the cut surfaces consists of a hyaline, granular, and indistinctly striated mass, in which there are numbers of rounded, oblong, elongating, or irregularly-shaped corpuscles, varying in size from $\frac{1}{5000}$th to $\frac{1}{2300}$th of an inch in diameter, those in the adjacent cartilage measuring more uniformly about $\frac{1}{3000}$th of an inch. The corpuscles are more numerous in the substance connecting the cut surfaces than in the cartilage itself, and the inter-cellular substance of the same part is slightly more transparent than that of the adjacent texture, the appearance of fibres being most distinct in those parts which are directly in contact with the cartilaginous surfaces. (Fig. 3.) In sections obtained from the cartilage of the femoral trochlea the mass between the cut surfaces is less transparent, its fibres are much more perfect, and the corpuscles are smaller and less easily seen. (Fig. 4.) The fibrous and nucleated membrane formed on the surface of the cartilage is continuous with the uniting medium, and differs from it merely in having its fibres parallel to the surface.

Fig. 3


Fig. 4.

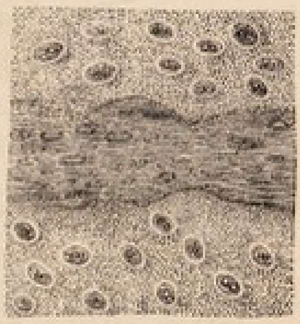


Fig. 3.—Vertical section of the cartilage of the patella of a dog passing through an oblique incision made twenty-four weeks and five days before examination, and showing perfect and firm union of the cut surfaces.

Fig 4 —Section of the cartilage of the femur of a dog passing through an oblique incision made twenty-four weeks and five days before examination, and showing the perfect fibrous tissue developed in the healing of the wound.

It may be here remarked, that the lameness which occurred in this case is by no means to be viewed as the result of the injury to the cartilages; for except when dislocation, or some other accidental occurrence, takes place, incisions in the articular cartilages of the knee-joints of dogs are attended with no lameness or evidence of suffering whatever, after the first few days which are required for the healing of the external wound. Neither is it to be supposed that articular cartilages are in a favourable position for the healing of wounds; for, independently of the continued movement, which is no less detrimental here than in the healing of ordinary wounds, many actions which take place in these textures proceed very slowly, and, therefore, are in greater danger of being interfered with in their progress. In an instance in which I made three incisions into the cartilage of the patella, and two into that of the trochlear surface of the femur, no adhesion had taken place in any of the instances when the parts were examined twenty-nine weeks afterwards, though no inflammation of the joint, dislocation, lameness, or other apparent cause for the want of union had occurred. Yet some of the cut surfaces were in such close contact, before the parts were examined by means of sections, as to lead to the supposition that union had taken place. On the examination of these wounds, no effused matter of any kind appeared on the perfectly smooth cut surfaces; but as the cells near to them in the substance of the cartilage were obviously enlarged and rounded, having in their interior three or four corpuscles into which their nucleus appeared to have divided, or a number of bright granules, there appears reason to believe that union might still have occurred had more time been allowed.

After the foregoing observations, I no longer entertain the slightest doubt that wounds in articular cartilages are capable of perfect union by the formation of fibrous tissue out of the texture of the cut surfaces. The essential parts of the process appear to be the softening of the inter-cellular substance of the cartilage, the release of the nuclei of its cells, the formation of white fibrous tissue from the softened inter-cellular substance, and of nuclear fibres, by the elongation of the free nuclei. It does not appear necessary that the cells should become much enlarged or crowded with corpuscles, as they are seen in Fig. 1, for the union represented in Figs. 3 and 4 is still more perfect, and it took place without any enlargement of the cells, or increase in the number of their corpuscular contents; these changes, therefore, though they may contribute materially in some cases to the rapidity of completion of the process under consideration, are clearly not essential in any of its stages.

