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INFLAMMATION,

AND

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BY

BENJAMIN TRAVERS, F.R.S.,

SURGEON EXTRAORDINARY TO THE QUEEN,

AND

SURGEON IN ORDINARY TO H.R.H. PRINCE ALBERT.

LONDON:

SAMUEL HIGHLEY, 32 FLEET STREET.

1844.

1816

Faciamus ampliora quæ accepimus: major ista hæreditas a me ad posteros transeat. Multum adhuc restat operis, multumque restabit: nec ulli nato post mille sæcula præcludetur occasio aliquid adhuc adjiciendi.

L. A. Senecæ Epist. ad Lucilium LXIV.

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TO

SIR BENJAMIN C. BRODIE, BART., F.R.S.,

SERJEANT-SURGEON TO THE QUEEN,

AND SURGEON IN ORDINARY TO H.R.H. PRINCE ALBERT,

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THIS TREATISE

IS DEDICATED AS A TESTIMONY OF

FRIENDSHIP,

OLD, UNINTERRUPTED, AND SINCERE.

PREFACE.

The subject of these pages comprises the rudiments or first principles of our Art; and from an imperfect knowledge or insufficient improvement of them arise the chief errors of our practice.

The stirring spirit of these times has somewhat disturbed the articles of our physiological faith, and renders superfluous any apology for re-adjusting and, if possible, reconciling the discordant dogmas of modern sceptics and orthodox Hunterians. Such indeed is the ardour of progress that has of late sprung up among the votaries of science in all departments, sym-

pathetic perhaps with the increased velocity of our locomotion, that in not a few instances, the reaction of the drag upon the revolutions of the wheel seems as necessary to our progress as to our safety, verifying the maxim "obstando promoves."

My object in this little Treatise has been to extend our acquaintance with the phenomena of Inflammation, as far as the present state of science permits, by the joint aid of physiological and pathological observation, each deriving force from the other. I entertain the opinion that a practical pathologist employs his microscope and his mind on these phenomena to an advantage, which neither the pure physiologist, nor the mere clinical student can command. The chemical Professor, or the farmer by profession, treating respectively of the management of soils and crops, would for the same reason be less advantageously circumstanced for extending practical information than the philosophical agriculturist, who made

his estate subservient to his acquirements in that important branch of chemistry.

In my reports of experiments, which to some readers will appear tediously minute, I have been less solicitous to avoid prolixity or tautology, which to a certain extent is impossible, than to present faithful pictures of appearances, impressed by being repeatedly witnessed.

To the common-place objection, that we are not warranted to apply inferences from experiments upon cold-blooded animals to the human subject, I reply, that the field of microscopic observation is narrowed by the indispensable quality of transparency of texture, and that the analogy of all animal actions is fully sufficient to direct us to general principles, and corroborates, in a great degree, even minute details. It may be said, that an aperture by perforation of web or membrane is not precisely analogous to a flesh wound of the same diameter, this having a

permanent floor or bed, the other none; but what we see in the healing of the perforated web we should see in the healing of the hole bored for an ear-ring, or in the filling up of the crown orifice in the cranium after the use of the trephine, allowing for the assistance of the contiguous dura mater; and thence, the share which the bed of the flesh wound contributes to the operations on its margin may very easily be deduced. Such modifications suggest themselves. Time, industry, and ingenuity will doubtless carry us further; mean time, "est quadam prodire tenus."

The Physiology of Inflammation is important in a double sense to Pathology; first, to elucidate the nature, secondly, the order and reciprocal relations, of its several processes. My object was to include both; it is for my readers to say with what success it has been accomplished.

But, considering wounds and fractures, ulcers and tumors of casual origin, as the simple

every-day illustrations of the *Physiology* of Inflammation, to render this Essay as complete as I should be glad to leave it, the constitutional varieties which form the *Pathology* of Inflammation should be set down and described in order. Thus the tumors and ulcers of scrofula, cancer, and syphilis, with all their cachectic varieties, would serve to illustrate the adhesive, suppurative, and ulcerative processes; while carbuncle and malignant pustule, erysipelas phlegmonodes, and hospital gangrene, would furnish the pathological examples of gangrenous inflammation.

B. T.

Bruton Street, Berkeley Square,
Nov. 20, 1843.

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PHYSIOLOGY OF INFLAMMATION,

AND

THE HEALING PROCESS.

INTRODUCTION.

The microscope, since the improvements which it has of late years undergone, and the more accurate application of its powers by scientific and practised observers, has opened new and important insights into the field of anatomy, and rectified some long-established errors in the departments of physiology and pathology. It is remarkable, and at the same time conclusive of the soundness of Mr. Hunter's doctrines of inflammation, that the additions thus made to the illustration of this great subject of his researches, though materially affecting details, so far from invalidating, tend strongly to confirm the general principles which he has laid down, to carry out the views which he entertained, and to embody those which he had left in shadow.

Some of these corrections bear so directly on the theory of inflammation, its phenomena and progress, that it becomes necessary for a writer on the subject to establish an understanding with the reader as to those points which may be received, and those which, though assumed by reputed authorities, require further investigation, being as yet undetermined.

The theory of a closed instead of open structure of the sanguiferous systems, and of the mechanism of transpiration, being admitted as not at variance with the results of observation applied to the functions of circulation, respiration, secretion and absorption, and to the explanation of healthy functions, materially simplifies the phenomena of inflammation.

The universal prevalence of a cellular or vesicular rudimental form, even from the blood-vesicle upwards,—extended to the fabric of superadded structures as well as that of increment or growth,—inasmuch as it gives unity and simplicity to the mechanism and functions of the healthy economy, renders more intelligible by analogy the processes of inflammation, and their development in the removal and augmentation of original parts, and the addition of new structures. And it is obvious, as the relation is worked out, which has been to some extent established, between the fluid and solid

elements of animal as of vegetable bodies, that not only the just balance of their contributions towards the phenomena of life and health will be ascertained, but their respective influence in those which ensue, when that balance is disturbed, will be more correctly appreciated.

From careful observation it is deducible that the blood, viewed as a whole, is compounded of ingredients derived from two sources; first and chief, from the chyle or nutritious part of the food; secondly, from the refuse and decay of the various textures of the body collected by the lymphatic system; that its homogeneity is maintained only while it preserves the form necessary to its circulation; that its separation by coagulation is a general, though not invariable, or exclusive result of its extravasation; that it is never deprived of its colouring matter so long as it circulates, whatever be the tenuity of its current; but that this may be, and is in certain parts and circumstances, so exquisite as to render it colourless, and its containing vessels imperceptible to the eye.

The blood in circulation differs from the blood which has undergone coagulation, thus: the liquor sanguinis, or fluid portion of the blood, in which the red particles float during life, separates when coagulation takes place into two parts, the serum, and the fibrine which was

previously in solution. The fibrine coagulating entangles within it the red particles; the serum still contains the albumen in solution, which, remaining fluid after the coagulation of the fibrine, is not to be confounded with the liquor sanguinis.

The separation of the constituents of the liquor sanguinis, or fluid of circulation, is capable of being effected within the vessels by the operation of vital causes.

An interruption to the local circulation, either on the arterial or venous side, disturbing the due equipoise of the inferent and efferent, the secreting and excreting systems, operates to produce a change in the relative proportions of the circulating blood. Thus, what are called determinations and congestions, are the forerunners of dropsy and atrophy. The separation of the fluid constituent in inflammation, independent of lesion, if only such as results from this interruption to free circulation, is to be classed among the incidental and passive phenomena of that action, which may occur either at its commencement or its crisis, as determined by its exciting cause, its seat, character, degree.

The blood presents varieties, not only in the different species of animals, but also in individuals of the same species. These last are to be referred to circumstances which influence its formation and the relative propor-

tion of its constituent parts, as the material and process of its nutrition, and also the freedom and vigour or otherwise of its circulation. The richness and poverty of blood are not mere vulgarisms of speech. In general terms the former is determined by the abundant proportion of the red corpuscle and the fibrine to the aqueous part, and the latter by the converse of this. In the blood of a person repeatedly blooded and at short intervals, the progressive loss of consistency and colour is apparent to common observation.

The age, the temperament, an habitual excess or deficiency of action in one or more excreting organs, and the presence of organic disease, are doubtless all productive of variations from the normal standard, which the observations of competent physiologists may one day elucidate.

But in the mean time more subtle elementary questions have to be determined, among which the following may be enumerated: the ultimate purpose of the blood-cell in the economy; its attendant phenomena of temperature and nutrition, and the changes which it undergoes from its germinal to its degenerated and refuse state; the subservience of the pure fibrinous ingredient to the primitive fabric, growth and repair of the living solid, and the uses and appropriation of the proper liquor

sanguinis, or of the fibrinous and albumino-aqueous portions respectively; the intimate nature of the allied processes of absorption and secretion; the maintenance of unvascular and transparent parts, and the general preservation of form, volume, texture and properties. These, and the constitution of the various morbid products, are points yet to be ascertained. Our physiology must necessarily be conjectural and imperfect until these problems are solved. Their solution will go far to establish in a comprehensive sense the Levitical aphorism, "in the blood is the life thereof."

The blood holds an intermediate position to the matter of nutrition and the matter of excretion,—in its proper individuality independent of both,—yet deriving its rudiments from the chyle, and furnishing in like manner their base to the secreted fluids; it is therefore the vehicle of nutrition and repair, and of the waste and excrementitious matters of the body; in the first office, by its circulation through the pulmonic-nutrient; in the second, by its circulation through the pulmonic-excretory system.

In both relations, inferent and efferent, the circulation of the lungs is indispensable to the offices performed by the blood, for it is thence it derives the faculty of exciting and entertaining the power of the nervous system,

and of communicating the animal temperature, equalized by its distribution; and thence also that it rids itself of the useless and effete materials with which it becomes loaded in its circulation, and repairs its losses of the vivifying principle and of temperature.

The changes which the blood undergoes within the vessels are of two kinds,— 1st, that which is respective of its intrinsic functions; 2nd, that which is respective of its extrinsic functions: the former applying to the phenomena of growth and nourishment, the latter to those of decay and disorganization. These are its normal phases; and the gradual encroachment of the latter upon the former function, by the operation of time and wear, determines the period of natural life in the healthy individual.

Its anormal or morbid changes differ from the above more in measure than in principle, being rather owing to a redundance, defect, or perversion of natural action, than to an action *sui generis*. Occasional exceptions constitute varieties. Thus the type of all diseased action may be traced to that of health; the infinite varieties presented by functional and temporary irregularities of action occupying an intermediate district, and rendering the exact boundaries of health and disease obscure or indefinable.

The variations in quantity (proportion) of the blood and of the natural secretions from it, and of the solid fabric of the body by redundance or defect of supply, partial or general, comprising a large class of chronic maladies, are often independent of any textural change, and manifest only functional derangement. The more important, because less remediable forms of disease, pertain to deviations in quality, inducing changes of structure in one or more vital organs of the body; and these owe their origin for the most part, whether partial or general, to the presence of inflammation.

The changes which the blood is subjected to under inflammation are due, first, to the negation or imperfection of such as are necessary to its health by the effective operation of the secreting and excreting organs, upon which its nourishment and purification depend; hence the disorder of the digestive system invariably present more or less; secondly, to the altered action of the blood-vessels upon the blood consequent upon this change.

A certain relation or affinity subsists between the blood and the blood-vessels; no other fluid can be substituted for blood, nor can the blood of one animal be substituted for that of another of a different species; substances introduced into the blood-vessels prove speedily

fatal, whether their tendency be to preserve or destroy the coagulating principle, and none more rapidly than the air of the atmosphere. It is obvious that an alteration of the relation between the blood and its vessels cannot in ordinary circumstances be instantaneous as in the operation of poisons or cerebral injuries, but must occupy some period of time, during which a disordered condition of the system prevails, more or less; and that, consentaneous with the change in the properties and relations subsisting between the blood and its vessels, must be a change of action in the whole circulating system, affecting not only the organs proper to nutrition, but the brain and nervous system, and the physico-chemical function of respiration. Thus the fever of inflammation presents all varieties of deranged secretion, temperature, sensation, &c.

What may be the peculiar nature of the changes which the blood in the vessels undergoes, and what the change of relation between the blood and the blood-vessel, is not yet fully ascertained. First, a difference in the proportion of its constituent parts must ensue upon a failure of reciprocity in the changes produced in its transit through the lungs, or through the extreme capillaries, which are essential to its integrity; if not upon a defect in its elementary constitution and prepa-

ration from the chyle. Secondly, the disturbance of the relation, be it physical or chemical, or both, on the part of the blood-vessels, must be contingent upon such alteration, since their action is not only demonstrably influenced by the changes in the blood's composition, but directly depending upon its presence, and cannot be maintained without it.

We have familiar opportunities of witnessing the aggregation of the blood-corpuscles to actual stasis, and the partial remora of the circulation by their cumulation in glomera, in transparent parts subjected to irritation; and also the quicker transition of the blood through the vessels in the contiguous parts. Further, we have evidence afforded of considerable variation in the proportions of the several constituents, as the corpuscles, the fibrine, and the watery part, under different conditions of the circulation and the health, in artificial and natural extravasations; and we know that the transfusion from one subject to another of the watery portion divested of the corpuscles will not support life. The transfusion of blood, which has become de-oxygenated by interrupting the function of respiration (asphyxia), is as fatal as its deterioration in the individual; while the original circulation of mixed blood, which very feebly supports life, is incapable of accomplishing

development, and invariably fatal soon after the age of puberty, if not long before.

Further, we know the effect of its impregnation with respirable gases of different qualities upon the action of the heart, and of the partial withdrawment and restoration of the blood to that organ; and that the due change of the blood in its passage through the lungs is indispensable to maintain the action of the heart, the mechanical engine of the circulation.

The arteries possess a capability of dilatation and a power of recovery: whether muscular or in virtue of a proper contractility of tissue, or compounded of both, physiologists are divided, Mr. Hunter's experiment showing the difference between the living and the dead artery notwithstanding. In the larger arteries the muscular, and in the small the contractile property is said to predominate; but whether any order of vessels possesses more than the elasticity which accurately preserves the vessel under its varying dimensions in a state of fulness, is an open question. The proof of elasticity is furnished by the varied states and rapid changes of the capillary circulation in the temporary phenomena of blushing, and by the more permanent conditions of nævi and varices in all their modifications. The increased colour of a surface depends on an extraordinary quan-

tity of blood in its capillary vessels; the increased paleness indicates the contrary condition of these vessels, being deviations in the opposite extreme from the natural and healthy standard of its circulation. The presence of acute inflammation affords the best example of the first, and the state of syncope of the second condition.

A lesion of texture is the only occasion which admits of the escape of the cruorine or crassamentum of the blood from its vessels. Where blood is mingled with the healthy secretions, as the urine, or the morbid, as pus, there is lesion. It follows that the secretions are confined to a part only of the mass of blood, and that this is exclusive of the globules and colouring matter. All the elements of the blood, with these exceptions, are detected in the secretions in diverse and variable states and proportions. Under inflammation, the fibrine or coagulable lymph is secreted, the only element capable of organization. Its separation in its purest state is when inflammation affects sound textures, or is unaccompanied by lesion. In simple lesion its separation is extra-vascular.

The alterations of which the composition of the blood is susceptible, and those of the relative and reciprocal actions of the blood and the vessels, which may be fairly

presumed, if not ascertained to follow thereupon, are data abundantly sufficient to furnish forth all the phenomena of inflammation, and to supply the rationale of their occurrence.

The observations are sufficiently multiplied which demonstrate the effects of air, its various composition and properties; of temperature, dryness and humidity; of food, its varieties in the quantity and convertibleness of its nutritive ingredients, and the presence or absence of such as are innutritious or positively deleterious to animal life, on the one hand; and on the other, of such exposures of the animal machine to the operation of noxious agents, and to the casualties, mental as well as physical, incidental to the several conditions of life in all its various grades and localities of tenure, to afford "ample scope and verge enough" for all the complications and varieties of disease.

The absorbent system is not, as formerly taught, one of orifices or patent mouths, whether upon the villi of the intestinal surface or upon any free surface whatsoever; nor has it any direct communication with the blood-vessels, except that by which its trunk terminates at the angle of the left jugular and subclavian veins. The precipitation of the chyle on the mucous membrane precedes the rudimental formation of the blood-

corpuscle by a process analogous to that which derives the urine, the semen, the milk, from the ultimate secerning vessels of the kidney, the testis, the mamma, and all the natural secretions from their proper glandular structures; exemplified also by the transformation which the blood undergoes in passing through the pulmonary cells. If this be so, the blood-particle is not the chyle-globule, nor, in strictness, is the arterialized the original corpuscle. To this conclusion the minute anatomy of the secreting apparatus, as well as that of the secreted fluids, irresistibly conducts us, and it applies with equal force to the diversities of morbid secretions. The absorbent and blood-vessels of the alimentary membrane of the turtle injected with the finest size and vermilion, and with quicksilver, and the several serous and cellular membranes, so prepared, exhibit a perfect reticular arrangement and an unbroken continuity of surface; while their interlacement with the capillaries of the vascular systems is such as to afford all means of inter-communication, subject to the laws of their respective functions. Hence we are compelled to adopt the system of vital transference observed in plants and the lower classes of animal life—all vascular arrangements being continuous, and displaying the looped or arched disposition—*i. e.* the percolation or straining off

from the chyle as from the blood, (the blood itself being a separation, under the influence of certain laws of vital physics,) of the proximate principles of the chyle into the blood, and of those of the blood into its multiform secretions; the process of separation being invariably proper to the blood-vessels, and preliminary.

The phenomenon of post-mortem transudations exhibits the fact referred to by contrast, viz. by the dissolution of the vital influence which presides over and preserves the textural and functional integrity of parts. The post-mortem transudation of blood, bile, urine differs from the vital process in being, like effusions from lesion during life, partial and indeterminate, except by the accidental influence of structure, position, &c. The morbid process of bile passing into the blood exhibits an inversion of the process of its secretion, but being subject to vital domination, is for the most part temporary and recoverable; sometimes it is permanent, and then sooner or later fatal.

The almost instantaneous passage of the volatile particles of certain odorous bodies, animal and vegetable, into the urine, and the colour imparted by others to the excrementitious matters, and even to permanent deposits, attests the fact of the rapid and real transit of the elements of these secretions from the blood.

The appearance of the colouring matter of blood in the urine, milk, semen, in various shades, and in mucus and pus, show a corresponding degree of disorganization interrupting the perfect function; so also the caseous and ichorous varieties of scrofulous, as compared with healthy pus, show the morbific influence exercised over the secretion in certain states of constitution.

The passage of the serous and fibrinous materials of the blood from the vessels is seen,—the first, in cases of compressed or interrupted blood-vessels or absorbents independent of inflammation, and also as an effect of inflammatory action, into the cells and cavities of the body; the second, as an exclusive result of that peculiar mode of inflammation called the adhesive. The separation of the effused mass of blood exhibits the serum as distinct from the cruorine or remaining constituents; and in some circumstances the fibrinous ingredient becomes so far separated, as to present the appearance of a buff-coloured cake; in which case the globules and colouring matter are held loosely together, and the coagulation is semi-solid or grumous; the lymph so separated does not admit of organization, nor is the cruorine capable of serving any useful purpose, being destitute of the tenacity of a coagulum. These changes, when extra-vascular within the body, are protected

only by the vital principle: in many circumstances this fails, and the effused blood and secretions, whether natural or morbid, prior to elimination from the body, undergo decomposition.