*Removal of Articular Cartilages after Amputations at the Joints.*—The foot of a young dog was amputated at the ankle joint, and treated in the usual way; union by the first intention took place and was complete in a few days, after which the animal appeared in perfect health, and went about as if nothing had happened, only occasionally bringing the amputated limb to the ground. The part was examined at the end of forty-six days, and presented the following appearances:—The cicatrix is firm, and adheres to the end of the bones. Two or three of the ligatures applied upon the vessels are enclosed in small dense cysts containing a small quantity of reddish fluid. All the divided tendons have elongated swellings upon them near their ends. The swellings are composed of dense fibrous tissue with fusiform cells, and present a large number of nuclei after the action of acetic acid. Under the skin a considerable layer of very dense fibrous tissue covers the ends of the bones, and adheres very strongly to the cartilage, but can be detached in several places if much force be employed. The cartilage is but little thinner than usual; its deep surface presents a few calcified cells, but in other respects it appears healthy. The cells of the superficial layers are enlarged, many are rounded, and measure about $\frac{1}{3700}$th of an inch in diameter, others remain of the elongated form, and measure $\frac{1}{1850}$th by $\frac{1}{5000}$th to $\frac{1}{2460}$th of an inch, one measures $\frac{1}{1000}$th by $\frac{1}{1500}$th of an inch. Each cell contains a large nucleus and a number of bright granules, varying in size from $\frac{1}{10{,}000}$

to $\frac{1}{5000}$th of an inch. The inter-cellular spaces are much greater than in the superficial parts of the corresponding cartilage of the opposite limb, and are occupied by hyaline substance in which there are traces of fibres, which are continuous with those of the fibrous covering of the end of the bones. On proceeding in the examination towards the skin, the walls of the cartilage cells gradually disappear, and their contents—nuclei and granules—become mixed with the fibres of the fibrous tissue, where the nuclei can be seen distinctly elongating to form nuclear fibres, especially after the application of acetic acid. The formation of white fibres in the intercellular substance, quite independently of the cells, is also distinctly observed, so that there can be no doubt that the cartilage substance is converted into fibrous tissue, of which the white fibres are produced by transformation of the hyaline substance, and the yellow or nuclear fibres by elongation of the nuclei of the cartilage cells. The appearance of the cartilage at the point of connection with the fibrous membrane, is almost precisely similar to that which forms on the surface of costal cartilages in the neighbourhood of parts irritated artificially, and is represented in Figs. 5 and 6.

Fig. 5.

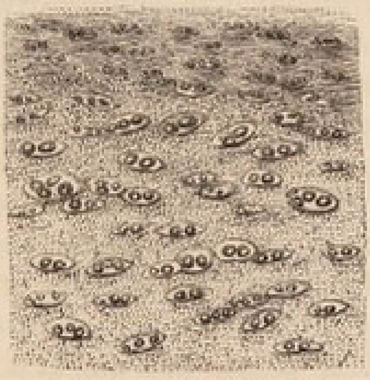
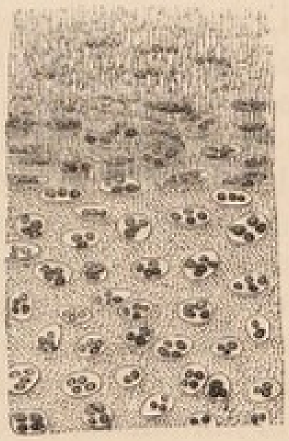


Fig. 6.