In the case of the natural secretions, as *e. g.* the mucus, the saliva, the bile, the urine, the deviation from the state of health is either functional, *i. e.* depending upon the temporarily deranged innervation and circulation of the organs concerned in their production, or upon an actual change of structure, such as to interrupt and render imperfect the elaboration: and such a state, from one or other cause, there can be no doubt extends to the preparation of the blood itself in scrofula, scurvy, malignant fevers and animal poisons.

The ultimate structure of the nervous fibre, as developed by the microscope, corroborates the universal prevalence of the vesicular arrangement before mentioned. A more elaborate scrutiny into the composition of its centres, and the origin and distribution of the chords of communication, aided by much experiment and observation, has clearly demonstrated the distinct adaptation of its several parts to the two great purposes of sensation and motion, and has proved a source of much additional and valuable information to the pathologist. The organic system of the great sympathetic nerve

on the one hand; and on the other the cerebral and cerebro-spinal structure with its nerves, their boundaries and blendings, their direct and reflex functions—forming the system of animal life, of perception, sensation, and motion—involve the harmonies and sympathies which are more or less auxiliary to life in every possible variety of circumstances. And if not indispensable to existence, the intellectual faculties, of which they also are the seat and instruments, are among the most powerful agents, as they are the most characteristic in terpreters of human maladies.

It is as indispensable to the understanding of any part of the doctrine of disease, as of the economy of health, to appretiate the influence of this system; all morbid phenomena are traceable to one or other of its properties; and it may be received as an axiom, that the disturbance of consent and relation, as their uniformity turns upon the nervous organization, constitutes the most prominent feature, if it be not the exciting cause of morbid action. Inflammation, therefore, stands in the same relation with all morbid affections, whether functional or organic, to the powers and uses of the nervous organism; nor can we stir one step towards an explanation of its causes, phenomena and laws, its symptoms, or their indications, without appeal-

ing to its guidance. The vitality of the blood, its formation, and transformation into the solids and fluids of the body, the capability, seemingly inherent in solids and fluids, of certain interchanges which they undergo by means of their reciprocal affinities and agencies—still preserving their respective homogeneity—and the resistance which collectively they are enabled to maintain against injury and disease, as well as the power of repair, are referrible to their nervous endowment.

Inflammation is susceptible of a purely functional as well as an organic form, and presents, even in its origin, the extreme conditions of elevation and depression of the vital power; being the principal and most comprehensive, though not the sole agent of the disorganizations to which the animal body is subject, and in all cases employed as a subordinate or consequent, where it is not a leading and predominant instrument.

If this be so, how above all things important does an acquaintance with its natural history, its phenomena of origin, progress and conclusion, in all its varieties, become! Next to the knowledge of the structure and the uses of parts, unquestionably ranks the knowledge of that modifying principle which approximates to the formative in its power of reparation, and to the destroying agencies in its uncontrolled dilapidations of struc-

ture; for it is idle to talk of the infinite degrees of a scale of nutritive, or of nervous, or muscular power, as offering even a satisfactory hypothesis, far less a substantive idea, of the problem of inflammation. These agencies and their fluctuations are incidental, it is true, to the various conditions of health and disease, but they stand only in the relation of signs* to either state.

The secretion and organization of fibrine, the formation of pus and of granulations, the separation and removal of parts destroyed by violence or disease, and the process of disorganization, are all distinctive and inimitable characters of inflammation. Their sequences, relations and modifications, subservient to certain vital laws, constitute the foundation of pathology, for they include the phenomena of disease and of restoration. In the practice of surgery they are for the most part visible, in that of medicine they are plainly inferrible by analogy of symptoms, and sooner or later demonstrated in their effects.

The first main distinction which disease presents is constituted by the line which separates functional from organic changes; this affords a general basis of classification. The second is that which marks off reparable from irreparable disease, depending on the character of the action, the organ affected, and the extent of the

* See page 9.

morbid process. These, as they are subject to the modification of circumstances, internal or belonging to the individual, and external or affecting his position, afford another and comprehensive ground of classification. In all the latter and most formidable class of diseases, inflammation is present; if it be not displayed in the origin, it is conspicuous in the course of their career, and its tendencies and results are the critical incidents determining the issue, for life or death.

It follows that a knowledge of the phenomena of inflammation, the laws by which it is governed in its course, and the relations which its several processes bear to each other, is the key-stone to medical and surgical science. Their physiology can only be illustrated by a close, cautious, and extended observation of morbid changes, corrected by an accurate reference to the standard of natural and healthy actions.

In this brief introductory sketch I have refrained from introducing the disputed physiological questions now pending, and shall endeavour to keep aloof of such breakers in the pathological portion of this treatise. Large allowance must be made for the jejune observations and visionary hypotheses incidental to the employment of a new faculty, almost equivalent to the inlet of a new sense, and not less for the intemperate assault

and valiant overthrow of established systems. Scepticism and credulity are born of the same parent, if not twin children. The rapid strides of some over-zealous 'slaves of the microscope' abundantly exemplify the truth of this statement, of which proof enough might be adduced from metaphysical researches, in which the reasoning powers are not employed upon the objects of external sense. The doubts thrown upon the existence of the transparent lymphatic system, despite the labours of Mascagni, from the inadequacy of the glass to its satisfactory demonstration, are a fair counterpoise to the discovery of the primordial blood-cell in the mucus of the Fallopian tube, and its adaptation to the composition of mucular fibre.

CHAPTER I.

PRELIMINARIES.

Inflammation is the term applied to a series of phenomena resulting from a change in the properties and distribution of the blood. The phenomena of inflammation varying in extent, duration and intensity, are exhibited in all the animal tissues; but their aspect and course, as well as their disposition to recur, are modified by the capacities and peculiarities of different textures.

Inflammation is either primarily or secondarily associated with so large a proportion of diseases incident to the animal body, that it is to be regarded in a generic sense as comprehending almost all the varieties of organic change in its subdivisions. To dispute about the universality of its agency is as idle as it would be to question its existence, although by some the term may have been from ignorance erroneously employed; or from

an affected scepticism, a love of paradox, or an ambition of novelty, by others have been discarded. Nothing is better known in the aggregate, than the indications and tendencies of that state which pathologists have long been accustomed to denominate "inflammation," and in their detail few things are less clearly understood and satisfactorily explained.

Before attempting to analyse the phenomena which characterize inflammation, I shall offer some preliminary positions which I consider essential to a right understanding of the subject.

1. The occasional causes of inflammation are many and various, chemical, mechanical, and vital; the immediate cause is one and uniform. Cold and heat, wounds, foreign bodies, stricture, and poisons are chief among the former; the latter is an interruption to the proper circulation and uses of the blood in the part affected. Spontaneous inflammation, a term in common use, is a solecism in language. Inflammation is always a forced state, however temporary and susceptible of resolution.

2. The interruption above mentioned varies in degree as inflammation varies, and its signs or symptoms are demonstrated accordingly.

3. The actions or processes of inflammation are several, and well-marked, and bear reciprocal relations to each

other, influenced by the character of the inflammation; under which term I include its origin, intensity, extent, duration.

4. The tendency of inflammation to preserve or destroy is not to be confounded with, much less employed to designate its pathological character and denomination; because all its actions are capable of serving, and actually do serve both salutary and destructive purposes, determined by the existing circumstances of the part or the system, as time, place, order, need, degree. Thus adhesion is often destructive, and gangrene conservative; and the same may be said of suppuration and ulceration.

5. Inflammation is not seated exclusively in the blood, the blood-vessels, absorbents or nerves of the part, nor confined to the capillary system of vessels, nor the cellular tissue which connects and supports them. These several parts forming a homogeneous whole, cannot be disjunctively affected, in morbid more than in healthy action; each being an integral element in the composition of the other, reciprocating organization and function, acting and acted upon respectively, their peculiar functions are merged in the production of general phenomena, whether healthy or morbid, to which each is indispensable. Thus, neither heat, pain, swelling, nor redness could be demonstrated in inflammation,

more than temperature, sensation, figure and colour could be maintained in health, if the blood or the vessel, the nerve or the absorbent were taken away. We might as well expect nutrition to go on in the absence of the stomach.

6. It has been a vexed question in which of the systemic series of parts, of which every animal structure is constituted, the inflammatory process commences, *e. g.* whether in the solid or fluid, admitting that the entire constituency is ultimately involved: whether the blood, the blood-vessels, arterial or venous, the invisible capillaries, the lymphatics, the nerves, or the tela cellulosa which serves as their common base. And connected with this is the question, whether in the onset the change is physical, chemical, or nervous? Now I recur to my last statement, that the proper structure and functions of parts are so interwoven and identified, that although their consent or harmony may be disturbed or destroyed, they cannot be exclusively affected, even for an instant. Suppose therefore a foreign particle, or a chemical stimulus or sedative, the most simple and single that can be employed, to be the occasion of exciting inflammation, it will operate as instantaneously and certainly, to the extent of its operation, upon all the parts and actions of the organism, as the most complicated injury. Whether

the foreign body be a part disorganized by injury, or in its nature extraneous; whether it be a chemical or a nervous agent (concentrated caustic alkali or tobacco) that operates to produce a change, it is, to the extent of its operation, of necessity implicating the whole system of parts forming the structure, and of the actions which they perform. If therefore the blood, or the solid which it permeates, is so affected that the natural and vital attraction which subsists between them is neutralized, the sentient phenomena are to the same extent arrested: and if the nervous system be first struck, the physico-chemical system is to a corresponding extent embarrassed. The first visible or sensitive change would be a very imperfect, perhaps delusive, index of the first real change; the congestion of the blood in the vessels, creating a blush or a swelling, or the new and peculiar sensation of the part, whether painful or not, may be the first manifested, but the last actual change.

7. Inflammation is not the less inflammation because the development of one, or even all its signs is so feebly and obscurely manifested as to render its presence questionable to inexperienced observers, or because of its occasional tendency to yield in a remarkable manner to the operation of stimulants, even in its commencement. An

eminent modern writer* has assumed that inflammation is not favourable, but adverse to healing; that it interrupts or retards the process of restoration when its presence is indicated: that therefore all our efforts should be directed to prevent inflammation coming upon wounds and injuries. If the epithet "undue" or "unnecessary" be prefixed, there is no difference between us. From the slightness of many injuries and the concurrence of a good habit of body, the exaltation of sensibility and of heat, the increase of fulness and of colour are imperceptible, and it is to continue this happy state of imperception and to prevent their becoming palpable, that rest, position, soothing and cooling applications and medicines are enjoined; in other words, it is to preserve the subdued state of inflammation, which favours healing, and not to supersede it, which would more effectually retard or preclude healing, than the aggravation caused by an improper treatment.

For many superficial cuts, favourably situated, the clot of blood is a sufficient plaster to shield the part from the air and from other irritants, to bind its sides together, and to induce almost immediate healing. But if by any accident irritated or rudely handled, such a

* The late Dr. Macartney of Trinity College, Dublin.

wound becomes sore; if the clot is dislodged, it festers, reddens, swells, suppurates, scabs; a second and troublesome action is superinduced, but even this scarcely amounts to pain; and heat, colour and swelling are little, if at all, perceptible. The same series of actions on a microscopic scale ensues upon the slightest wounds, as on those which are more severe: in the first, they may be rendered palpable by maltreatment; in the latter, from an opposite course, they may be so soothed as scarcely to excite observation. A graduated scale of inflammatory action commencing from this scarcely appreciable 'zero' would, if the instrument were as true as delicate, conduct us through all its successive stages from simple phlogosis to self-destructive gangrene. Degree, though not the parent, is the great indicator and instrument of change.

I am quite satisfied that an inflammation beyond the necessity retards, as a certain modus of inflammation promotes, nay, is indispensable to the healing of a wound. But we are told there can be no inflammation where there is no pain. I reply that there are many, and destructive too; a joint, an eye, nay, the lungs may be destroyed by inflammation without pain; he is a speculative, not a practical pathologist who does not know this. It would be easy to superinduce pain in either of

these cases; but let there be no interference, and the work of destruction in numberless cases is as silent as it is sure.

8. Most of the theories of inflammation are based upon the fact of an obstruction to the passage of the blood, whatever be the cause, real or supposed, of such obstruction. Some have represented this remora as mechanical, others as chemical, others again as a nervous phenomenon. To constitute inflammation it must be all or neither, for the mechanical, chemical, and vital properties are all implicated and altered by inflammation. But either, if of a certain amount, is competent to originate inflammation, viz. an actual stasis of the blood in the vessel from a change in the diameter and action of the vessel, or in the properties of the blood, or in the natural innervation of the part; and in either case respectively, the two latter are an unavoidable and direct consequence of the first. An interruption, more or less, is occasioned if the impelling and resisting power be not balanced, as in the healthy circulation, no matter which default is the initiative condition; whether the inequality is induced by the loss of vital attraction between the corpuscles of the blood, or between the blood and the vessel, and the consequent aggregation of the particles of the blood in masses; or by the influence of various

agents upon the vis nervosa, either stimulant or sedative in their nature.

The same effect, therefore, is brought about by causes distinct, it may be, in their origin, but consentaneous in their operation; for with whichever we commence, the remaining changes are unavoidable; and in inflammation, as in all other animal actions, healthy and morbid, the mechanical, chemical and vital functions are co-ordinately and inseparably affected.

9. In order to the production of inflammation, the exciting cause must be of a certain extent and duration. The mere impediment to the passage of the blood, or its increased afflux upon a point, or the operation of many powerful nervous agents, are inadequate to this end. A certain amount of provocation is necessary to produce the nisus, and the subsequent permanent phenomena characterising the inflamed state.

10. When the trouble of the circulation in a part, the subject of inflammation, has subsided, and any effusions which may have attended it are removed, and the part recovers its former sanity, its natural size, temperature, colour, or transparency, and sensation, so as to be without a vestige of the morbid action, the inflammation is resolved, or, as it is said, "terminated by resolution."

When on the contrary, instead of yielding, it continues, and other organic changes succeed to the first, these constitute its actions or processes. When the inflammation is either directly or mediately, by one or more of these processes, destructive to organization, and all action is consequently arrested, inflammation is presenting its opposite grand termination, viz. in gangrene, or death of the part.

The various modifications of the inflammatory process adapted to wounds of soft parts, fracture and displacement of bone, intrusion of foreign bodies, stricture and ligature; also to such ablation of parts as directly or indirectly abridges the body of its proportions, are especially the study and province of practical surgery. The joint objects of medical and surgical pathology are, the changes of the same description which supervene upon inflammation, affecting the internal and hidden surfaces, as well as those which are exposed to view, and result from the operation of atmospheric and constitutional causes. Such are heat and cold, impure air, animal poisons, derangement of the nutrient, the vascular, or the nervous system, and the vices of the blood thence arising. It is needless to point out that the distinctions which obtain in practice are purely conventional proprieties, and have no countenance from nature

or reason. It would be easy to show, that whatever basis of subdivision be adopted—whether the presence or absence of fever, the constitutional or the local origin, the internal or the external situation, the necessity or otherwise of local appliances, or the distinction of these into such as require manual aid, and such as do not—each is open to exceptions in force and frequency, subversive of the rule, if attempted to be enforced.

CHAPTER II.

DIRECT EFFECTS OF STIMULI AND OF WOUND.

The first effect of a drop of stimulant fluid or of a wound upon a transparent web (frog's foot), as seen in the field of a powerful microscope, is to arrest the circulation at the part. Around the point of absolute stagnation the column of blood oscillates, and the particles are seen to separate and congregate in small irregular masses, presenting varieties of shape, some being perfect ellipses, others spherical. The vessels are dilated, and in proportion their fulness is increased and their pink colour heightened. Still more remote from the stagnant centre, increased activity of circulation prevails. The point of stagnation—the very slow circulation in the part immediately surrounding it, the current still oscillating in parts—and beyond this the more rapid and vigorous circulation, are manifested for several

days. The contrasted appearance of one portion of the web stationary, and another in brisk circulation, is striking. The labour also of the current, the sudden overcoming of the obstacle occasioned by a too crowded passage, and the instant velocity succeeding thereupon, reminds us of the swaying backward and forward, and at length the inrush of a crowd emerging into an open space from a narrow avenue.

A saturated solution of common salt, the muriatic acid, spirit of wine, ammonia, and a wound with a puncturing or cutting instrument, all coincide in producing these phenomena.

Salt.—At the expiration of eight days from the application of the solution of salt, I found that the greater part of the capillaries continued loaded with motionless particles of blood, even as far as their junction with the large vessels parallel to the toes. The passive capillaries had an increased diameter, and the accumulated particles gave a deeper red colour to them. A circulation going on in small vessels, at distant intervals of space, was so much slower than usual, as distinctly to allow the form of the globules to be seen, as they proceeded by an oscillatory movement. The web consisting of a double layer of membrane, the active capillaries were seen crossing the passive ones on a different plane. The

whole character of the circulation suggested the idea of its being subservient merely to maintain the vitality of the part. The web, to the naked eye, presented all the characters of the inflamed state, such as might be expected twenty-four hours after the application of the stimulus, yet the phenomena revealed by the microscope exhibited a state of inaction and dilatation of at least one-eighth of the whole vascular system of the inflamed part. The web would in fact represent an injected preparation, but for the languid circulation going on in the small portion of the capillaries above described. On the tenth day the circulation was obviously recovering, *i. e.* going on in a larger portion of the web, the globules moving freely through many of the previously stagnant channels, but slower than usual.

On the twelfth day the circulation was re-established over the whole web, which remained thicker and more opake than the healthy web, but without other change. The colour had disappeared with the resolution of the congested state of the capillaries.

Ammonia.—The application of ammonia produced an instant increase of velocity, then stagnation, with the deepened tint of colour and enlargement of vessels. The second and following days it presented exactly the same condition as the salted web, except that the pro-

portion of the re-established circulation was somewhat greater, and the motion of the blood particles comparatively quicker. The colour of the passive and distended capillaries was as bright as in those stimulated by common salt; in both the two layers of capillaries in the web were very distinctly demonstrated, and served clearly to show the difference of diameter in the active and passive capillaries, the latter apparently dilated by turgescence. On the fifth day the whole web was opake and thickened—some large trunks congested with red globules, and perfectly passive—the circulation very gradually re-establishing itself. This state continued, the circulation going on briskly over an increasing portion of the web from day to day, the large congested capillaries before mentioned excepted; and when, on the eleventh and twelfth days, it was wholly restored, the web continued opake and thickened.