A different process, which, however, there is good reason to believe would have terminated in the same manner, occurred in an instance in which the leg of a dog was amputated at the knee-joint twelve weeks before the examination of the parts. The patella was left, but its lateral connections were sufficiently loosened to allow it to be drawn upwards on the thigh. The stump healed completely by the first intention in a few days; the animal got very fat, and did not manifest the slightest uneasiness when the part was freely handled, or at any other time. The following were the appearances:—The patella lies loosely on the surface of the femur, half-an-inch above the edge of its trochlear surface. The cicatrix is firm, and the covering of the end of the bone perfectly healthy, and very moveable everywhere, except in one spot, a line in diameter, near the lower part of the external condyle of the femur, where a little oozing occurs, and a firm adhesion to the deeper parts exists. The muscles of the thigh are healthy ; the fibres of the gastro-cnemius are pale, soft, and flabby. The integument can be dissected with the greatest ease from the subjacent parts, except at the spot above named. A thin, but very strong membrane, covers the articular surfaces of the femur, and its interior is lined by a synovial membrane which extends upwards covering the articular surface of the patella, is reflected upon the femur half-an-inch above its trochlear surface, and passes beyond its articular surfaces so as to cover a large portion of the lateral aspect of each condyle. A few adhesions exist between this synovial membrane and the cartilages of the condyloid surfaces of the femur and of the patella, at a little distance from the edges of the surfaces.

A superficial inspection of the cartilage might lead to the belief that a large portion of it is unchanged, but a more careful examination by the naked eye, or by the aid of a lens, shows that almost every portion of the surface is marked by a number of very small pits, producing something of the appearance of sand paper. The pits are very distinct on the patella, and on every part of the surface of the femur, except on the deepest part of its trochlea. They are obviously produced by the irregular removal or destruction of the superficial layers of the cartilage. Near the outer edge of the external, and the inner edge of the internal condyloid surface, there is a much more obvious destruction of tissue over an elongated surface of one-fourth of an inch in extent on each side. On the outer condyle the patch just named is sprinkled over with red spots and lines (blood-vessels seen through thinned and transparent cartilage), most numerous at the centre of the patch, where, also, are a number of small pits, erosions, or ulcerations, separated from each other by septa of less changed tissue. On the inner condyle the patch presents a distinct and continuous erosion, with well-defined edges, and a base sprinkled with red spots and lines, and marked by small reddish prominences, presenting, in fact, precisely the appearance of a granulating ulcer in any other tissue. The adjacent surface of the cartilage at the posterior extremity of this patch is marked by small pits or erosions, reddened at their deepest parts like the corresponding spots on the opposite side.

Fig. 7.

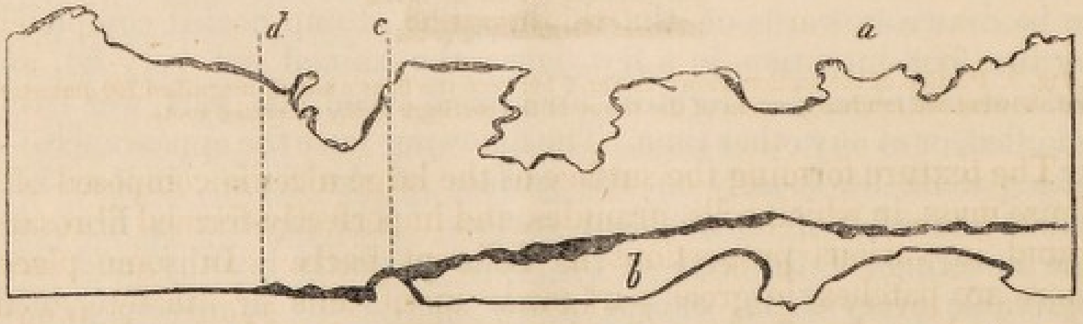



Fig. 7. Outline of a section showing the small pits or erosions of the cartilage on the inner condyle; d, the irregular free surface; b, a calcified layer of cartilage at the attachment to the bone. Magnified 66 diameters.

*Microscopical Examination.*—The muscular fibres, which are paler than natural, have indistinct longitudinal and transverse striæ; acetic acid acts more readily upon them, producing greater transparency, and showing the nuclei more distinctly than in healthy muscle. There appear to be more fat vesicles amongst the fibres than are found in the muscles of the healthy limb.