Wound.—The web of a frog's foot was divided midway between and in the direction of the toes by a pair of sharp scissors, when the edges of the cut retracted immediately, leaving a triangular gap ∧. After some seconds, blood-globules escaped from the mouths of the divided veins on one side, of various shapes, as they presented their surfaces to the eye—some elliptical, others round. These appeared to rest on a serous or

filmy substratum, and to be gradually filling the interstice, when a sudden jerk of the animal swept them away, and left the space void, as at first. A similar effusion to a less extent took place from the vessels of the opposite side.

On the second and third days the borders of the wound were perfectly divested of circulation, and the space of the wound was contracted; numerous globules lay in masses upon a transparent pellicle, the edges of which were raised or thickened, and opake; there was no arrangement of vessels to be perceived; the surrounding vessels were circulating the blood slowly, and their currents oscillating in parts, and beyond these the circulation was brisk as usual.

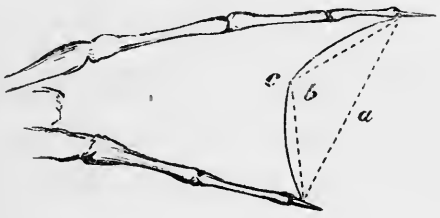
On the eighth day the cut edges appeared thickened and smooth, the circulation contiguous to them re-established, that in the neighbourhood proceeding apparently quicker than usual; the web at this part a little more opake. No other change was observable.

On the ninth day the circulation was re-established in the edges of the wound, which were thicker, and exhibited a linear cicatrix at the reunion of the two layers of the divided integument. The wound had gaped wider.

On the eleventh day the edges continued thickened

and smooth; the wound presented a much more open angle, and the circulation was with difficulty observed, on account of the greater degree of opacity and thickening which the wounded web presented, compared with the stimulated web.

On the twelfth day the angle of the wound was obliterated, and the effect of a shortened web produced.



The dotted line *a* gives the original outline of the web; *b* shows the angle of the recent wound, and *c* the curve of the cicatriced wound. Ecdysis of the cuticle had taken place, which explains the opacity noticed on the eleventh day. Thus the arrest of the circulation, and its gradual restoration, comprehending the termination by resolution, correspond in their attending phenomena, and in time, in the cases of a stimulant applied and wound inflicted; and the formation of a cicatrix by the adhesion of the equally retracted edges of a peripheral and membranous cut wound, involving simply solution of continuity, is ac-

complished within the same period; the more dense opacity being in the latter followed by exfoliation.

In these observations, made in the summer of 1841, I had the advantage of being assisted by Professor Owen. The more minute details of the healing process in wounds are reserved for a later and larger series of experiments.

CHAPTER III.

LOCAL SYMPTOMS OF INFLAMMATION.

We will now consider, and, so far as we can, explain the signs of inflammation. Pain, swelling, heat and redness, in combination, are always and surely diagnostic of inflammation. Severally, either may be present in the absence of inflammation; the two latter transiently and more rarely than the two first. Nervous excitement or irritation is sufficient for the temporary production of pain, heat and redness; swelling, from obstructed veins or lymphatics, and other causes, may be quite independent of inflammation. Let us consider them seriatim, as the external signs of inflammation.

1. *Pain,* like all modifications of perceptive sensation, has its source in the brain, although it is referred to, as if it were seated in or emanating from the inflamed part. This is only partially demonstrated by the experiment of intercepting the nervous communication; because, while the circulation continues, the proper

nerves of the blood-vessels escape division. But in a complete arrest of sensation and voluntary motion, as from a certain amount of injury to the brain or spinal chord, the circulation continues, and the sensation of parts so situated is equally deficient when undergoing inflammation, as in others not so affected.

The following curious observation offers no exception :—A gentleman, whose spine was broken low down by a fall in hunting, and who was utterly deprived of sensation and motion of the lower limbs, had sloughing of the right hip, exposing the glutæi and trochanter, the surrounding integument hollow and bagging, *i. e.* no adhesion, and an unhealthy pus in abundance. On this hip he had been constrained to lie, and lay without pain; but on the other (left) hip, though repeatedly attempting it, he could not lie without severe pain; though inflamed on the point, it had not gangrened. Being equally insensible on both hips, he was at a loss to comprehend how this difference could be explained. The displacement of the fracture was on the left side, and the effect of pressure on that hip was to irritate the left lumbar plexus at the joint site of its division and emanation from the chord. Thus pain is referred to parts utterly devoid of sensation.

Inflammation, therefore, may exist without perceptive

sensation; and that severe pain may exist without inflammation is exemplified in the pure neuralgia. Every part of the body has its proper seat of representation in, and chain of connexion with the brain; thus to a certain extent we can call up sensation by imagining it. Not, indeed, such as to counterbalance a substantive physical endurance—

> "O, who can hold a fire in his hand,
> By thinking on the frosty Caucasus?
> Or cloy the hungry edge of appetite
> By bare imagination of a feast?
> Or wallow naked in December's snow,
> By thinking on fantastic summer's heat?" *

nor even to fix the character and amount of uneasiness; but the nervous hypochondriac feels, there can be no doubt, the pricking in the skin, the pain in the stomach, heart, kidney, bladder, which he so graphically describes, as his mind pictures either organ the seat of disease. Sensations of pleasure are also excited at will, and carried out by vivid images and recollections, in certain excited states of the cerebral system, especially under the influence of dreams.

Pain, to whatever region referred, has its real seat in the brain; and in diseased states of that organ, its alpha and omega are cerebral, a fact of which the proofs fur-

* Shakspeare's Richard II.

nished by such cases are often subtile, but many and convincing. Partial organic cerebral changes are the source of the most severe and incurable cases of the tic douloureux. In vain do we divide every twig of sensitive nerve; the agony is still the same, for its origin is beyond the reach of our anatomy. The principle is analogous to that which preserves so faithfully the idea of the amputated extremity. Cerebral regions and cerebral agencies are as indispensable to the production of local physical sensations as to the operations of the mind.

The phrenological system, I may here remark, owes its existence to the countenance which it derives from a twilight of truth, though only sufficient to serve as a beacon to the absurdities with which it is encompassed.

Inflammation, however, in a sound state of the system, is seldom unattended with sensations more or less painful, although the degrees are as diverse as the varieties of pain. In some inflammations, motion or pressure, or the extraordinary function of the affected organ is necessary to rouse pain, and the absence of these conditions is sufficient to allay it. In some instances it is unceasing, in others it is remitting; in others again it recurs at distinct or fixed intervals, and is periodical or intermitting. Pain, therefore, is depending upon some condition common to parts inflamed and parts not in-

flamed, arising out of the various modifications of nervous tone and vascular action to which they are subjected from the operation of different causes. Thus, one pain is lulled by the magnetic fluid, another is suspended by the irritation of a blister; one by ammonia, quinine or arsenic, another by opium or aconite; one by taking food, another by its rejection, or by abstinence.

The description of pain unattended with inflammation differs from the pain of inflammation, although the former is subject also to varieties in kind, duration and intensity. Throbbing, lancinating or pulsatile pain, *i. e.* pain accompanied with a sense of motion of the fluids in the part, is the most characteristic distinction of acute inflammation; and an obtuse, aching or heavy pain belongs to a congested state of the local circulation. Neuralgia is generally attended, more or less, with muscular cramp or spasm, and such pain is either intermitting or periodical. The nature and often the seat of an inflammation is detected, and the treatment directed by the character of the pain, taken independently, or in conjunction with other symptoms. External and internal medicaments, which permanently relieve inflammation, assuage its pain; and if they do not relieve inflammation, they not only fail to relieve pain but generally aggravate it. Such as relieve pain in

the absence of inflammation, have little or no beneficial effect on the pain of inflammation. Blood-letting aggravates neuralgia and relieves inflammatory pain. Steel and arsenic aggravate inflammatory pain and cure neuralgia. Opium relieves inflammatory pain when following loss of blood, and combined with mercury, antimony, or ipecacuanha; singly, it generally augments it.

A congested state of the blood-vessels, as we have said, is productive of obtuse pain: on the resolution of this state and the recovery of a free circulation, by whatever means, pain ceases. An inflamed part is not relieved of pain in any stage, until, by natural or artificial means, its vessels are unloaded; extravasation, exhalation, effusion, suppuration, all being modes of relief to the circulation, are such natural means. Blood-letting, purging, and the action of nauseating and sudorific medicines, and local evaporants and fomentations, are artificial modes of procuring similar relief. The pain of inflammation then is directly or indirectly connected with the state of the blood-vessels, of which we shall speak anon. Pure neuralgia is not accompanied by a similar state of the blood-vessels, and is not relieved by a like mode of treatment, direct or indirect. The blood-vessels, as well as the parts by which they are surrounded, are plentifully endowed with sensitive nerves;

the circulation is neither locally nor generally affected in pure neuralgia, unless secondarily, from nervous exhaustion; in inflammation it is always more or less sensibly affected. It is therefore probably the nerves of the blood-vessels that are first excited in the pain of inflammation; in neuralgia there is no direct evidence to this effect; the pain follows and maps the course of the free sensitive nerves, and seems to be originally belonging to that system.

2. *Swelling* is an inevitable effect of the overloaded state of the blood-vessels of a part, whether arising from the excessive importation or the deficient exportation of blood; constituting the loss of balance of its healthy circulation. When extravasation or effusion comes to the relief of the congestion, swelling explains itself. But prior to this stage it must be referred to the dilated state of the capillaries beyond their mean diameter, and the consentaneous yielding of the surrounding parts. The detention of the blood by ligature of a part, the operation of the cupping-glass, and plunging the arm in a vessel of hot water, though acting on different principles to produce the same effect, are rude but familiar demonstrations of the fact. It is remarkable that, in inflammation of parts whose texture does not readily admit of swelling, and this relief

is consequently withheld, pain is more severe, and is aggravated in proportion as the texture is unyielding (inflamed eyeball, inflamed fascia, cancelli of bone, &c.). The inflamed states of those peculiar tissues, which have been termed erectile, may furnish a comparative idea of the change in this respect undergone by other textures in a state of intense inflammation; their special provision for increase of volume being taken into account.

3. *Heat.*—The equal distribution of heat is due to the equal force of the circulation and distribution of the blood, which is subject to be influenced by other causes than the presence of inflammation. The marble-cold extremities and the goose-skin, as well as the parched burning skin and the scalding secretions, are examples of the contrasted conditions of the parts in the extreme variations of plenitude of the blood-vessels; the two former states are not present during inflammation, but sometimes precede it. The actual difference in the heat of inflamed and healthy parts, as ascertained by the thermometer, is less than the seeming difference, both to the subject and the examiner; but the nerves measure the sensation rather than the degree of heat; and this is a widely different scale from those of Fahrenheit or Reaumur.

Some invalids are tormented with a sense of heat, whose surface indicates no deviation of temperature from the ordinary and healthy standard, either to the hand or the thermometer. The sense of heat in an inflamed part subsides as the inflammation declines, that is, as the freedom of the circulation is re-established; the vessels being unloaded by the restoration of the suspended perspiration, or the effusion of some of the constituents of the blood in its crisis. It is not easy to comprehend how the heat evolved in a part can, under any circumstances, exceed the standard heat of the blood in the left ventricle of the heart; and the experiments tending to establish that fact are not conclusive, as the standard heat is certainly liable to variations within a certain range. But it is not denied that the sensation of increased heat is perceived by the physician as well as the patient in permanently inflamed or congested surfaces. The determination of blood to the capillaries in blushing is accompanied with a distinct though transient sensation of burning heat to the individual, yet not such as could be ascertained by the most delicate thermometer. It is most probably to be referred to the extraordinary inlet of arterial blood into the capillaries; its longer detention by the congestion proper to inflammation, and the consequent increase and vigour of the

neighbouring circulation would give permanency to the sensation, and render the actual increase of temperature appreciable.

4. *Redness.*—This sign of inflammation depends upon the demonstration of previously invisible vessels by an increase in the volume of their circulating blood, from the lightest to the most intense shade; upon their number, capacity, and the degree of fulness compatible with motion. For although the oxygen of the atmosphere will redden the blood in the congested vessels of the surface, while circulation, however imperfect, continues; from the commencement of the state of absolute stagnation, the colour gradually undergoes a change from pink to purple. In some modes of inflammation this shade of colour prevails even from the beginning, and soon turns to livid, resembling that of the ecchymosis in which the venous blood is extravasated, or of the gangrenous spot where it is decomposed in the lifeless vessels. These varieties are due to the state of the general circulation, which gives its character to the inflammation, and an attending change in the constitution of the blood. In general the readiness with which a part under inflammation assumes this symptom, and the degree of intensity to which it is carried, depend upon the strength and activity of the inflammation, in con-

nection with the cellularity and vascularity of the structure. Compare the mucous with the fibrous membranes, the muscular with the cartilaginous textures.

CHAPTER IV.

CONSTITUTIONAL SYMPTOMS, OR EFFECTS OF INFLAMMATION ON THE SYSTEM.

We have seen in what the first changes and in what the signs of inflammation consist, and the further progressive changes attending the continuance of inflammatory action come next to be considered.

At what period the system at large takes up inflammatory action; if in all cases it participates therein; what change, if any, the blood undergoes in its composition, properties, and mode of circulation, and how this is shown, are points of which it seems to be essential that we should not longer defer the consideration.

Many inflammations are strictly local, *i. e.* they are not only developed exclusively in a part, but there is no evidence that the general circulation is in any degree affected. In many other cases it is only so affected as

the pain and vigilance it occasions explain, not as it is when it participates in the inflammatory action. Thus in addition to the restlessness, anxiety, and wandering aches and pains, the secretions are interfered with if not partially suspended, and the stomach is deprived of appetite for food or power to digest it, yet the pulse is not accelerated, nor fuller nor harder than usual, and the state usually denominated fever is not present. This state of sympathetic irritation depending partly on confinement, where that is imposed by the inflammation, and in part on the local morbid action, must not be confounded with fever, although it is the precursor of fever, if not relieved by soothing the inflammation, as by rest, reduced diet, aperients and anodynes.

When the local inflammation is in such organs or of such amount as to rouse the system, this partakes of the inflammation. The blood undergoes changes in passing through inflamed vessels, which affect its natural properties. The brain and nerves become preternaturally excited by it, the functions of the entire digestive apparatus and of respiration are hurried and imperfectly performed; consequently the excretions are altered in quality and in quantity, and the vitiation of the blood increases from the suspension of the relief

derived from its habitual and required issues; for what the blood in its circulation parts with, is as essential to its health as what it gains. Meantime the inflamed part undergoes changes very typical of those which the system indicates. No approach towards healing is ever seen in such a state of the system. The degree of fever, the seat and the symptoms of the inflammation must be taken as the index and measure of the changes which are wrought in the part. If the adhesive or granulating process has not commenced, it is prevented; and if it be in progress, it is destroyed. The ulcerative process becomes utterly indolent and ill-conditioned, or it passes into gangrene. The changes, more or less, are all on the losing side. The whole system is inflamed, and the local malady and its cure are merged in the general malady and its treatment. It is almost ludicrous to observe the nice distinctions and refinements of the ancient, and even of some modern surgeons, in the selection of local applications, when the parts take so subordinate a share of the disease, or are so far beyond reach of treatment by local remedies, as to be scarcely susceptible of either good or harm. It is like galvanising the muscles to restore life to the exanimate system.

When by proper evacuants and calmants the sympa-

thetic fever is allayed, *i. e.* the blood is restored to a healthier condition by the free and full action of the emunctories, and nature's own resources of sleep and appetite consequent thereupon, the local inflammation, in whatever stage of its action, resumes, and admits of local treatment with daily increasing effect. The surrounding integument assumes a bright rose-tint, circumscribed, instead of livid and diffused, and lies close and firm instead of puffy and hollow; new granulations sprout at the breach, the sloughs are cast off as they advance, and the sanious and ichorous discharge becomes healthy pus.

I do not deny that upon a miniature scale all this may be seen where the constitution has been unaffected; it is so because nature's operations are uniform; but I have not overcharged the picture where the inflammatory fever is present, and it is conformable to reason and observation to expect that the local changes, where the system has never been disturbed, should be the prototype of those which ensue, when such disturbance has been allayed, and the system recovers its tranquillity.

In inflammations which are set up by grave injuries, the system, if not at once disabled or in some way disordered along with the part, is frequently predisposed to an earlier sympathy, induced by the shock which it has at the same time sustained. This sympathy constitu-

ting "irritation," is often of a more dangerous description than inflammatory fever, as I have elsewhere fully explained*.

On the other hand, many inflammations having a very slight beginning, as regards their exciting cause, seem to owe their unmanageableness, and rapid transition from bad to worse, to a previously diseased or worn-out habit of body, and the typhoid diathesis prevailing in such circumstances. Some indeed originate from this cause independent altogether of local injury—such cases are always of serious aspect. But in favourable circumstances, of which youth and temperance are the foremost, the sympathetic inflammatory fever gets up gradually even after severe injuries, and evinces no more than what must be regarded as the unavoidable, nay the gratifying proof of universal and salutary consent between the whole and its parts; and the career of inflammation towards the accomplishment of the purposes to which it is instinctive, is but little retarded.

In the fever attending inflammation of the vital organs and their involucra and chambers, the free detraction of blood is one of the most important points of treatment; and this whether inflammation results from

* See "An Inquiry concerning Constitutional Irritation, &c.," in two parts. London, 1827.

injury or from other causes. The life of the patient seems in a great measure contingent upon his power to bear, and his susceptibility of relief from, the loss of blood,—conditions which are not at variance,—at first in larger and afterwards in smaller quantities. The subjects most prone to severe inflammation are generally those most requiring and best able to bear the loss of blood; but to this there are exceptions; and in injuries where the parity of these conditions is frustrated, it is in small quantities only that experienced practitioners bleed, looking always to the call upon the vital power for the support of the injury and its necessary consequences. In inflammations, however originating, whether from injury or from diseased habit, affecting the extremities, general blood-letting is seldom advisable or even practicable with safety. From the part blood is taken by various methods with very great advantage in such cases.

The choice of measures, *i. e.* local or general blood-letting, is determined, partly by the relation of the parts affected to the centre of the circulation, and in part by the more or less urgent necessity that exists for disembarrassing the general functions and arresting destructive inflammation. In visceral inflammation venesection is indicated and warranted to the utmost ex-

tent that the powers of life will bear; for here the mass of blood is so altered and spoiled for its proper and healthy purposes by the direct implication of the blood-making and blood-preparing organs in the disease, that relieving the system of its presence to the extent that can be borne, is the main resource we possess for its preservation. As we would remove a poison, a *materies morbi,* in such cases we take away blood. Its altered condition is palpable when eliminated from the body: it undergoes a peculiar separation of its parts, and presents other appearances not manifested by healthy blood. The difference of the blood within the vessels, from that of health, is not less if we could fully appreciate it. If inflamed blood be transferred into the vessels of a healthy animal of the same species, as his own is withdrawn, instead of supporting, it rapidly destroys life. A freer circulation through the small vessels, and those of the excretory glands especially, ensues almost immediately upon a full blood-letting: the sense of overwhelming oppression is relieved, and the inflammation, if not abridged by its effects, is disposed to a kindlier termination.