The superficial cells of the cartilage of the inner condyle are parallel to the surface, considerably enlarged, measuring as much as $\frac{1}{750}$th by $\frac{1}{2500}$th of an inch, finely granular, and, in some places, seen with difficulty, owing to their great transparency. They are clearly seen to open and discharge their contents, thus destroying the texture, and leaving the surface uneven and notched. The cells and inter-cellular substance of the deeper parts have their healthy arrangement and appearance as far as the eroded or ulcerated spots, on the edges of which the inter-cellular substance becomes softened and more transparent, allowing the cells to escape on the surface, where they also degenerate and are seen to be irregular, shrivelled, losing their walls and discharging their contents, or reduced to mere granules,—the whole texture being thus removed by ejection of variously-sized particles on the surface. Where the surface presents numerous small pits or erosions, the superficial parts of the cartilage have disappeared, and the deeper parts are undergoing the changes just named. (Fig. 8.)

Fig. 8.

Fig. 8. Portion of the section shown in Fig. 7 between the lines *c* and *d*, magnified 200 diameters, and showing the gradual ejection of the tissue of the cartilage at the ulcerated spots.

The texture forming the surface of the large ulcer is composed of a dense mass, in which cells, granules, and imperfectly-formed fibres are found in various proportions in different parts. In some places there are patches, in great part made up of cells $\frac{1}{2200}$th by $\frac{1}{5600}$th of an inch in size, finely molecular, but difficult to discover from the granules and imperfect fibres in which they lie (Fig. 9); in other places, elongated dark patches are the only indications of the existence of cells which have become further changed, and the fibrous mass appears more perfect (Fig. 10). When acetic acid is added to parts like Fig. 9, the mass becomes more transparent, and cells with a few granules are more distinctly seen; after the addition of the same acid to parts like Fig. 10, the granular and fibrous mass becomes hyaline and gelatinous, and numerous elongated cells or nuclei appear, which measure from $\frac{1}{2000}$th to $\frac{1}{1600}$th of an inch in length, by $\frac{1}{10,000}$th in width (Fig. 11).

Fig. 9.

Fig. 10.

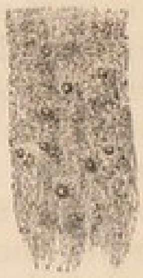
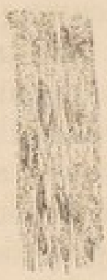


Fig. 11.



Figs. 9 and 10. Fibrous layer at the bottom of the ulcer, showing its mode of formation.
Fig. 11. Portion of the fibrous membrane similar to Fig. 10, acted on by acetic acid.

On every part of the surfaces of the femur and patella, where any microscopical change has taken place, an appearance of erosion exists when the part is very closely examined by the naked eye; and whenever any change has occurred, it is marked by similar characters. On proceeding from a healthy towards an eroded part, the first change noticed is a darkening and indistinct appearance of the superficial layers continuing until a fibro-nucleated membrane becomes evident on the surface. This membrane consists of imperfect fibres formed by the breaking up of the inter-cellular substance, intermixed with small cartilage cells, and the discharged nuclei or granules of larger ones. Acetic acid renders the whole of the fibres transparent, and brings into view the nuclei, which are seen to be elongating to form nuclear fibres. In the absence of erosions, the membrane appears to cover the surface for some time; but when erosion commences, the indistinct fibres and the hyaline substance which remains become gradually softened, and the cells, nuclei, and granules thus set free, fall into the interior of the joint, and are probably removed by absorption. When the process has reached the deeper parts of the structure, these become in like manner converted into fibrous tissue, which remains, in many cases at least, to constitute a permanent covering for the end of the bone.

The conclusion to be drawn from the foregoing observations is, that when articular cartilage is rendered useless, and has been relieved from pressure by amputation through a joint, it gives place to another tissue, which constitutes part of the general covering for the end of the bone. The newly-formed tissue is fibrous, and composed of white fibres originating in the splitting of the inter-cellular substance, and of yellow or nuclear fibres produced by elongation of the nuclei of the cartilage cells. Or, should the synovial membrane opened by the amputation become completed, and again converted into a closed secreting sac during the cicatrization, so that free movement is allowed between the end of the bone and its fibrous covering, still there is no use for a covering of elastic cartilage on the end of the bone, and it becomes removed altogether, or partially converted into fibrous texture, as happened in the last observation.