There are two false doctrines concerning blood-letting for inflammation, which cannot be too strongly condemned; the first, anticipatory blood-letting, by which I

mean, the large and repeated detraction of blood before inflammation, being considered inevitable, has actually manifested itself—on the hypothesis of starving the action, and thus rendering it tractable—which is a direct attack on the vitality, and fatally perverts the action, if it do not destroy the resisting powers of the system. The second, continuing the employment of the lancet so long as the last drawn blood exhibits the signs of inflammation, which if drained to the last drop it would do; or, in other words, not reflecting that there is a line beyond which the practice becomes destructive instead of remedial; and that there are many inflammations which do not admit of arrest by depletion, and upon which other modes of treatment are efficient for this end, even though not an ounce of blood be drawn. Many lives have been sacrificed to the prevalence of these irrational and absurd notions, and many preserved in their extremity by being fortunately placed beyond the reach of the surgeon; especially, I am induced to believe, in military practice.

When the change of the mass of blood ensues upon local inflammation, wherever seated, some of the internal organs especially, but all more or less, indicate the effect produced by it, and fever is established. It may be that these organs are not actually inflamed, though

this is often the case in death from remote inflammations; but their natural actions are deranged and interrupted in such a way as to occasion fatal effusions either into their substance or their cavities. The whole secretory apparatus is at a stand-still, the heart is unduly excited, then oppressed; the same order of changes takes place in the brain; and lastly, the lungs are suffocated by repletion, and can no longer admit the air to operate its necessary changes upon the portion of blood which they transmit.

If it be asked why, if this reasoning be correct, we do not combat the general inflammatory fever of the system, when arising from a complicated injury, or a wound, or fracture, or ulcer of an extremity, as when affecting the visceral organs, the answer is clearly this,—that in the former case the inflammatory fever is secondary and not idiopathic; that the local injury or inflammation attending it has already produced its effect upon the nervous system to the extent of materially deranging and depressing its powers; and that we dare not reduce them directly, as by the lancet, lest we destroy the vitality of the inflamed part, if not sink the general power too low for sustaining life under its burthen. But even in this case, if from a seeming metastasis, or from any cause, the visceral organs indicate inflammation, we do

not hesitate to employ general blood-letting, and in all such cases instantly and freely employ topical bleeding.

The principal change in composition which the blood drawn under inflammation presents, is, that it becomes sizy, *i. e.* the fibrine and colouring matter tend to a more complete separation than in the healthy state, when the former becomes concrete; while, at the same time, the proportion of fibrine to the other constituents is increased, so that the aggregation of its proper particles renders the coagulum preternaturally firm and contracted. This is a tendency not depending on any variation of the time required for coagulation, though it may be additionally affected by it. It is a change gradually wrought in the passage of the blood through the inflamed parts until it extends to the blood over the whole system. The change as regards quantity transmitted under inflammation is determined by the fact, that the whole quantity returned by the vessels of an inflamed part is three or four times greater than from the opposite sound part when the inflammation is severe; the acceleration of the blood through the vessels of the neighbourhood more than compensating the retardation through those of the inflamed part.

This change in the properties of the blood is accompanied by a very notable alteration in the acting power

subservient to its distribution, through the medium of the nervous system. The heart subject to its agency, and excited to action by its presence, becomes stimulated to a more rapid and vigorous movement, and, as far as its influence is capable of propagation, the extremities of the circulation respond to it. If the force by which the current is moved through the capillaries, in which order of vessels inflammation originates, is capable of being relaxed or exerted to a certain extent, independently of the heart's action, as is seen in nascent and purely local inflammations, the continuity of the lining membrane places the entire vascular apparatus in consent, and the *vascula minima* react upon the trunks in obedience to the impulse communicated by the heart, and the more animalized and stimulant quality of the blood which they transmit.

The setting up of fever is gradual; it is not established under many hours, more than local inflammation: so is the alteration in the properties of the blood which induces it; so are the changes to which it gives rise. Whether the first morbid impression and action is upon the nervous system, transmitted by the nerves of the part injured or inflamed to the nervous centre, and thence to the organs of circulation, is a moot question. To my mind the pathognomonic signs, as well as the facts of physiology, are in favour of this opinion. The premo-

nitory symptoms, viz. headache, lassitude, disquietude, nausea, chilliness, and rigor, are indications of the more or less troubled condition of the nervous centres: to these the alteration in the measure and force of the circulation, the permanent and sensible changes upon the internal and external surfaces, and their secretions, succeed, viz. quick pulse, hot skin, dryness of mouth and fauces, furred tongue, vitiated and scanty excretions, &c. Of the changes that ensue in the parts which are the seat of inflammation, we shall speak in another place; but that the action of fluid and solid is reciprocal in the production of inflammation and fever, as it is in the functions of health; and that it is inconsistent with all we see and know of the animal functions to imagine the possibility of either being exclusively in fault, is a proposition which scarcely needs to be exemplified.

Here then is material sufficient to account for the frequency and fatality of the fever of inflammation: the period of its accession is very variable, its extent, nay, its existence is uncertain, and depending on too many circumstances incidental to the occasion and the subject, to be laid down with any approach to precision. The same may be said of the character of the fever, whether dynamic or atactic, to which indications the treatment must of course be subservient.

CHAPTER V.

THE PROCESSES OF INFLAMMATION.— EFFUSION.

The effect of local irritation upon secreting surfaces is to quicken and increase the exudation of their proper fluids. When to this the act of inflammation succeeds, the natural secretion is arrested, and the inflammatory is substituted. The lacrymal secretion from irritation of the conjunctiva; the mucous, from irritation of the pituitary and bronchial membrane, or the membrane of the urethra and bladder, are familiar instances. Such also are the accumulations which take place in joints and bursæ, unattended by the signs of inflammation.

Palpable deviations in the consistency and other characters of these fluids, in addition to quantity, are frequently observed antecedent to inflammation; and are sometimes corrected without the act of inflammation supervening. These, therefore, are not to be regarded

in the light of inflammatory effusions, but as the simple results of local irritation and congestion.

Dropsical accumulations, commonly denominated effusions, are frequently unattended by inflammation, and owe their origin to local causes of a nature wholly different. Such for example are the ordinary hydrocele, hydrops articuli, and anasarca of the lower limbs. Upon all these the act of inflammation being superinduced, a mixture more or less of the vitiated secretion natural to the organ coexists for a time with the product of inflammation, whether serum, lymph, or pus; but is eventually superseded by the latter, as the inflammation, more or less active, proceeds and becomes established.

The first change external to the vessels in inflammation is not a permanent change, and looks like a measure of temporary relief to the overloaded vessels which surround the inflamed centre. It is an aqueous exudation from the colourless capillaries into the adjoining cellular texture. It would seem to be a passive mechanical effect, as it doubtless often is, but for the precedence of other unequivocal signs of inflammation. Its appearance is by no means uniformly indicative of the strength or activity of inflammation; in some being scarce noticeable, in others occurring to an extent over-proportioned to the degree of inflammation, as marked by other

symptoms. The loose texture of the connecting membrane seems to favour it, judging from its greater frequency and extent in such parts as abound therewith, and *vice versâ*. It undergoes absorption in variable times, but however considerable, seldom remains beyond a few days, perhaps hours.

It may present an admixture of the colouring matter of the blood, in which case its disappearance is not so speedy. The escape of entire blood seldom attends inflammation, nor does its extravasation, *quoad* blood, induce inflammation; but enough of the colouring matter to render serous effusion sanious is not uncommon.

The effusion which commences, and more or less increases from the accession of the injury, as contusion or fracture, is a result of lesion antecedent to inflammation, and generally furnishes a measure of its amount. It is commonly supposed to augment rather than relieve the ensuing inflammation, by reason of the tension it gives to parts in the vicinity. If, however, we except luxations and fractures attended with displacement, it is probable that the after processes are beneficially influenced by the evacuation, and that the tension which for two or three days prohibits artificial appliances, is more than a substitute for the benefits to be derived from their use, by the actual immobility and

support which such a mode of equal compression communicates.

After a considerable effusion of blood into the cellular membrane, the absorption of which proceeds more gradually, a degree of thickening and of firmness of texture remains for a period; this is owing to a partial coagulation. The same effect follows, in a more remarkable degree, a large effusion under inflammation of the liquor sanguinis unmixed with colouring matter, *i. e.* the part recovers slowly, becomes thickened and opake, perhaps indurated, and does not soon resume its figure. [Chronic chemosis, phymosis, glandular and bursal inflammation.] This is the distinction between the aqueous effusion occasioned by mechanical irritation or compression, and the fluid effused under active inflammation.

The purer the serum, *i. e.* the nearer its affinity to that fluid, as separated from the other constituents of the blood in the act of coagulation, when little or no fibrine is held in solution, the more rapid and complete will be its removal by absorption. But the fact last stated may admit of a different explanation. The loss of figure and transparency, the thickening and induration, when considerable, are perhaps not so much depending on the nature of the fluid first effused, as upon the inflammation of the distended or compressed cells, and

their consequent subjection to the adhesive process next to be described. Effusion, when amounting to excessive distention, is thus often most important in its operation, as a promovent and an aggravant of the inflammation.

The effusion of serum under compression, œdema, or lesion, devoid of blood particles, as in sprain, is to be distinguished from the effusion of the liquor sanguinis in wound and inflammation: the former being the albumino-aqueous and saline compound forming the serum of the blood, the latter the fibrinous constituent separated either from the effused liquor sanguinis, or within the inflamed vessels; the last alone being susceptible of permanent organization.

The process of absorption admits of quickening by position, by cold and spirituous applications, and when inflammation has ceased, by friction with stimulant embrocations or ointments, and by pressure. Saline evacuants, as the neutral salts; and nauseating medicines, as antimony and ipecacuanha, and especially the preparations of mercury and of iodine, are the powerful medicinal agents.

When effusion takes place unpreceded by inflammation, as in simple œdema and dropsy, the effect of distention is very slow to produce inflammation, and especially the adhesive. Pitting on pressure is sometimes

followed by induration to a considerable extent, the result of extreme distention, and at length inflammation is set up, attended by pain, heat, and redness; suppuration follows, then ulceration, or even gangrene. In this case the obstruction is purely mechanical, the balance being gradually lost on the side of the absorbents, and the distention thence resulting acting upon uninflamed parts. The case is therefore altogether different and distinct from that in which the effusion has been rapid, and upon parts already involved in the inflammation.

The rapid power of absorption residing in the healthy cellular membrane is displayed by nothing more strikingly than the complete removal of the fluid of a large hydrocele, which has been gradually let out by acupuncture of the tunica vaginalis into the scrotum, in about eight and forty hours; an observation which I was, I believe, the first to make and apply.

The perfect absorption of effusions from injury or pressure within a short period, nay, their frequently sudden disappearance and the complete recovery of the part, in a vast proportion of cases, serves to show that the effused fluid is in such cases either a preternatural transpiration of the aqueous part of the blood through the capillaries, or a sudden suspension of action of the

lymphatic absorbent vessels, and not a secretion or constituent of the fluid blood separated by a process of inflammation. On the other hand, large serous accumulations, that have originated from blows and sprains, will sometimes remain in the subcutaneous cellular membrane, as in cysts and sacs, without inducing any inconvenience but what the chronic swelling of the part occasions. This occurs chiefly in cases of partially obstructed or enfeebled circulation.

CHAPTER VI.

ADHESION.

The tendency to separation of the constituent parts of the blood of which we have spoken, is most remarkably shown in the detachment of the fibrine or most animalized of its constituents, for the purpose of new organizations,—a property peculiar to this ingredient of the blood, which, if deprived of it, would be incapable of coagulation.

If it had not this property of solidification, its organization would be impossible; and if coagulation were not an exclusive property of blood external to the sound vessels, circulation could not go on. The tendency to separation within the vessel, which marks the first access of inflammation, is carried out externally to it for the purposes of inflammation, to an extent which would be otherwise incompatible with circulation, and consequently with life.

In what consists the difference between the serous fluid which is exuded in the congested state of the vessels under inflammation in its first stage, and often independent of it, which, though it constitutes the swelling incident thereto, is susceptible of early and complete absorption, and that which, in a more advanced or more powerful inflammation, is separated from the blood and immediately assumes the form of fibrine or coagulated lymph? In extensive and strong inflammations they are present together: the concreted matter is found lining the walls of the cavity and floating in detached masses in the serous fluid which fills the chest in pleurisy, for example. Is the fibrine ever effused until after the exudation of which we have just spoken? Is it effused in a separate form? or does it separate by concretion from the permanent fluid part, as we see it do when inflamed blood is drawn from the body?

The actual separation must be subsequent to the effusion, else, instead of permeating, it would obstruct the vessels and prevent the process of transpiration. It must therefore retain its fluidity at the instant of its effusion, and only part with its fluid form when separated from the other constituents of the liquor sanguinis.

In cases of effusion and complete absorption, either

the fibrine is not effused distinctively, in the form we can demonstrate it to be capable of assuming by interrupting the coagulation of recently drawn blood, or it retains its fluidity as a constituent of the liquor sanguinis, when extravascular.

The effusion of fibrine is never unaccompanied with a proportion of serum, but there can be no doubt that the serous effusion may and does take place without any appearance of concreted matter or coagulable lymph.

In the instance of dissolution of continuity, whether of soft or hard parts, we have, independently of the effusion of blood and subsequent to it, a serous exudation into the cavity, organizable fibrine coating the sides and closing the mouths of divided vessels, and blood coagula in their interior extending a short space therefrom, thus presenting to a certain extent distinctly, the three constituents of the circulating mass.

It would appear that the first exudation, either in wound or preliminary to abscess, or when not attended by inflammation, is confined to the aqueous part of the circulating blood, but that the continued action of inflamed vessels determines the effusion of fibrine, which, abounding in a larger proportion and strengthened in its property of coagulation by the separation of the

blood particles already commenced, speedily assumes the solid form in its purest state.

I cannot view this phenomenon, as some have done, as a mere mechanical effect produced by a gorged state of the vessels; if it were, there would be no such uniformity as exists in the results of inflammation: we should oftener have blood poured out *en masse*, and not its separable ingredients; the change commencing within the vessels and perfected externally. The process is peculiar to life, and the operation of physical and chemical forces is in subservience to vital laws. Secretion, which signifies "separation," seems the least objectionable term which can be employed, since it intimates a vital power, and puts away the idea of a purely mechanical effect; and is also consonant with the sense affixed to the term applied to the proper secreting organs, since all the products of secretion are by a process, more or less elaborate, derived from the blood by subdivisions of that capillary circulation, by which alone the processes of inflammation are carried out.

All separation not immediately resulting from lesion is determined by a change in the affinities existing between the containing vessel and the contained fluid. Thus the immediate effusion following contusion is owing to the temporary failure or suspension of the

resisting or restraining property from the shock to the nervous fibre, and in effusion from pressure, as œdema, it is the like arrest or suspension of the absorbing or carrying power; in either case the balance of forces, and mutual relations, chemical or mechanical, being so far disturbed and interrupted. In inflammation, this alteration of the normal affinities between the vessels and their contents is invariable, conspicuous, and strongly manifested, and may be regarded as the proximate cause of its phenomena.

The mere extravasation of blood, we know, does not determine its coagulation, though it often retains the coagulable principle, as is proved by its immediate coagulation after many days, on exposure to the air. The comparative slowness with which it assumes the solid form in acute inflammation, and its greater firmness of cohesion when consolidated, both in and out of the body, depend on its high state of vitalization, and, in the former case, eminently favours adaptation by its first plastic and ultimately resisting qualities, which are equally indispensable to its organization.

The spontaneous coagulation of blood eliminated from the circulation is, if not the last act of life, the symbol of its inaptitude for any further purpose of the economy. If effused within the body, its coagulation

is prevented, or is partial and imperfect: it is virtually a foreign body. But the changes which it undergoes during the temporary congestion or actual arrest of the capillary circulation in inflammation, are preliminaries to its higher animalization, or adaptation to the wants and uses of the living system.

In a wound with loss of substance, which offers the most complete example of organization, the fibrine is very gradually deposited, little by little, at its margin, preserving at all points an uniform line of approximation to the centre. The margin is elevated, rounded and opake at its base; its salient edge is thin, sharp and transparent.

This presents no appearance of vascularity during the process, but the circumjacent vessels are observed to multiply and extend their branches of communication or anastomosis. These processes go *pari passû* towards the healing of the breach; the fibrine becoming fuller and more opake where it adjoins the original texture, and in the same proportion encroaching upon the void space. The wound preserving its figure, continues to diminish as the surrounding parts become organized by the production of transparent capillaries from the nearest vessels in forks and arches of communication one

with another, parallel for the most part to the margin of the wound. These vessels are visible in fine striæ before circulation can be detected. A single globule is first observed to enter, and this is followed by more, which have only an oscillatory motion for many hours, a flux and reflux derived from the impulse of the circulation in the parent capillaries; which see-saw movement continues gradually gaining in the direction of the nearest neighbouring vessel, into which at length the pioneer globules enter in single file. The next stage is the abrupt and rapid occasional transit of a globule, or of several isolated globules in succession, through the new channels, just as drops of rain course one another down a window-pane in the same track.

The conclusion of the process is a regular uninterrupted transition of a file of globules, by which a cross branch of communication is established. This is the simplest example, but the complications of anastomosis proceed in a similar manner. Instead of the meeting of parent vessels, one new vessel encounters another, and they join and divaricate at an angle; or one meeting another current in an opposite direction, is reflected at an angle so acute as to be refluent upon itself to the vessel from which it emanated, or to contiguous ramusculi from the same parent, and thus

arches and circles forming a mesh of anastomosis are established.

The nascent blood-vessels appear in the first instance destitute of colour, by reason of the paucity of the blood globules which they convey. When perfected, enlarged and multiplied, they become the nourishing vessels, arteries and veins, of the new texture, the motion of the blood being, as they are arteries or veins, conformable to that of the original texture. The appearances of vessels striking directly across the newly-deposited lymph to meet their opposites—of vessels seemingly engrooved in the lymph by a train of blood globules pioneering their track—of insular specks and zones in the fibrinous deposit, which generate and throw off pencils of vessels for anastomosis with each other and with those proceeding from the margin, are doubtless presented at different stages of the process; but being the result of occasional and partial observations, have been inaccurately dated and explained. The whole business of organization is of and from the margin of the wound, and it is upon the margin and its gradually developed organization and encroachment, that the healing action is first and last seen, *i. e.* until its obliteration by the cicatrix. There is no such thing as isolated or independent vascularization, although appearances

exist that convey this impression, as will be afterwards shown. The centripetal or convergent arrangement is the presiding and consummating genius of the operation; but the inherent contractility of the fibrine, and the primary institution of a fuller and freer anastomosis of the nearest marginal vessels modify the process of organization, and render the centre, as it is the most distant point, the last vestige of its completion. The loop, fork, or arch consists of an arteria and vena "comites," so that the continuity of circulation keeps pace with the extension of vascularization; it is the opening out of the angle of reflection which presents these varieties of arrangement at different periods, and explains the purpose of its existence and uniformity.