*Comparison of the diseases of Articular Cartilages, with the processes of Ulceration and Inflammation in other textures.*[1]

*Ulceration.*—It may be useful to examine in this place the nature of the process by which portions of articular cartilage are removed during ulceration or erosion, with a view to ascertain whether it is in any respects similar to known processes occurring in other textures, and especially to the ordinary process of ulceration.

I think it will be sufficiently evident, from the observations now detailed, and from those formerly published,[2] that the essential parts of the process of removal of articular cartilages (ulceration) are, —*the softening of the inter-cellular substance, and the release of the cells, very often attended with the escape of their contents by the destruction of the cell-walls,* all the parts of the tissue being thus ejected on the ulcerating surface: whilst the cure consists in the transformation of the inter-cellular substance, and of the nuclei of the cells of the adjacent cartilage, respectively into the white and yellow tissue of the fibrous cicatrix. In different instances, the cells enlarge in very various degrees before they open, and their contents are,—1st, one, two, or more ordinary nuclei; 2d, the ordinary nuclei with the addition of bright, highly refractive granules, oil globules, or molecular matter; or, 3d, irregularly rounded corpuscles, from six or eight to sixty or more in number; whilst the inter-cellular substance softens into a gelatinous and finely molecular mass, which gradually disappears by its particles falling off on the surface; or, 2d, it is converted into an imperfectly fibrillated mass, destined shortly to become disintegrated; or, 3d, it is resolved into a more perfect fibrous tissue, which is to form part of the cicatrix.

Ulceration in other tissues consists in the gradual detachment and ejection of dead pieces of their substance visible to the naked eye (sloughs),—in the falling away of changed portions of texture, so small as only to be recognised by the microscope, as in caries,—or in the discharge of a multitude of granules or molecules into which the part has degenerated. Being generally accompanied by inflam-

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1 It must be fully understood here, that what follows is to be held as applicable merely to diseases of cartilage, which has not previously suffered any structural change, and to such diseases as are not complicated by affections of the neighbouring textures.

2 Op. citat.

mation in tissues furnished with blood-vessels, part of the inflammatory exudation, consisting of blastema, granules, and cells, is thrown off, together with the disintegrated elements of the part, and these constitute together a very evident discharge.[1] The cure consists in the conversion of the nucleated cells of the inflammatory exudation into the white and yellow fibrous tissue of the cicatrix, the cells splitting to form the white, and the nuclei elongating to form the yellow fibres.

The process of ulceration in cartilage, and other tissues, is, therefore, precisely the same if we regard merely the actions of the essential elements of the textures;—in both, softening and disintegration occur, with ejection of the molecular or granular matter into which the part has been reduced; in both, small particles of the tissue are thrown off, and are capable of recognition by the microscope; in both, larger portions of the texture, visible to the naked eye, are at times detached, in the one case, in the form of sloughs of dead tissue, in the other, in that of large portions of much less changed cartilage; lastly, in both instances, the process may go on with extreme rapidity, or it may make scarcely perceptible progress for a very considerable period.

The points of dissimilarity are these,—articular cartilage contains no blood-vessels, consequently ulceration and other changes of structure confined to it are never complicated by inflammatory exudations, pus, &c., and can be examined very satisfactorily; ulceration in tissues containing blood-vessels is almost always complicated with inflammation, and the ejected particles of the tissues having undergone a very complete degeneration, and become mixed with a mass of structures formed in the inflammatory exudation, also degenerate, are, therefore, very difficult to recognise. Ulceration or other disease confined to articular cartilage has in no single instance been shown to be productive of pain,[2]—no doubt for the very simple

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[1] For a very excellent view of the whole process of ulceration, I would refer to Professor Paget's fifth Lecture on Inflammation, Professor Miller's "Principles of Surgery," Ed. 1850, p. 143, and to Professor Bennett's Treatise on Inflammation, Ed. 1844, p. 46.