Every wound presents the following phenomena:—the occlusion of all divided vessels not of large calibre by clot or coagulum of blood; the actual stasis of the circulation in the part, the first local phenomenon of inflammation, with or without lesion; the gradual deposit of fibrine devoid of colour, and the subsequent more gradual vascularization of that fibrine, by the opening of transparent channels for the admission of at first isolated globules, then a train or file of globules, and ultimately a column conveying colour; their intercommunication, anastomosis and reflection towards the

part whence they are derived; and lastly, the offset of stagnant meshes, like advanced posts from the parent blood-vessels, slowly acquiring motion and dispersing. All tend to demonstrate that the laying down of the organizable fibrine, the intrusion of the blood corpuscle, and thence the formation of the new vessels, are the work of the active coloured capillaries nearest to the point of stasis, aided and completed by the return of circulation, also gradual, to the vessels, trunk and branch, which had been rendered motionless by congestion.

The stagnation of the centre determines the increased activity of the circumference of the vascular area, and the collateral circulation is set up precisely as in the ligature of an arterial trunk. The new vessels, at first large, imperfectly defined and slowly transmitting their contents, become contracted, as the fibrine contracts in which they ramify; and the regularity of their transparent circulation is established by the elasticity which belongs to this extreme order of vessels; while those which ultimately transmit blood in volume sufficient to communicate colour, do so under the propulsive force which their intermediate relation to the two orders of vessels subjects them to receive.

Here it may be remarked, that the effects produced by the ligature of an arterial trunk will be found

to illustrate by analogy the effects of the stasis of inflammation, with or without breach, in the coloured capillaries, *mutatis mutandis*; not by any means warranting the inference that mechanical obstruction alone is the cause of inflammation, but showing that inflammation, artificially produced, exhibits parallel phenomena with that which arises from accidental and natural causes. The increased vigour or extent, if need be, of the collateral circulation after inflammation not admitting of resolution, and therefore terminating in breach, is analogous to that seen upon a larger scale after a tied artery; what belongs in this instance peculiarly to the artery being transferred in the other to the system of vessels supplying the inflamed or broken parts.

Is the blood, when effused from wounded surfaces, a medium of organized adhesion? or capable of becoming so? I answer in the negative: the question turns upon a delusion. If the wound be so small as that the effusion of blood is restrained by the adaptation of its sides, whether naturally falling together or artificially compressed, the separation of its colouring matter is shown by a plentiful oozing of sanies at its mouth and the formation of a crust. If, on the other hand, the wound be of such form or size as to prevent coaptation, or be attended with loss of substance, the coagulum of coloured

blood being in proportion, acts as a foreign body, and must be dislodged prior to healing. Hence the difference in the time, and often in the mode of healing of a small gaping wound left to itself, or a wound with loss of substance, and that of a larger wound, whose sides are immediately brought and maintained in contact. Thus the agglutination of the lips of a small wound by a thin layer of blood, a merely temporary expedient, is no bar to the union, but the contrary, both in respect of hæmorrhage and union, though never forming the permanent bond. In truth, no wound of any dimensions, however favourably situated for the adhesive process and rapidly united, has not, when fresh, a layer or pellicle of blood coating its surface; not admitting of removal by abstersion, but insusceptible also of healthy organization. The separation and deposit of fibrine takes place distinctly, and after an interval. This is marked even in cases of simple division of the solid, but in loss of substance occupies many days; being step by step, and only just ahead or in advance of vascularization. No preparation so exactly illustrates the temporary use, and the permanent non-effectiveness, of the clot of blood; and, on the other hand, the distinctness of organizable fibrine destitute of colour and available for union, as the wound of an artery by a round ligature.

The ultimate complete absorption of the clot is equally well exemplified.

Since this was written, I have perused with much interest the valuable observations of Mr. Dalrymple, "On the rapid Organization of Lymph in Cachexia*." I appreciate and recognise the original fact contained in this statement, and regard it as of great practical value. But neither the case of the seaman of the Dreadnought, nor the ingenious arguments brought in support of the opinion, that effused blood is susceptible of organization, convince me of the accuracy of that conclusion, or indeed shake my confidence in that which I have stated. As regards the preparation, an effusion of blood, filling to distention the connecting cellular tissue of the bone and periosteum, and dissecting the web of the nutrient vessels (Mr. Dalrymple's first and most obvious conjecture), is, to my mind, the true explanation, and neither admits nor requires the hypothesis of newly-formed, because newly-displayed blood-vessels; and most certainly, had they been so recently formed, the injection, however delicate, would have produced one mass of extravasation, so that the case is one that proves too much for the argument. I can well believe "the entire dissimilarity of the organization of this tissue (so infiltrated) from the

* Royal Medico-Chirurgical Transactions, vol. xxiii.

periosteum on the one hand, and the bone on the other." But let us take another view of the question: if a coagulum were organizable, would it be now announced, upon the authority of Mr. Hunter's solitary case of the injected tunica vaginalis in hydrocele, or this of the Dreadnought seaman, as a lapsed observation, or one about which a doubt hangs, when its daily and hourly occurrence must have furnished familiar and indisputable proofs? Admitting the explanation, and, for argument sake, the fact of vascularization of a clot, does this include the complete endowment essential to the developing and self-preserving principle which is the touchstone of vitality, an equal participation of nerves and absorbents, and all the apparatus of analogous structure and function? But it is useless to combat a proposition after rejecting the fact upon which it is raised. The pathological observation announced by Mr. Dalrymple is of undiminished and high importance; and here practical experience comes in aid of physiological research.

The cachectic and enfeebled system forms bad blood, bad lymph, bad pus, as compared with the robust; the prostrate system, so rendered by shock or by exhaustion, is incapable of detaching fibrine from the liquor sanguinis, and (instinctively only) sets about the vascularization of

fibrine not perfectly disentangled from the colouring matter of blood. Pure fibrine and pus also are elaborately produced in healthy subjects, for we see both improving under the progressive changes of granulation and its secretion from the commencement of the suppurative and ulcerative processes to their completion, and their utter stagnation and degeneracy in decayed constitutions. Cachexia displays all the phenomena of spurious organization, blood and lymph conjointly forming false membrane, and fungous granulation striated and intermixed with coagula, quite incapable of self-preservation, though effectually preventing the act of union or healing. Slow and sure are a pretty constant couple throughout nature, and the false coin of morbid states of the circulation only serves to give character by contrast to the true die.

But further, premature, hurried, and ineffectual efforts at organization are characteristic of the anormal, morbid and malignant structures of scrofula and cancer, and their infinite varieties in the adhesive stage, viz. warts, fungi, excrescential and parasitic growths, tumours and heterologous productions, solid and fluid. The type of the action is furnished more or less by the natural standard, "*ut vultus, ita simulacra vultus;*" but the materials as well as the machinery are so degenerate,

as to be not only incapable but mischievous. Hence, they either fall, break up, and perish, by reason of their spurious and imperfect vitality, an easy prey to the absorbents, stimulated to increased activity; or their action is, figuratively speaking, reckless and impatient of control, the structures attain an enormous magnitude, and involve all surrounding parts in ulcerative and gangrenous inflammation.

The preservation of the fluidity of the blood in its vessels, and the solidification of one of its component parts by a vital process, consentaneous with its separation from the mass, are the ultimate principles upon which the phenomena of inflammation rest. The principle of coagulation in the blood has no other relation to this condition than the circumstance of its dependence upon the same constituent, viz. the fibrine; it is a law of Nature, that under certain circumstances blood coagulates when out of the vessels; that in others this change is anticipated or prevented, and it remains fluid; that some conditions accelerate, others retard the process and in proportion separate its component parts, as in some circumstances it parts with its heat sooner than in others: all this bears only so far upon the change which fits it for organization as to show that the deposition of pure fibrine, in an organizable form, is a vital process,

depending upon an action *sui generis*, of which the coagulation of the blood, under other and ordinary circumstances, furnishes no example.

There is no structure insusceptible of this action, for in all it is commenced, if not completed, by vessels so delicate, as to be, for the reason before mentioned, colourless; parts opake and essentially transparent are therefore open to it, nor can any breach of the solid fabric of the body be healed but by this medium. That in some it is more ready and abundant than in others may be admitted; a difference, however, more apparent than real, and determined by the fact, that varieties of structure and of injury demand and present corresponding variations in the mode of repair.

In speaking of the formation of vessels, those which serve the office of veins as well as arteries are included; and the *réseau* formed by communicating branches, at indeterminate angles, exhibits the ultimate subdivisions of the vessels, and eventually a degree of vascularity approaching that which belonged to the original structure.

The presence and activity of lymphatic absorbents is evinced by the proportion and adaptation of the new to the breach or loss of the old structure, *e. g.* the changes ensuing upon fracture of bone; and the same descrip-

tion of proof is obtained of the reproduction of nerves, *e. g.* the restoration of sense and motion after their suspension by dividing wounds. We see the uniform distribution of these systems in original parts, and their mutual dependence and co-operation, and should be utterly at a loss to account for the visible, and tangible, and essential properties of united and newly-formed structures, without their combined agency.

The false membrane, as it is called, within the visceral chambers, canals, and blood-vessels, and all preternatural growths, the lining membrane of phlegmonous abscess (pyogenic membrane), investing and secreting cysts, are depositions of fibrine secreted by the capillary vessels under inflammation. Much of this is often effused in detached and colourless flakes floating in serum, and this albumino-fibrinous material is not elaborated in its secretion like that which is adherent to the inflamed surface, and undergoes a quick organization. This, upon free surfaces, often assumes a fantastic though uniform arrangement, as the cellular and septiform or honeycomb like, the foliated, the fringed; the form of loops or festoons, or depending branches of trees; grape or berry-like clusters, and all the varieties of warty and excrescential growths. An opposite surface partaking of, accepting (according to Hunter) the same action, union

speedily ensues through the medium of the organizable lymph; it is when union is interrupted or prevented, whether owing to the intervention of solid or fluid, the action of the parts, or their relative position and properties being opposed to it, that these varieties occur. Whether the production of lymph in these varieties, which are far too numerous and complicated to admit of particular description, interferes with the functions of life or not, depends upon the importance of the organ affected, more than upon the inflammation. The cauliflower warty excrescence covering the glans penis and prepuce in gonorrheal phymosis, and the honeycomb deposit upon the heart and pericardium in carditis, are both results of inflammation, depositing and organizing the fibrine of the blood. But the state of the system is as much as possible contrasted, and the difference is that between the inflamed condition of the mass of blood, the interruption to the vital changes, and the presence of destructive fever in the one case, and not in the other.

Thus, though the adhesive process, if favourably circumstanced and undisturbed, is capable of uniting wounds and restoring the health and use of parts; if originating upon surfaces independent of wound, and set up by other modes of irritation, local or constitu-

tional, is productive of all the inconvenience and danger resulting from interruption according to its degree, to the function of those surfaces, and the parts with which they are connected. Of this fact the larynx, the alimentary canal, the blood-vessels, and the urinary passages furnish frequent examples.

Nature has provided qualifying agencies in the counterplay of the processes of inflammation respectively. A foreign body is an interruption to union, but not to the adhesive inflammation; as we see in the encasement of such as are inorganic by an investiture of lymph; for example, leaden bullets, pins, &c. The travelling of pins and needles about the system, depending on other circumstances, could not be accomplished with safety, if the adhesive inflammation did not protect the parts through which they pass by a successive encasement of coagulable lymph; as the foreign body proceeds the channel closes and heals, and sooner or later becomes obliterated, and in the same manner extraneous fluids are conducted by sinuses to the surface. Some foreign substances, from attending circumstances, remain permanently in their original investing cyst, and are found in critical situations in post mortem inspections, even when their presence was, if not unknown, at least unheeded during life, being productive of no inconveni-

ence. To this, of course, there are exceptions, and their presence and position are indicated by fearful, perhaps fatal symptoms.

Other circumstances, mechanical and chemical, acting as a barrier to the union of parts, it is scarcely necessary to enumerate; but the union of parts and the inflammation upon which union depends are distinct things. The former may be, and often is, rendered impossible as a direct effect in certain losses of substance and in the various complications of injuries, but the adhesive inflammation is equally present, and its end is accomplished, though by a circuitous route; in fact, a secondary process, indispensable to the restoration of all lesions, great or small, simple or compound, which are incapacitated to perform the act of direct reparation. This we shall presently proceed to consider.

CHAPTER VII.

PERIODICAL PHENOMENA OF WOUNDS, ILLUSTRATING THE PROGRESSIVE STAGES OF THE HEALING PROCESS. DRIED SPECIMENS.

To the ingenuity and zeal of the late Dr. Todd of Brighton, we are indebted for a highly interesting series of preparations illustrating the 'Healing Process,' in daily stages, from the infliction of injury to the completion of repair. To accomplish this purpose, a corresponding injury was inflicted upon the webs of a large collection of fresh frogs at the same time, and a wounded web being removed at successive intervals of twenty-four hours, was dried, and then placed between two squares of glass and hermetically closed by a balsamic composition, which preserves appearances even to the shade of colour with remarkable fidelity; the date

of each specimen being registered and carefully engraven on the glass*.

The instant appearance of the part, especially of the blood-vessels and their colour, can only be preserved by such a mode of death as is instantaneous and without struggle, for which purpose Dr. Todd employed nicotine.

It is deeply to be regretted that the specimens are unaccompanied with any manuscript record or notes by way of illustration, although subjected to careful examination by the doctor from time to time with the design of working out the subject, and ultimately presenting it in a finished state to the profession. Neither the eye nor the mind of a survivor, however accomplished, can supply the place of those of an original inquirer. The time occupied for the completion of the process varies according to the nature of the injury, and allowances must be made for the incidental varieties of vigour or languor in individuals, and perhaps the influence of season, to reconcile the seeming discrepancies in the rate of advance; wherefore an interval of three

* This interesting collection was purchased of Dr. Todd's executors by the Royal College of Surgeons, and is now arranged in their museum. It also comprises some valuable preparations in the department of Insect Anatomy.

days furnishes a safer average index of changes than a shorter period. With such admission, it is remarkable how striking a uniformity prevails throughout this interesting collection, and how additionally corroborative of general results are these natural and necessary inequalities of progress.

The specimens exhibited are,—

1. Incised wound traversing an artery.
2. Incised wound traversing a vein.
3. Incised wound in the direction of the toes.
4. Excision of a circular portion of web.
5. Contusion.
6. Burn.

HEALING BY FIRST INTENTION.

1st Series.—*Incised transverse wound traversing an artery.*

Days.

1 and 2. Web highly injected. Coagulum filling the wound.

4. Divided ends considerably retracted; small coagulum. Anastomosis of vessels observable on both sides of the wound.

8. Clot small, surrounding vessels conspicuous.

10. A white streak only indicating the site of the wound, with disturbed pigmental spots.

Days.

12. Appearance of extravasation or clot?

14. Fine anastomosis of vessels around the wound. Clot pale.

15 and 16. Clot presenting a *dotted* or *stellated* appearance. Beautiful circle of anastomosis.

21. Slight vestige of wound.

24. Star-like extravasations, or remnants of original clot?

26. Idem. Original deposit of opake lymph organizing.

28. Organization of lymph by fine vessels coming from the margin.

30. Stellated appearance very faint; white interspaces, and the blood discs *both in and out of the vessels* clearly distinguishable.

34. Zones or arcs of new vessels, seen in a deposit of lymph one within another; faint stellæ.

39. Semi-pellucid appearance of lymph deposit.

42. Very faint stellæ, marking site of wound, surrounded by vessels freely anastomosing.

46, 48 and 50. New vessels anastomosing and arborescent on site of wound, which is a linear cicatrix.

54. Moleculæ of blood corpuscles visible in and between the new vessels.

58. Looped arrangement of new vessels, occupying the cicatrix.

60. The blood discs seen in the new vessels, and moleculæ of the same in the still remaining pale stellar spot.

2nd Series.—*Incised transverse wound traversing a vein.*

Days.

1 and 2. Coagulum of extravasated blood filling the wound. Divided extremities of vessel retracted and thrown into different lines; surrounding congestion.

7. Granular or dotted appearance of clot. Extremities of vessel out of the line to the extent of two diameters.

10. Clot, if any, absorbed.

12. Faint appearance of clot. New and very delicate vessels bordering the wound.

14. Fine surrounding anastomosis of new vessels.

17. Line of wound marked only by derangement of pigmental spots.

21. Intermediate anastomosis of new vessels. Small stellar masses resembling extravasations at either angle of the wound.

24. Small stellar congestion at one end of wound. New vessels of anastomosis between divided extremities.

27. Opake white line of cicatrix; faint vestige of congested vessels at either end.

29. Distinct appearance of lymph granules in masses; semi-transparent, as if commencing organization.

31. Mere vestige of wound.

34. Small appearances of anastomosis of new vessels.

37. The divided vein appears almost continuous. Scarcely

Days.

any trace of wound; fine capillary vessels bordering the white cicatrix.

39. Vascular spots, insulated and central, between the two contracted extremities of divided vein. Communication of these by a fine circle of anastomosis margining the wound.

41. Idem.

43. Intermediate colourless vessels shooting upon the new lymph.

45. Idem. Large collateral branch of communication; lymph traversed by new vessels.

47. New vessels in loops and forks on sides of the wound palely injected by surrounding capillaries.

49. Idem, communicating, *i. e.* traversing the wound.

3rd Series.—*Incised wound dividing the web in the direction of the toes.*

3. Void oval space, marginal line slightly raised.

4. Slight extravasation on left border. The layers of the divided membrane, being unequally retracted, leave an interspace.

6. Vessels much congested in neighbourhood of wound. Copious exudation on both sides.

8. Centre of wound void, and clear marginal layer of transparent lymph vessels.

10. Layers of web bent towards each other in progress to union. Wound not diminished.

Days.

12. Large wound; lymph border; particles of the lymph very apparent.
15. Particles of lymph conspicuous on the margin, forming a border of equal diameter.
17. Marginal layers condensed by adhesive union. Vessels without colour.
20. Wound a fissure; the larger vessels appear at greater distance; the area of the wound is diminished by the encroachment of a clear unvascular fibrinous exudation from the surrounding vessels.
23. Stellar extravasations or congestions within the area of the wound.
25. Wound small and coloured, as if stained with recent extravasation.
29. Slight vascular appearances, small injury, and healing advanced.
32. Lymph particles in the bed of the wound; faintly-traced vessels running towards it.
35. Cicatrix slight; pigmental maculæ reproduced upon its site; transparent vessels passing over it.
39. Dots or stars of new vessels. New and very faintly-coloured vessels striking into the fibrine of wound.
44. New vessels mapping the lymph deposit, and anastomosing with neighbouring branches.
49. Remarkable convergence of fine new vessels towards the centre of the wound.
57. Healing advanced. Vessels converging in radii to the centre.

Days.

60. Remarkable stellated appearance of the new vascularization; some vessels exhibiting the regular folded or looped termination.

64. Small central cicatrix. Converging vessels.

71 and 72. Scarce any visible trace of wound.

78. Converging vessels to central cicatrix.

88. Increased vascularity of cicatrix.

93. Small vascular points marking cicatrix.

119 and 125. Vascularization of cicatrix completed.

159. A venous trunk traversing the site of cicatrix.

HEALING BY GRANULATION.

4th Series.—*Excision of a circular portion of web by a sharp-edged instrument resembling a punch.*

1. Void circular space; unequal retraction of inner and outer layer; surrounding vascularity.

6. Idem: borders approximated, diminishing the canal of interspace betwixt them.

11. Vessels highly injected; one principal dilated vein; border of wound presents stellæ of extravasation; circle of vessels from adjacent trunks.

13. Vessels running parallel to the margin on either side of the wound; the disposition prevailing at the time of the injury?

19. Inner border of membrane appears rounded, as if raised by a deposit of lymph beneath it. Coloured discs in semi-transparent patches, as if of

Days.

fine vessels partially filled, of which the continuity is lost by interspaces.

22. Narrowing of the wound by an increase of a border deposit of lymph, without any sign of vascular organization; arcus of surrounding vessels faintly marked; lymph globules on the border.

30. Vascularity of and around the margin more strongly indicated.

33. Dotted or stippled appearance presented by the coloured corpuscles upon the margin of the wound, and lymph globules in the interspaces.

37. Idem.

43. Much deposit of lymph contracting the wound, and striæ of colourless vessels touching its edges.

44. Same appearance of stippled patches mingled with lymph globules, more strongly marked; new vessels passing over or through them from the margin of wound.

49. Much diminished wound without corresponding vascularity; the new matter consisting apparently of lymph, without an appearance of vessels in it, or much increase in size or number of surrounding vessels, as if the process of exudation were carried on distinctly.

52. Stippled appearance remarkable, and abundant deposit of lymph particles towards the centre of the wound.

Days.

57. Central coloured spot. Clear transparent vessels belonging to the new skin overrunning it.

64. Coloured vessels; convergent radii to the cicatrix as to a centre.

71. Idem. Convergent vessels strongly marked.

78. Blood discs seen distinct and with intervals in the new vessels, under a high power.

81. Vascular loops and forks partially traversing the cicatrix at one end, and completely at the other.

86. Congestion of vessels occupying cicatrix; large veins terminating in it.

90 and 103. Vestige of wound very faint. The reproduction of the cuticle in horizontal scales seen in some of these advanced cases at a little distance from the cicatrix.

106. New vessels, blended with dots of congestion, arranged in converging loops.

112. Complete cicatrization.

116. Convergent forks and loops of new vessels at the cicatrix.

126. The greater number of loops joined by anastomosing branches, not all; still very faint stellæ of organization.

152. Direct circulation re-established; cicatrix very obscure.

162. Idem.

174. No distinctly visible cicatrix.

P.S. A beautiful specimen of the repairing process re-

Days.

cently completed in a web, illustrating the above. Injury and its date unknown.

5th Series.—*Contusion by a blunt force, as a blow from a hard body.*

1 to 7. Ecchymosis, with different degrees of vascularity of surrounding web; days 4, 5, 6, pale web; days 3 and 7, much injected.

9. Extravasated blood nearly absorbed, the displaced pigment marking the seat of the injury.

13. Coagulum still abundant.

15. Gradually disappearing by absorption.

18. Trunk of a ruptured vein; greater contiguous vascularity.

19. Considerable extravasation in one spot; in another great congestion, as if threatening a second extravasation.

21. Disturbed pigment only.

23. Great turgescence of vessels.

25. Increased vascularity only.

28. Vascular trunk interrupted or discontinuous; a number of small detached particles, query, lymph globules, deposited in an opake central spot.

31. Anastomosis of vessels from surrounding trunks running towards the congested spot, which appears stippled or stellated.

Days.

35. Appearance of gap or break in a trunk, as in 18 and 28; anastomosing vessels surrounding it.

36. Very extensive clot; injury more severe.

37. Faint appearance of lymph particles in the blank space corresponding to injury; free anastomosis of vessels around it.

39. Small remnant of clot; surrounding vessels gorged and tortuous.

41. Blank space; fine hair vessels converging to it from all sides.

42. Idem; small semi-transparent particles grouped in heaps and chains; fibrinous deposits.

44. Trunk divided, as in 35; beautiful exhibition of new vessels and dilated capillaries around it.

45. Central spot opake; its particles more conspicuous.

47, 48. Idem.

50. Pigment deficient; no other vestige; but vessels have a forked arrangement toward the opake spot.

51. Vessels run across opake spot from its circumference.

52. Anastomosis of new vessels advanced, but imperfect; hair-like conjunctions of new vessels in circles and chains of unequal diameter; globules of blood in the new vessels very apparent under a high power.

6th Series.—*Burn with actual Cautery.*

Days.

1. Cauterized or shrivelled appearance of opake spot.
2. Demarcation of shrivelled opake circle; small extravasation on margin.
3. Carbonaceous mass in opake centre.
4. Condensed extravasation at the line of demarcation, and cupped or raised margin of dead portion.
7. Circle of extravasation spots; absorption commencing; lymph globules filling injured space.
9. Faint appearance; small extravasations from surrounding vessels.
11. Delicate dots of coagula, marking absorption in progress? charred vessel crossing.
13. Idem, and turgescence of neighbouring vessels.
15. Star-like circle of congestion; vessels emerging to all points of the circle from the nearest branches of the uninjured web.
18. Clot absorbing.
20. Idem.
24. Coagulum thinning; surrounding vascularity increased.
26. Faint vestige of coagulum.
28. Carbonaceous spots intermixed with particles of lymph; no clot.
35. Injection of cicatrix by fine new vessels in loops and forks from the proximate branches.
36. Contracted cicatrix; vessels organizing lymph; remnants of coagula interspersed.

Days.

40. Organization advanced; small coagulum and cicatrix; new vessels carrying blood discs through it.

45. Beautiful specimen of vascularization; new vessels running at right angles, chiefly from those in neighbourhood to seat of injury.

48. Opake central spot of colourless lymph; fine vessels directed to it from all points of circumference.

52. Finished process.

56. Idem; appearance of pigment spots in and around cicatrix.

60. New semi-tinted vessels permeating cicatrix.

70. Faint vestiges of extravasation from more extensive injury, though small and finished cicatrix.

77, 86. Faint trace of cicatrix.

110. Anastomosis of light-coloured vessels; organization complete.

118, 126. Idem.

SUMMARY OF APPEARANCES PRESENTED BY THE ABOVE SERIES OF DRIED PREPARATIONS.

1st and 2nd Series.

Stage.

1st. Retraction; relative dislocation of divided ends of vessels; coagulum of extravasation more or less; surrounding congestion.

2nd. Appearances of absorbing clot; anastomosis of original vessels around the wound.

3rd. Deposits of semi-transparent fibrinous or lymph globules, commencing at the margin and thence occupying the area of the wound, which appears shrunk or contracted in diameter.

4th. Appearance of new and very delicate transparent striæ on the margin of the wound.

5th. Conspicuousness of new vessels, becoming tinted, presenting the appearance of loops or arches from the original vessels, and converging from the circumference to the centre.

6th. Vascularity of the cicatrized spot; blood discs visible in the new vessels, which freely anastomose with each other.

3rd Series.

1st. Gaping of wound, oval-shaped, surrounding congestion; coagulum of extravasation more or less; unequal retraction of marginal line.

Stage.

2nd. Marginal layers condensed and rounded off; lymph globules deposited there, and presently occupying the place of the wound; stellæ of new vascular formations here and there.

3rd. New and very fine vessels striking into the lymph deposits from all points of the margin.

4th. Vessels become more conspicuous, looped or arched toward the centre.

5th. Vascularity of cicatrix, and its diminution compared with original wound; free anastomosis of the new vessels.

4th Series.

1st. Circular area of wound; surrounding congestion; unequal retraction of marginal layers, which become raised and rounded.

2nd. Increased vascularity of neighbourhood; marginal production of colourless lymph gradually extending to the centre, thus contracting area of wound; here and there spots or masses of congestion.

3rd. Apparent diminution of lymph border by encroachment of fine shoots from the nearest vessels, forming arches parallel to the border of wound.

4th. Lymph globules abundant and colourless filling the wound, having a fine granular appearance; stars of vascularization intermingled with them.

Stage.

5th. New vessels passing from the margin, and convergent to the centre; their arrangement in loops, and anastomosis; faint tint of colour; complete organization.

6th. Dwindling and disappearance of cicatrix.

5th Series.

1st. Ecchymosis, with variable vascularity of surrounding web; occasionally ruptured blood-vessels.

2nd. Progressive absorption or clearing of wound, and synchronous appearance of lymph globules in opake central spot corresponding to injury.

3rd. Anastomosis of vessels around the opake centre, and small vascular heaps and masses intermingled with lymph particles.

4th. Appearance of new and delicate vessels in arches and forks traversing and anastomosing upon the site of the wound.

5th. Blood discs in new vessels; circulation completely restored.

6th Series.

1st. Similar appearances; the carbonaceous spot mingled with the coagula of extravasation, indicating the slough; this, by the absorbing process, becomes gradually circumscribed and uniformly opake.

Stage.

2nd. Organization so blended with the process of clearing as almost to convey the impression that the new deposit was but the fibrine of the clot deprived of its colouring matter, owing to the vascularization commenced and advancing during the absorption of hematosine, and obscured by the latter.

3rd. Ultimate opake spot of colourless lymph traversed by new vessels of anastomosis derived from all points of circumference; organization complete.

4th. Faint trace of cicatrix.

CHAPTER VIII.

OF GRANULATIONS AND PUS: SUPPURATIVE INFLAMMATION.

The second or advanced stage of adhesive inflammation provides repair not only for solution of continuity but for loss of substance. This consists in the formation of granulations or small eminences, into which the lymph pellicle, common to all wounds, is elevated, so organized as to constitute a temporary or occasional apparatus for the secretion of pus. The granulation is a mesh of the terminal loops of capillary pencils, formed, as has been described, under the adhesive inflammation, in the newly-deposited fibrinous membrane coating the surface of the breach or cavity in the original solid. The figure and colour of the granulation are determined by the state of its circulation; where that is feeble or oppressed, and inclined to stagnate, the granulation is broad, flat and spongy, and either pale or of a livid

purple hue; where, on the contrary, it is vigorous, the granulation is conical or acuminated, and of a bright and florid tint. The aspect of the suppurating membrane also varies to such extent as scarcely to exhibit, in some circumstances and situations, the granular form, *e. g.* upon the walls of abscesses and upon the free surfaces of mucous and serous membranes; but the fibrinous bed and the capillary loop of new formation, and a corresponding alteration of the pus-secreting surface from its normal state will always be detected upon careful examination, being essential elements of the suppurative process. The product of granulations is a yellow, unctuous, inodorous fluid of a cream consistence, which is necessary to their function, and not less to their existence, until the purpose of their formation, viz. their coalition and levelling, is accomplished by the free anastomosis of their proper vessels; and the new substance, be it skin, muscle, membrane, or bone, is perfected. The granulation is hollow or cellular when first produced, and the secretion of pus within it is progressively substituted by the secretion of the material required, which gives it the permanent figure of the new solid; the pus always diminishing in proportion as organization proceeds, until the secretion of pus ceases altogether, and the granulation properly so called disappears.

Pus is said by some physiologists to be simply the decolorized particles of the blood denuded of their external coat, notwithstanding that the pus particles are larger than those of the blood, and the figure of the blood particle is uniform, while that of the pus globule is infinitely irregular. In truth there is no analogy between them. Other physiologists consider pus as a morbific matter, and the suppurative process as established for the purpose of delivering the system from its noxious agency. According to the same authorities, not only is matter presenting the characters of pus secreted by free and entire surfaces, as of the bronchi and blood-vessels, but detached coagula of blood in the heart, lungs, liver and blood-vessels are met with containing isolated deposits of pus, where no inflammation affects the organ or the neighbourhood, and in some instances, when it is not elsewhere present in the system.

I do not believe that the fluid which we see formed by the granulating surfaces of abscess and ulcer in one case, and by the inflamed mucous and serous surfaces in another, the adventitious and the proper laboratory being in reality of very similar construction, varies in any material degree. The mucus of the nares, the larynx, the conjunctiva, the intestinal tube, and the bladder,

may be suspended and substituted in inflammation by a purulent fluid, identical, so far as its appearances and properties are detectable, with the matter of abscess and granulation; but I challenge the proof that this fluid is a transfiguration of the mucus or of the blood particle or the broken down solid, the change taking place within or without the vessel. How appearances may be explained which give countenance to this hypothesis I pretend not to say, but it is probable that the mind of the observer partakes of the optical illusion, for the explanations offered to reconcile difficulties are additional complications of the problem, at which our natural sense revolts.

Pus may be present without granulations proper, as on inflamed follicular surfaces; but as regards granulations the converse does not hold. The varieties of pus, according to the health or otherwise of the secreting surface, whether original or new structure, are marked by its consistence, colour, odour, &c. Among these is its admixture with the colouring matter of the blood, sanious or bloody pus, and which is evidently depending on a diseased state of the secreting organ, allowing of the admixture of the two fluids by which the homogeneity and properties of pus are destroyed; as in the case of sanious milk, semen, or urine, with

which fluids it ranks equally as a vital secretion, *i. e.* as the product of a vital chemistry incapable of being artificially performed. In no other sense than this, the capability of production by artificial means, can the term convertibleness be employed, a phenomenon at variance with all we know of the living animal machine and its economy. "*In nova mutatas dicere formas corpora,*" is the prerogative of the poet, not the physiologist, except in the sense of change through the medium of a vital action.

The blending of pus and mucus seen in bronchial inflammation and early phthisis, notwithstanding a certain resemblance between them and that transition state of the inflammation of mucous and other surfaces, which so blends the natural and morbid secretion as to have given origin to the phrases, puriform mucus, mucopurulent secretion, &c., are examples in like manner of the distinction really subsisting between these products and their absolute and respective inconvertibleness.

The material of all secretions must be derived from elementary ingredients of the blood, not at second hand, as by conversion of others, whether permanent or excrementitious. Every secretion presents the varieties of the organism to which it owes its origin, and especially those formed under the forced state of inflammation.

Hence the varieties which pus exhibits are at least as remarkable as those of the healthy secretions; the pus laudabile, as our forefathers called it, being neither the incipient nor the final state of the secretion, but the intermediate, when the organ is in its most perfect condition of development.

The difference between the exuded serum and pus is probably owing to the larger proportion of albumen contained in the latter; and upon microscopic examination, we find particles of size and figure resembling those of lymph, as seen in the disengaged fibrine both within and external to the vessels during inflammation; or as shown by passing the liquor sanguinis, in Muller's experiment, through a sieve.

Is pus ever unpreceded or unattended by inflammation? I cannot say that I ever met with pus in such circumstances. Collections of pus in all states, where inflammation has passed away and left its vestiges, in altered or adventitious structure, are familiar to us. Does any practical man recognise its appearance independent of such vestiges, in the absence of active inflammation? If not present, there are other and signal indications that it has been, even if the history were silent.

Is pus ever produced unpreceded by adhesive inflam-

mation, as it is shown in a separation of fibrine from the blood? If upon careful inspection of the free surface of mucous membrane secreting pus no appearance exactly resembling granulation can be observed, the membrane is altered, *i. e.* raised and thickened by a deposit of hyper-vascular lymph in the interstitial or subjacent tissue; and so of serous and other membranes. In the suppuration produced by unorganizable or disorganized matters, such signs are never wanting, as the newly-organized secreting surface which lines the cavity or abscess, and fortunately seals the mouths of severed blood-vessels.

Does abscess of the lymphatic glands, the liver, the testicle, nay, the brain, ever exist without such a lining membrane? Do we call to mind a fresh wound which has suppurated, or an ulcer, new or ancient, without such a provision? for this, I am quite aware, does not always present the structure of perfect granulation. The circumstances which especially determine the formation of granulation we shall consider in another place.

The suppuration in diffused cellular inflammation, the suppuration in cold abscesses, "abscès froids," after typhus fever, and other cases of constitutional exhaustion, as especially erysipelas and animal poisons, are the cases which appear to authorise the belief that pus may be

formed independent of adhesive inflammation. But it is my belief that in these cases the effused fibrine dies before its organization is accomplished, as granulations perish in certain ulcers; the vitality of the blood is so low as to render it unfit in quality for organization, or the circulation is so feeble as to be incapable of organizing the deposit; and thus the adhesive process is either imperfectly performed, or is destroyed by the counteraction of ulceration, or by gangrene. The case is equivalent to that of ulcer in which granulation is wanting and cannot be produced, or if produced, maintained, owing to the preponderance of the absorbent over the depositing action, or the failure of all action. And in confirmation of this opinion are the sweeping extent and devastation of these abscesses, the bad quality and early decomposition of the pus they secrete, the frequent escape and admixture with it of blood and of gas, and the enormous sloughs of cellular membrane and fibrinous deposits by which they are accompanied. It is therefore no pathological exception, unless indeed an exception establishing the rule, since the same order of actions is preserved, but the constructive are cut short or overpowered by the destructive, from the diseased state of the blood and of the general habit.

Pus, then, is always an inflammatory product: in its

healthiest condition it is elaborated by its special structure, the granulation gland; and when this is wanting, the secreting surface, if entire, is such, or so altered, as to be subservient to the same end, or a substitute for the proper granulation structure.

The purpose which the formation of pus serves in the economy is, in conjunction with another act of inflammation, to open a communication with a contiguous surface, either for the purpose of liberating matter incapable of organization, and therefore superfluous or hurtful; or as indispensable to reconstruction, or the effacement of lesions by granulation, the second or advanced stage of adhesive inflammation. By this I mean to imply that granulation, being a glandular organ, is, like other such structures, incapable of carrying out its purpose without the due performance of its function. If not so entertained, it perishes by reason of its fragile and temporary construction; if its secretion be vitiated (the common ground of the several varieties of ulcer), it cannot be a basis of new structure; at least of a healthy and permanent solid, and it is only by the maintenance of a healthy secretion that it can be maintained, until its secretory apparatus is obliterated by its identification with surrounding structure. The gradual diminution in quantity and alteration in quality of

pus, accompanying the contraction of granulation up to the period of cicatrization, is one of the most beautiful harmonies in pathology; and where we have the opportunity, as in the formation of ulcer, of witnessing the development of the process, the change, *e converso*, from its nascent to its matured state, is not less striking and conclusive.

The phenomenon of late years brought under the notice of pathologists, of what are called secondary deposits, and of which I have seen many examples, require only to be so far referred to here, as the question, whether inflammation be indispensable to the production of pus, bears upon such cases. I consider them to form no exception to the universality of this law, and consequently repudiate the accounts of insulated deposits, unless in cases of admixture of pus with deposits of fibrine and coagula of blood, as in inflammation of veins, which I have seen both in the human subject and in animals, the subjects of experiment.