[2] It is somewhat gratifying to find that the decided statements formerly made regarding the diagnosis of disease of articular cartilages have recently undergone modification, in two very important quarters at least. Sir B. C. Brodie, at p. 192 of the fifth edition of his work on "The Diseases of the Joints," April 1850, in speaking of the pain which exists during ulceration of articular cartilages, adds, "Still I am myself more inclined to the opinion, that the increased sensibility in these cases is in the bony plate beneath the cartilage rather than in the cartilage itself, and that the presence of severe pains, with involuntary startings of the limb, is always to be regarded as a sign of the bone partaking of the disease." And Professor Miller, at p. 510 of the second edition of his "Principles of Surgery," 1850, says, that simple destruction of cartilage leads "to little pain, or perhaps none, if the cartilage alone be involved;" and again, at p. 512, after repeating his former statement, that "the symptoms of destruction of cartilage, although invariably indicative of that affection, are not

reason, that these structures contain no nerves; in other textures, ulceration is often attended with very severe pain from implication of the nerves ramified in their substance.

The *healing of ulcers* in articular cartilages, and in tissues freely supplied with blood-vessels, differs in this remarkable particular, that in the former, the fibrous cicatrix is invariably made up of the changed substance of a portion of the cartilage not subjected to the process of ejection,[1] and in the latter, the cicatrix as constantly results from the development of the inflammatory exudation. This difference admits of the following explanation: in the case of the ulcer affecting no texture but that of cartilage, there is no other matter from which a cicatrix can be produced than the actual cartilage tissue remaining; and it may be remarked, that cartilage is a very simple cellular texture, and that the greater number of the tissues are originally formed from cells,—that the cells of cartilage have a natural tendency to transformation into fibre, as is shown in the development of fibro-cartilage,—and that the inter-cellular substance shows as remarkable a disposition to produce the same result in its diseased state. In the ulceration of tissues supplied freely with blood-vessels the reverse maintains; for the degeneration and destruction of the tissue actually involved is so complete, that this can in no way assist in the formation of the cicatrix; and there is, therefore, nothing left in this instance but the inflammatory exudation from which that substance can be formed.

*Inflammation.*—In now directing attention to the process of inflammation, to ascertain how the diseases of cartilage stand in relation to it, it is, in the first place, absolutely necessary to state what is meant by inflammation,—for, though we may not be able to frame a definition of it which will be universally acceptable, and which will exclude tubercular, cancerous, and other morbid growths, every man is bound, in the use of a particular term, to intimate what he means by it, if it be one which has no general acceptation.

What is to be understood here by the term inflammation, is "*a peculiar perversion of nutrition or of secretion*," *attended with certain changes in the blood and blood-vessels, and including exudation as its most important and characteristic phenomenon.*[2] This definition in-

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always indicative of its amount, because not uniformly proportioned thereto," adds, "They rather indicate the amount of disease in which the other textures of the joint have been involved."

[1] When the whole thickness of the cartilage is thrown off without the occurrence of disease in the neighbouring parts, a fibrous membrane has never been found on the end of the bone, and the only cure which has been observed is that by eburnation or porcellanous transformation on the articular surface of the bone.

[2] Professor Alison first pointed out that a peculiar perversion of nutrition or of secretion is essential to the very existence of inflammation, and that effusion from the blood-vessels must be included in our general notion of this process. Dr Bennett subsequently showed in what manner inflammatory exudations become developed, and that the perversion of nutrition which establishes the process exerts its influence in very many instances until its completion.

dicates sufficiently well for our present purpose the nature of the process understood in ordinary professional language and in practice as inflammation, but it does not separate cancerous and tubercular exudations, &c., from those which take place in ordinary inflammation in healthy persons; nor is this to be expected,—for, as there is scarcely any healthy structure, in man or other organised beings, which is capable of being separated from all the rest by definite lines of demarcation, it is not to be expected that diseased structures and the phenomena which occur in them will be capable of subjection to strict limitation and definition. As it is clear, however, that inflammation, and every process which is at all allied to it, are strictly processes of anormal nutrition, it is necessary to inquire, What are the essential conditions of nutrition in general?