In the substance of the lungs, the heart, the liver, and the spleen, pus is only seen in company with fibrinous deposits, unless this be previously destroyed, as in the spontaneous opening of abscess or diffused suppuration, by the advanced stage of ulceration, in common with original structure. Further, I am disposed to be-

lieve that lymph deposits presenting the same tint of colour, and often scarce varying in consistence, are sometimes set down as purulent when no pus is present. Soft yellowish-white and amber-coloured lymph, in flakes and drops, in various organs, is very easily mistaken for pus, as I have had abundant occasion to notice. The theory of the consentaneous or consecutive occurrence of these deposits of lymph, and abscesses in parts remote from the seat of inflammation, is a distinct question, and to be so treated.

Suppuration, therefore, I regard as the necessary consequence of an interrupted or incompetent adhesive action, whether occasioned by loss of substance, by the irritation of a foreign body, or by effusion of blood or lymph in an unorganizable form and quantity; by a morbid structure, by an obstruction to outlets or canals, or by such violence done to the texture of parts as disqualifies them for the simple adhesive process, and demands other modes or terminations of inflammatory action, as ulceration or gangrene.

The removal of a part by operation to such extent as completely to dissolve continuity; the formation of phlegmonous abscess, and of abscess imbedding foreign bodies; hard tumors, strictured outlets, and complicated injuries, as gunshot and other wounds, or bad com-

pound fractures, are all familiar examples of the incitements to suppuration; of its necessity, owing to the incompetency of the first, or simple adhesive action, and its efficiency by the second, viz. granulation, which is the organ of purulent secretion and of repair.

The form of granulation, as of all deposits, depends on the modelling action of absorbents; while the frequent, rapid, and various changes of the figure and surface of ulcers, and the contrary condition demonstrate the activity or indolence of these vessels. It is upon the accurate balance between the capillaries, arterial and venous, that the passive nourishment of the organizable lymph depends, and upon the due proportion of the absorbent depend not only form and growth, but its very existence. Indeterminate or chaotic deposition obtains until the part is furnished with this important element of organization; and an appearance of uniformity and adaptation is a sure proof of its existence and efficiency.

The sensibility of the lymph deposit is likewise evinced by its respondency to external agents, beneficial or noxious, soothing or irritating, as well as to the vital power of the system, both of which influences are marked in its subjection to the impressions and sympathies proper to the nervous system. Thus form,

growth, function, and the self-preserving principle are derived from the union of these systems in the organization of the new deposits; and they are equally indispensable.

Whether the act of absorption is performed by lymphatic vessels exclusively, or in part by veins; whether it is accomplished by imbibition, as of pores or mouths, or by a chemico-physical and vital transudation through the coats of the vessels, endosmose and exosmose, remains a question, like that of the circulating forces, *sub judice*; and to this may be added the question, touching the power of the absorbent vessels to remove parts not previously prepared by a softening or solvent process, which belongs to the subject of ulcerative inflammation; but a solution of these arcana is not necessary to the conclusions above stated.

The uniform figure and disposition of granulation being immediately subservient and preparatory to the process of cicatrization, is only met with when seen in connection with the surface; but organized lymph under every variety of arrangement, is the secreting organ of pus, if pus be present. In a very large proportion of cases a broken surface has preceded the formation of pus; the effusion of adhesive matter, organizable fibrine, is inseparable from lesion, if preceded

or followed by inflammation, as in the healthy body is invariable; and in cases where no breach can be discovered upon a suppurating surface, evidence is not wanting of the presence of adhesive inflammation, in the altered condition of that surface.

Thus in all cases, whether the formative apparatus be simple or complex, whether quickly perishing from defect of constitutional power, subverted by a destructive action, or capable of resisting destruction and undergoing permanent organization and ultimate connexion with the solid fabric of the body, the formation of pus is subsequent to the adhesive inflammation, and the secreting surface has undergone the adhesive change.

The cavity formed by introduction of a foreign substance becomes coated by a pellicle of lymph, which suppurates; the death of a portion of the cellular substance or of a portion of bone presents the same order of changes; and in the formation of primary abscess, the deposit into and around the cells of the inflamed membrane, of which the texture is condensed and spoiled, renders it, like the foreign body, the irritant to suppuration. Even the presence of pus operates, by the stimulus of distension, to increase the secretion, and the gradual changes of quantity, consistence, and colour which it undergoes are signs

of its more and more perfect elaboration, and inversely, when the action is subsiding, of its cessation. These, and its vitiation by various morbid states of the system,—by the admixture with it of air, blood, disorganized matters, as dead lymph, sloughs of cellular membrane, portions of decayed muscle and bone, the debris of ulcerative action, and the various excreted fluids,—are sufficient to show that pus is as much an unique and original composition as bile or urine, and not a metamorphosis of the blood, or of any special product, solid or fluid, although, like every other secretion, derived from the constituent or elementary ingredients of that fluid.

ABSCESS.

The continuance of inflammation beyond the term required for union in simple solutions of continuity, in cases which are beyond reparation by the direct adhesive process, and in phlegmon or adhesive deposit unaccompanied by external lesion, entails an addition of the suppurative to the adhesive action. This is announced by a more or less defined swelling, a sensation of acute throbbing pain, and a pink blush upon the raised and stretched teguments. The swelling, firm at its base and softer toward the centre, gradually assuming a conical form, indicates an increasing elasticity, and at length the pre-

sence of a fluid undulating or fluctuating between the fingers applied to its opposite sides. By a process of thinning, hereafter to be described, the contained fluid approaches and at length reaches the surface; the darker or more livid tint, the excentric "rides" of the surrounding skin, and the cracking and peeling of the apex announce the yielding of the integument. The cavity, so formed, is surrounded by an effusion and lined by a pellicle of lymph (pyogenic membrane), whence the pus is furnished. The abscess, having discharged its contents, may terminate in gradual contraction and obliteration of the cavity by the adhesive process, now capable of concluding the action; or being, on the contrary, exposed and extended by ulcerative inflammation of its anterior wall, it may be converted into ulcer. A section of an abscess from circumference to centre presents the condensation of the wall by the deposit occupying the cells of the cellular membrane, the secreting membrane, the semi-solid flakes of lymph, and the collection of pus forming its contents; the arrangement, appearance and proportion of each varying according to the stage of the suppuration.

The act of suppuration is often productive of fever, where the action has appeared to be strictly local. The pain attending it is peculiar, and modified by the acute-

ness of the inflammation, the rapidity and extent of the suppuration, and especially its seat. In a loose unresisting texture it is least painful, indeed is often accidentally discovered; in a firm resisting texture the patient's suffering is most severe, and the nervous system sometimes becomes excited and prostrated to an alarming degree. The sympathetic inflammatory fever announces itself by rigors in the setting-in of the suppurative action, provided its extent and situation be such as to produce fever, or that a febrile disposition be present. The fever subsides on the free discharge of the abscess, if it be attended by no other malady.

The furuncle, or skin abscess, is a miniature of the phlegmon, viz. diffused thickening, reddening, pointing in the centre, and pus seen beneath the transparent cuticle, supported by the viscid and indurated secretion of an obstructed follicle, imbedded in the lymph effused prior to the change of the vessels for pus. Glandular abscesses contain an intermixture of detached masses and flakes of lymph, with pus varying in consistence and quantity according to the strength of the suppurative action: in scrofula this admixture is characteristic, and it is called "imperfect or ill-digested" pus; it undergoes, however, no improvement in quality by time.

In the parenchyma of visceral organs, the same rela-

tion of semi-solid lymph and pus, the former being the nucleus or bed of the abscess, and both contained within an adventitious membrane, which is the secreting cyst, is found invariably. In emptying an abscess, the orifice, if not free, is now and then choked by the wedging of the lymph masses, or the sloughs of spoiled cellular membrane. By the covering layer of membranous fibrine forming the sac or cyst, and its organization prior to the suppurative action, the surrounding structures and chambers are protected, and hæmorrhage is prevented. In certain cases this preliminary adhesive process is supposed to be wanting, as in the diffused suppurations of erysipelas. I have already explained that I believe it has in such cases partaken of the general dissoluteness and loss of vital tone which the system exhibits, and has perished with the structure in which it was deposited, for the entire cellular membrane infiltrated with pus and completely disorganized, separates sooner or later, *en masse*. Solids and fluids, original and recent structures, involved in the suppuration, share the same fate. But although masses of dead lymph are abundant in these collections, hæmorrhage is equally provided against, proving the preliminary adhesive action to have sealed the contiguous blood-vessels. If exceptions occur, they are rare.

To conclude, suppuration must be regarded as a process consecutive upon the adhesive, and equally indispensable for the purpose required, when the first is inadequate. But the two would be still incompetent without further aid. The temporary provision of a secreting structure, which may repair a breach or promote the discharge of a foreign body by conducting it to the nearest surface, requires the addition of an apparatus for the removal of parts that are obstructive or useless, and the adaptation and adjustment of the new texture to the breach.

CHAPTER IX.

PERIODICAL PHENOMENA OF WOUNDS, ILLUSTRATING THE PROGRESSIVE STAGES OF THE HEALING PROCESS. RECENT APPEARANCES.

The repeated examination of Dr. Todd's cabinet, while it developed some very interesting facts and analogies, from the want of all record beyond the name and date of the injury, left a strong desire in my mind to repeat the experiments on the more useful plan of permitting the animals to live, that I might witness the stages of the healing process until it was perfected in the same individuals. To secure the truthfulness, which only a practised anatomical microscopist can command, I obtained the assistance of Mr. John Quekett, one of the students of the College of Surgeons, a gentleman universally allowed to stand as high as any living authority in this department, to which the labours of his student-

ship bear abundant and highly interesting testimony. I take the present opportunity of publicly expressing my obligations to Mr. Quekett for his zealous and valuable assistance in conducting these experiments.

EXPERIMENTS, SUMMER 1841: APPEARANCES TO THE 11TH DAY.

Puncture with an instrument of a triangular shape.

Days.

2. Perfect and extensive stagnation; coloured margin of wound; partial extravasation.

   Another, smaller and round; small clot; wound contracted, so as to be scarcely visible, but adjacent circulation stagnant; active at a smaller distance than the first.

4. More appearance of effusion; angles of wound more raised and rounded; no contiguous circulation.

7. Marginal deposit of lymph narrowing the wound; surrounding circulation stagnant.

11. Slight appearance of lymph globules in the deposit; no circulation on the borders, which are more rounded off.

Incised wound with a lancet.

2. Extravasation margining the wound. Complete stagnation of circulation.

Days.

4. Stagnation extending to the large vessels in the vicinity of wound.
7. Idem: small indication of injury besides.
11. No circulation in immediate neighbourhood of wound, now more conspicuous from the deposit of lymph which occupies its place.

Lacerated and contused wound by a sharp blow with a blunt body.

2. Clots of extravasation or ecchymosis on angles and borders of wound; no surrounding circulation.
4. Idem. Appearance of stagnant blood distending a large vessel passing nearly round the lacerated edge.
7. Wound has a more defined smoothed edge; slow circulation commencing in its vicinity.
11. Much exudation and congestion in the neighbourhood, and highly injected capillaries; but no trace of circulation.

Actual cautery, or heated iron.

2. Discoloration, opacity and stagnation of surrounding blood-vessels, which are gorged.
4. Blood still stagnant; margin of burn somewhat less opake.
7. No circulation, but distinct demarcation of injury by a lightly-coloured margin.
11. Found dead.

Another example; oval piece burnt out.

Days.

4. Extravasation surrounding the wound, and complete arrest of the adjacent vessels, but circulation active at the further margin of web.

Web divided between the toes.

2. Rounded margin; perfect stasis.
4. Angle more rounded and somewhat opake; no visible circulation near the injury.
7. Idem.
11. Circulation stagnant as before; margin of wound more rounded, and angle becoming obliterated.

EXPERIMENTS, AUTUMN 1841: APPEARANCES TO 20TH AND 41ST DAYS.

Excision of a circular portion of Web of the Frog's foot.

1. Congestion and perfect stasis of the circulation for a considerable space around the wound; beyond this the circulation slow and in jerks.
2. The same; the border raised, opake, and smoothed by a deposit of lymph.
4. Circulation still stagnant; border more rounded; appearance of a small effusion.
7. Stasis perfect; small effusion; the margin, opake and rounded off, encroaches upon the area of the wound.

Days.

11. Appearance of globules in the lymph deposit; circulation in minute vessels nearer the margin; large vein remains turgid near the wound.

13. Stagnation in the immediate vicinity, but not extending to so great a distance as before, the web becoming more vascular.

15. Part more vascular; circulation nearer the more rounded edges of the wound; blood particles seen in the new matter of deposit in motion, but not in *visible* vessels; oscillating trains of blood globules in the lymph.

16. Circulation brisk to the edge of the wound, which is considerably narrowed by a layer of opake lymph of equal diameter; general surrounding vascularity increased.

17. Circulation reaches nearer the edge of the wound, which becomes thicker and more rounded, but the motion of the particles previously described, as seen in the new deposit, is not observable.

19. No trace of circulation in the new matter, nor of the particles before mentioned; the capillaries more dilated, and the small insular spots of congestion disappearing. This sudden arrest of the changes in progress was referrible to the languor of the circulation, for on the 20th the animal was found dead.

Note on the above.—The 16th day presented a beautiful view of the circulation restored since the 14th up

to the margin of wound; two days afterwards it was stagnant. "The lymph deposit projects equally all round; the surrounding arterial circulation very bright, and forming an arcus of anastomosis around and beyond the deposit, which is smooth and opake; the whole web much injected; the dense and raised deposit of lymph within the line of section reduces the diameter of the wound nearly one-third. The deposit is as yet colourless, but evidently continues to encroach upon, until it fills the void space of the wound; while the circulation keeps advancing in the rear of it, till the vessels so approximate as to anastomose in all directions."

Excision repeated.

Days.

2 and 4. Circulation stagnant; no extravasation; edge of the wound opake and rounded.

5. New matter deposited at the margin; circulation stagnant.

8. Circulation approaching the margin.

10. Margin more rounded; circulation still stagnant around the wound.

11. Parts more vascular, *i. e.* the capillaries visibly injected, and with more blood than usual.

14. Margin of wound still void of circulation; the blood corpuscles becoming more numerous in the capillaries, and giving them a slight red hue.

Days.

15. Oscillatory movement of blood discs seen in the margin of the wound.

18. The animal was this morning found inclosed in a block of ice; circulation very languid; the lymph margin of the wound still much in advance of the blood-vessels; the oscillatory movement of the corpuscles, in lines adjoining the wound, conspicuous, where no blood-vessel is seen.

19. No difference in appearance; the same oscillatory movement of blood discs in *invisible* vessels very evident in the close vicinity of the wound.

21. In addition, vessels appeared in places perfect, but empty, when every now and then a blood disc traversed them with great rapidity; coloured circulation approaches nearer the margin; some globules are seen evidently differing from the blood globule.

22. Oscillation very marked; gap of the wound much diminished in size, although no circulation or movement of any kind at the extreme margin.

23. Oscillation beautifully distinct; in some large trunks globules were again seen much larger than the red discs, and of a pale yellow hue; these were often stationary, single or in clusters; now and then driven on by the current, then again stopped, and then passed into smaller vessels. They appeared perfectly round, not discoid, and not miscible with the red particles.

Days.

25. Circulation on one border of the wound is perfectly established; vessels large, containing numerous red discs, but the movement slow. The lymph particles very numerous in some trunks, and when viewed with a 1-8th object-glass, were found to contain several small granules in their interior.

27. Circulation perfect on one border; the new vessels looked like veins, from their size, the slow movement of the blood column, and their dark colour from the number of the red discs contained in them. The large globules at first very visible had nearly all disappeared a quarter of an hour after the examination commenced, but soon afterwards began to reappear.

28. Circulation nearly complete upon the entire margin; the vessels being large and full of blood discs, gave a very deep red colour, the movement in them was much slower than in the neighbouring trunks. One continued line of red globules seen at one angle of the wound having an oscillatory movement, evidently a new vessel about to be formed; numerous globular bodies seen in the surrounding vessels and in those of the new deposits, all of which last had the form of arches of different curves.

29. Circulation fully established in the new vessel mentioned, as seen in the act of formation yester-

Days.

day. A slight oscillatory movement was seen in another part of the margin, and by watching it attentively for some time, the circulation was found to be nearly established while the observation was being carried on. Connected with this was another vessel, which was only recognized by a slight see-saw movement of the discs; so that the former, it is probable, would soon become a trunk carrying the circulation.

31. Circulation fully established in the vessel mentioned in last report, and connected with it were other new loops in different stages of formation, *i. e.* circulation; the whole margin was now completely supplied with new vessels, excepting one angle, and here the fingitive process was going on. During the formation of the new vessels the diameter of the wound does not appear to have been much diminished.

33. Wound now much diminished; the blood discs pale coloured; numerous particles of lymph, as before described, seen in the vessels in the immediate vicinity of the wound.

34. Web of this foot swollen, and appeared dropsical as compared with its fellow, which accounts for the pallid appearance of the discs in the vessels; a few lymph particles seen on the margin of the wound.

Days.

35. Wound much diminished; not so vascular at the ends or angles as at the sides.

36. Wound nearly filled up, only a small slit-like aperture left, the margins being closely approximated; between them a motion seen of exceedingly minute particles, like those contained in the large lymph globules; and on the edge many of the larger or lymph globules aggregated in masses, and some few detached; an appearance of puckering or drawing in of the wound at both ends of the narrow slit, like a cicatrix. From the swollen state of the web the parts appeared less vascular than a week before.

38. Wound now entirely filled; few lymph particles in circulation; numerous vessels full of red blood on all sides of wound; at the ends an aggregation of red discs or corpuscles, from which it appeared as if new vessels were springing. Some discs that escaped from the web on to the glass became beaded on coagulation, like the human.

40. Part excessively swollen; vessels in neighbourhood of cicatrix very large and clogged with blood; the cuticle has grown over the surface since last report; its nucleated cells distinct and beautifully displayed. The aggregations of red discs before spoken of still seen, and the part of the

Days.

wound last healed in their vicinity was seen to be composed of the lymph particles closely packed together; only a small trunk or two in the vicinity of the cicatrix showed any sign of circulation or motion.

41. Animal exhausted; very languid circulation.
42. Found dead.

Observations on the foregoing Experiment.

This experiment gave the same result of stagnation for the first fourteen days, when the circulation became visible on the outer border of the lymph margining the wound, or at a small distance from its sharp edge. The motion was slow; the coloured vessels appeared to be veins. The surrounding vessels were injected and active, arteries especially; the area of the wound was contracted, and the lymph finely bevelled down to it.

21st Day.—An oscillating or see-saw movement of the blood-discs was remarked in the lymph adjoining and parallel to the border of the wound; the globules were in single file, working backward and forward, evidently from some communicated impulse of the circulation; but there was no visible appearance of a vessel where this process, which was obviously progressive,

was seen. In other parts single globules were shot, one after another, at irregular intervals, from vessel to vessel, across the interspace, like balls from cannon; both orders being yet colourless, but distinct arterial tracks. The round detached globules, more numerous and larger, and of a totally different figure from blood particles, lying in the veins single, or in glomera, every now and then carried, or rather swept on by the stream of circulation, and again remaining stationary, the current passing over and beside them. They were seen only in the track of the vessels, which appeared, until they moved with the circulation, as if lying more superficially.