*Healthy nutrition* requires a supply,—1st, Of material of a certain definite amount and quality; and, 2d, Of vital force competent to convert this into tissue.

*Hypertrophy* consists in an increase in the amount of material and of organising force.

*Atrophy* results from a deficiency in the amount of material, or of both material and vital force.

*Anormal nutrition* is produced by various alterations in the quality of the material supplied, and in the nature and action of the organic force,—conditions which are generally, but perhaps not necessarily, associated.

Now, for the establishment and continuance of these processes, it is not of the least importance whether,—1st, the nutritive material be supplied directly from without, as in the lowest animals and plants, or be carried to particular parts by means of a circulating system, for, in either case, when material is supplied of a certain definite quantity and quality, the first condition is fulfilled; nor, 2d, does it matter whether the vital or organic force belong directly to a particular tissue, constituting its only distinction from dead matter, or be communicated to it or controlled in its action by a special nervous system; if the force exist, it is enough for the second condition.

When, therefore, we are engaged in the examination of the healthy or diseased states of the lowest tribes or tissues of organised beings, we have nothing to attend to but the structure and mode of action of the part itself; but when we take up a part which contains living vessels and nerves, as well as its own proper texture, the examination becomes a very complicated one, and requires a thorough investigation of the nature of the changes in structure and action of every part of which the compound body is composed.

I think that the demonstration has been fully made, that every morbid action which takes place in the structure of cartilage is referable to an anormal nutrition of its texture, and, in so far, all these morbid actions resemble inflammation: they differ from it, 1st, in not being attended with exudation, because the texture in which they occur contains no blood-vessels; and, 2d, in not giving rise to pain on account of the absence of nerves.

If, therefore, inflammation be *merely* a process of anormal nutrition, it takes place in cartilaginous as well as in other textures; but if we include *exudation* as an essential phenomenon of inflammation, it never affects the human articular cartilages, which contain no blood-vessels, and present no exudation in disease.

So with ulceration,—if we are to separate the softening, degeneration and ejection of tissue in the formation of an ulcer from the exudation, which is an almost constant attendant on this process in vascular tissues, and forms cicatrices in them, then ulceration in cartilage and in other tissues is identical, though the method by which ulcers heal in the two forms of texture is altogether different; if, on the other hand, we include in the term ulceration, the production of exudation and its transformation into the tissue of the cicatrix, then it is equally clear that ulceration in cartilage and in vascular tissues differs in the occurrence of those phenomena in the latter case and not in the former.

Finally, I would call attention to the following conclusions:—

1st. Wounds in articular cartilages heal perfectly by the formation of fibrous tissue out of the cut surfaces.

2d. The fibrous cicatrix consists of white and yellow fibres, which are formed out of the inter-cellular substance of the cartilage, and out of the nuclei of its cells respectively.

3d. Articular cartilages disappear after amputation at the joints, either by being transformed into fibrous tissue, which is mixed with that of the cicatrix,—or by slow ejection of their particles into a newly completed synovial sac.

4th. Ulceration in articular cartilages differs from that in other tissues, in neither being accompanied by exudation, nor attended with pain,—differences which depend on the absence of vessels and nerves.

5th. Ulcers in articular cartilages heal by transformation of the surrounding cartilage tissue into fibre, but those occurring in other textures are cured by the formation of a cicatrix out of newly exuded blood plasma.

6th. Inflammation, regarded as a process of anormal nutrition, attended with changes in the blood and blood-vessels, including exudation as an essential phenomenon, does not occur in articular cartilages in man, simply because these textures contain no blood-vessels.

7th. The whole diseased states of cartilage are referable to a changed or anormal nutrition of the texture, and to this alone; when unaccompanied by disease in other textures, they produce no pain or other symptoms by which they can be recognised, and have much less surgical importance than they have for many years been supposed to possess.

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