27th Day.—The formation of vessels, by insulated blood globules running in a course one after another, just as drops of rain follow each other down a pane of glass, and thus going from one colourless vessel to another, sometimes direct, sometimes serpentine or tortuous, until they struck each other and coalesced, was most curious and beautiful. This is going on in one part, and the preliminary oscillating action in another, the latter being the grooving or tunnelling of the lymph in its formation, the former the first opening of the vessel for circulation.

34th Day.—The vessels immediately adjoining the

wound, which had an oscillatory motion for the first ten minutes of the inspection, afterwards took up a slow but steady circulation, *i. e.* the particles passed in one direction. An intermediate condition to these states was observed, *i. e.* the streams going by a jet or with a pause, but not receding.

The new circulation presented colourless streams or currents of insulated globules proceeding to and from the coloured vessels in arches and loops, and at every variety of angle opening communications with each other. The large round particles of lymph were most abundant and conspicuous, some lying in masses or heaps, but all distinct; some insulated in the vessels, lying on their under surface or sides, and swept on by the current, seeming to oppose a resistance and not amalgamating with the blood discs, but presenting a remarkable contrast, being much larger, round and colourless, preserving figure, and stopping or sticking; the elliptical corpuscles, coloured or tinted, running by or over them in regular streams, and often passing with more or less celerity through the vessel in single file. What are these bodies, seen only in the original vessels? dots under a high power are visible in them, as if compounded of smaller; they are not visible in the new vessels, but retain their size, figure and number

during the actual filling of the wound from the twenty-first day onward, and when healing is perfected they are no longer seen. They must be the fibrine separated under inflammation, and afterwards seen occupying the margin and bed of the wound; they do not coalesce, nor seem to belong in any way to the circulating blood, except as being moved onward by its current; they are the new deposit being carried to its destination, (the bricks of the building,) their separation continuing till the deposit is complete, and no more required. The blood discs alone form the vessels deriving their impulse from the restored circulation. Whence are these particles derived? I think the adhesive process, direct and by granulation, consists in their separation from the liquor sanguinis by an altered action in the next moving series, contingent and consequent upon the remora of the circulation, and that they are laid down on the margin of the wound in close contiguity by the capillaries, on the recovery of their action, to form the new solid or intermedium.

41st Day.—The wound quite healed; the whole bed is of small granules of lymph; the margin retains its appearance, but the centre of the cicatrix much narrowed; no coloured circulation on the site of the wound, and little or no motion but on the borders, which is in

transparent vessels of anastomosis derived from the nearest coloured vessels, and passing in all directions from one to the other. The lymph particles in the vessels still seen in smaller number, sometimes stopping, sometimes carried along by the current.

EXPERIMENTS, SUMMER 1842: APPEARANCES TO 15TH DAY.

Exp. 1.—*Incised wound of the web's edge with Scissors, midway between toes.*

Days.

6. Circulation distant and languid; at margin and adjoining it perfectly stagnant; some vessels full of blood; margin looks thick and opake.
9. Circulation distant and languid; the lymph-bed broader at the margin.
13. Appearance of new vessels gorged with red blood and stagnant at margin of wound, and parallel to it; neighbouring circulation active.

Exp. 2 and 3.—*Large punched hole or excised portion of web by a blowpipe shortened.*

6. Margin of wound thickened and opake, and quite still; surrounding web smirched with lymph;

Days.

yellow smooth surface; small and oscillatory circulation at one angle of the wound; some large neighbouring vessels filled with coloured blood and perfectly stagnant. Second subject, same date, paler and more torpid circulation, otherwise similar appearances.

9. New vessels in vicinity of the lymph-bed at margin, of different size and anastomosing; some oscillatory trains, others with the particles wide apart. Second, as before, more torpid.

13. Addition to lymph border; very active small circulation in neighbourhood of wound; the new vessels close and parallel to the edge, and on the lymph-bed gorged with red blood to stagnation; evidently over dilated. Second subject, same appearance; circulation less active and general, but the red masses of new vessels, at and parallel to the edges, look like extravasations, from their engorgement and perfect stagnation.

15. The red tumid vessels margining the wound were now somewhat relieved of engorgement, in motions of oscillation and circulation, and in colour paler; lymph border extended.

16. A violent storm of thunder and lightning which did much mischief last night, (27th, 28th July). The three frogs found dead. I examined the dead wounds with a high power; the disposition of lymph particles in strata, like bricks in a wall, of

Days.

different sizes, smaller as they were nearer the edge, and seemingly fixed in and fastened like a mosaic pavement, most conspicuous and curious; web entirely bloodless.

Exp. 4.

20. I examined the same injury of another frog which had survived; it was of the same date with the three which were found dead on the 28th July. The appearances were as follow:—active circulation in new vessels to the outer margin of the lymph layer bordering the wound; a very great number of the isolated round particles of lymph in the circulating vessels, not forming part of the current, nor blended with the blood, but stationary, either single or in groups, then carried on from time to time in vessels which have the appearance of veins: again, these or similar particles accumulated at the outer edge of the wound permanently at rest and disposed in rows forming the new lymph-bed of organization. The blood disc, quite unlike them in size and figure, is in some parts passing in single file, in others apart, and at intervals followed by another and then another, one coursing the track of the other, sometimes with great velocity, sometimes abruptly stopped in its course and slowly work-

Days.

ing on till an accumulation which, assuming a deep red colour, gives the heap the appearance of extravasation. The stage of oscillation, or creation of new vessels, appears past or suspended, the vessels of much smaller diameter than when it existed, and very slightly if at all tinted. The greater number are brisk and uninterrupted in their currents. The organization is at the outer margin of the deposit; upon the inner, which is in advance, and without vessels, the lymph granules are smallest and most numerous.

Several experiments of October and November 1842, amplify and confirm the observations of last autumn, the progressive changes being slower than in summer. Up to (about) the 14th day the stasis adjoining the wound continues; then oscillation, and labouring, slow circulation in the trunks of the original vessels lying nearest to the opake raised circumference of the wound, which has a thin transparent edge, and remains of the original dimensions; this action becoming gradually increased towards the wound until the circulation is re-established.

Then new channels or courses, at first colourless, are opened in its immediate vicinity, as before described, by the intrusion of blood corpuscles, in single file, into the plasma forming the border of the wound; first, absolute congestion, next see-saw motion, while the general surrounding circulation has become stronger and more active, especially the arterial. This is the state of things in the third week: and the fourth presents an increase of deposit or margin, and likewise of the size and number of the new vessels under formation; and the completion of their circulation is marked by their enlargement, colour, and multiplied anastomoses with the trunks and with each other; the fingitive nisus continuing around the wound, and this sensibly, though not rapidly, diminishing its area. Next appear the lymph globules, single and in groups, yellow, small and round, standing at the angles of union, or on the sides of the original veins, and swept on by the central current from time to time. These become more conspicuous for their number in the fourth week. The superficial nuclei of the epithelium scales, marking the geometrical figure of the cells by their regular equidistant position, also appear in the fourth week. The intermediate channels, viz. the transparent capillaries, betwixt the coloured vessels (arteries and veins) are distinctly

seen in the fifth week; at first seeming to be tracks only, not tubes, and of insufficient size to admit a blood corpuscle, being of smaller diameter.

6th Week.—The general parallelism of large vessels (veins chiefly), new formed and turgid, to and adjoining the border of the wound, which is now reduced by a broad margin of opake lymph visible to the naked eye; the going off of new branches in loops from their convex side next the wound, and after short half circles re-entering the vessels from which they sprung, thus,  or joining the bifurcation of a trunk thus:  their gradual formation nearer and nearer to the wound, by oscillatory pushes in a marked line of succession of the blood corpuscles, without appearance of vessel or colour, are remarkable. Also, the intermixture of the lymph with the blood corpuscles, their amalgamation and circulation; the lymph particles not now insulated and stagnant at intervals, as before (a week ago), but still by their shape, and pale yellow colour and size, readily distinguishable.

7th Week.—The border of the wound of which the area of clear space is now reduced to half or less, is contracted and fixed at equidistant points of the circumference, presenting a hexagonal or octagonal figure; the extent of new deposit is marked by the pigmental

lines bounding the original texture; the epithelium nuclei are distinct to the margin of the wound, and presenting regular interspaces and symmetrical figured scales; large veins in full and free circulation are permeating the newly-deposited lymph, in lines more or less obliqued from the margin; no arteries are distinguishable here, but in the original surrounding texture they are acting vigorously, in opposite directions toward the margin. On the extreme edge of the deposit close to the wound, *i. e.* the most advanced of the new formation, lie small masses of coloured particles looking like extravasations; they are either motionless or making only small oscillatory wavings to and fro; intermediately their connection may be traced out with the capillaries at one or both extremities, so that the course and connection of the future anastomosis can be plainly seen; the already briskly-circulating loops and arches of communication of the new capillaries adjacent to these are very numerous and beautiful.

8th Week.—In the course of this week a most extraordinarily increased deposit has taken place, of countless granules of lymph, so opake as to require focussing the glass to see the vessels distinctly through them. The progress differs materially in different animals.

In one of great vigour, the reduction of the wound by an almost sudden deposit of lymph, is such as to leave it a very small aperture; in another this deposit has scarcely narrowed the original aperture. In a third the lymph margin of the wound, though considerable, is still transparent, the granules less obvious and the anastomotic circulation nearer to the border than in the stronger and more forward animal; in which the red masses adjoining the edge are motionless and resembling extravasations, but are evidently new vessels yet unfinished, into which one corpuscle at a time, adding to the heap, is seen escaping from a contiguous vein at an angle, whence the new channel is produced.

9th Week.—The wound covered some days past with opake lymph in the strongest animal, in two others is yet uncovered, but the orifice is small in one, a mere pinhole; in another puckered into an irregular slit, and in a fourth it is still large. The opake centre in the first is surrounded by turgid vessels in an irregular circle, no motion is seen in those most contiguous to the centre, even now, four days since the cicatrix was complete, but the lymph is considerably more opake. The surrounding circulation is very brisk; nearest the wound the veins are most conspicuous, all radiating or centrifugal from the cicatrix. At one or two points only can the

capillary arteries, which are nearly colourless, be detected from their opposite direction and different impulse, acting with great energy. The other specimens in which the wound is still existing present a similar appearance, and their central transparency renders the observations more easy and clear. The most remarkable fact is the shapeless turgidity and absolute stasis of the newest vessels, deeply coloured next the centre both of the wound and of the scar. Beyond this, oscillatory, or rather jerking and pausing movements, are observed, in which the corpuscles pass edgewise and single, or in files, with various degrees of propulsive force; also a very free anastomotic circulation in all the new venous ramuscules, and their ultimate communication with two, three or more large trunks lying slantwise, and receding from the wound. The impetuous dash of the colourless arterial capillary streams towards the wound or cicatrix, every here and there, seems to scatter the corpuscles in all directions. They are not traceable into the veins, nor seeming to have any direct communication. Nothing can be more opposed than their motion, direction and colour.

The perfect opake cicatrix is in one animal now covered with vessels, without any visible motion except at one or two points close adjoining the margin, and the near-

est to the venous currents, which are running in oblique and parallel lines around the cicatrix. This motion is a very slow and gentle one, with pauses, and only perceptible by looking for some time intently at the part. The new central vessels are turgid with red blood and motionless. The circulation is steady, not very brisk, and the anastomosis still in progress, as is seen by the oscillations of some intercommunicating currents. The arterial capillaries bringing the blood to the cicatrix, which is returned by the veins, are few and not vigorous in their action at the boundary line of the circulation; a little further from the cicatrix, *i. e.* on the sound web, the action of the vessels is very brisk. In the animals whose cicatrix is unfinished, a small pinhole aperture being left, the veins form an arcus anastomoticus; at a little distance from the border of the unvascularized deposit and completely surrounding it, new transparent channels are opening here and there into the lymph from the concavity of the arcus.

10th Week.—I examined the wounds of four animals, of the same date, but presenting different stages as markedly as if of different periods.

1. The perfected cicatrix had now very small central opacity, and the vascular organization was so nearly perfect as to render it chiefly distinguishable by the

dark greenish spots of the new pigment, corresponding to and defining accurately the extent of the original wound. The stagnant mesh of new vessels had opened into a minute and beautiful anastomotic circle in full activity. All patches resembling extravasations and arrests of circulation, complete or partial, had disappeared.

2. A second specimen had the orifice of the wound reduced to a pinhole so as to be filled by an air-bubble, the vessels coursing close to the opake marginal line, and as last described, forming a perfect and very active anastomotic circle. Scarcely any imperfection, *i. e.* obstruction, could be detected; loops and half circles of vessels presented their convexities to the lymph margin, and it looked as if a finished process, to the wound's edge.

3. A third had a somewhat larger aperture, and the vessels on the margin unequally advanced on the two sides; the oscillatory nisus was detected in the blood-distended capillaries here and there, and lost in the small red patches of unfinished vessels which were perfectly stagnant. The new transparent vessels were circulating blood corpuscles like chains of beads, with complete interspaces. The organization however was so far equal to the deposit, that the transparency was very little obscured.

4. A fourth had scarcely advanced beyond the commencement of the healing process, or the period of recovered action following the stasis. The aperture was almost of the size of the wound, but had a narrow opake shelf of lymph, and the circulation was not interrupted as yet by the stagnant red discs or germs of new vessels, the vascularization having to all appearance kept pace with the deposit, being close up to the border of the wound. It was evident that the healing process had been greatly retarded, and the effusion was scarcely advanced beyond the active anastomosing capillaries. A beautiful contrast of the arterial and venous circulation was seen at a small distance from the wound, the vessels lying side by side.

Second Report of 10th Week. The several stages of healing exemplified.—1. The complete cicatrix an opake spot, traversed centrally by a very turgid cluster of veins; circulation imperfectly visible under the higher power.

2. The smallest aperture with brisk circulation to the margin and all around, the disposition of the branches in loops; many transparent channels conveying currents of detached globules.

3. The larger aperture slit-like; close to the margin some oscillating vessels and jerking circulation.

4. Aperture very large, as if the deposit had scarcely diminished its area, yet the opake lymph-bed distinct, and circulation brisk at a distance from the margin.

11th Week.—1. Dense white opacity of the whole cicatrix; cluster of turgid veins; blood particles seemingly motionless in the centre.

2. Still small pinhole aperture; brisk circulation almost to the edge; anastomosing transparent loops convex to the margin, some complete, others only half formed, as if by the deficient impulse of the circulation in the vessel from which they are detached.

3. The aperture still irregular and stellated; the epithelium scales and nuclei beautifully exhibited on the margin of this and of all except the first, where they are hidden by the opacity. The vessels do not approach the margin so close as in 2, or on one side as on the other.

4. A broad border of lymph yet unvascularized.

Second Report of 11th Week.—1. Not examined, toes being ulcerated.

2. Orifice closed, but semi-transparent; vessels very active, and many so scantily filled as to circulate detached corpuscles, and these slowly and in all directions, sometimes side foremost, and rolling over or turning on

themselves at an angle of their course, or junction with another vessel.

3. A large outshed of lymph, and the irregular oval aperture extremely minute; the lymph particles (granulations) quite diverse from the epithelial scales and very conspicuous, being made more distinct by excluding the light from beneath the object-glass. These granules are of irregular figure and vary in size, but occupy the whole face of the deposit.

4. The forming of the new vessels by short anastomosing loops, many in progress, and many star-like masses of new vessels stagnant from over distension, are beautifully seen. These are much in advance, looking at first as if detached from the circulating veins which are further from the margin, but all are traceable to them by transparent channels, which admit one or more globules from time to time to add to the heap. The lymph-bed is now so extended and opake as considerably to narrow the wound, and the granules are as close packed as the stones of a pavement.

12th Week.—1. Small opake spot divested of pigment, surrounding loops numerous and active, and no congestion.

2. Small slit-shaped cicatrix; large vein lying parallel to and beside it; lymph granules abundant; cir-

culation close up and uniform; that is, no pause or congestion.

3. Wound unhealed but small, the lymph granules lying all around, shortening its angles and crossing the aperture at one-third of its length; loops of new vessels at some distance; congested channels and transparent striæ produced from their convexity towards the wound.

4. Large aperture; vessels nevertheless active on the margin; lymph granules in their interstices; numerous coloured masses in oscillation, and gradually dispersing by circulation.

13th Week.—1. Cicatrix only recognized by opake spot, delicate vessels passing across and anastomosing over it.

2. Very small vestige of puckered scar; vessels mapping the opake spot.

3. Wound now perfect cicatrix; epithelial scales; the circulation very active; no congestion; vessels still preserve the looped arrangement, but delicate branches traverse and anastomose over the opake spot.

4. The aperture, still considerable, is just included by the circumference of the field; the formation of the new vessels beautifully seen in all its stages, but the lymph border quite in advance of them; several congestive deposits, one or two seeming insulated and stag-

nant, just showing faint tracks by which the blood particles have reached them; others only beginning to form by angular offsets from the parent, and oscillations backward and forward at each round of the circulation, the advantage being yet in the reflux or back stroke; numerous transparent channels; globules passing deliberately sidewise through them, others suddenly and at very acute angles liberating the masses, and these reducing from shapeless deposits and mere tracks of corpuscles into defined vessels. This animal now very vigorous, and the process presenting all the stages of vascularization, which had been stationary for many weeks following the injury. Superficial course of arteries here and there crossing the veins, and the scattering of their contents, as before observed, over the lymph deposit.

14th Week*.—1. (4.) The only unhealed wound; reduced aperture; vessels forming, as before described, at a short distance from the margin. The masses seen a week ago are now loops of anastomosis in active circulation; other transparent channels opening from them towards the margin.

2. (3.) The last healed, presents the very opake centre with no blood-vessel crossing, but many loops playing

* The second figure refers to the subject.

around it; the lymph granules conspicuous on the unvascular cicatrix.

17th Week.—1. (4.) The still unclosed wound; two meshes stagnant on margin; active loops; an artery distinctly feeding several transparent capillaries; lymph particles abundant.

2. (1.) The first healed wound; small opake unvascular centre denoting cicatrix; loops forming crescentic arches all round in active circulation; convexities to the cicatrix; distinct termination of arterial branches in three or four venous capillaries, or rather of branch artery in branch vein, the latter going off nearly at right angles.

3. (2.) The narrow opake line of the slit or fissured wound and cicatrix; very little trace besides.

4. (3.) The vestige very slight; an opake point; the circulation rather slow, and presenting nothing remarkable.

The opacity and sparing vascularity of and about the cicatrix the only point noticeable in the two last.

20th Week.—These experiments having been made on the 10th October 1842, I examined the four webs carefully on the 1st March 1843 (140 days). The thickened or slightly opake centre, marked by an irregular disposition of the new pigmental maculæ, was

noticed in three out of the four; in 2, the first healed, slit or fissure wound, the arc or zone-like arrangement of the vessels round the cicatrix still conspicuous; in 3, the scar was traversed by the vessels, but even now there was a slight pause or remora in the circulation at that spot, and that only; 4 was still unhealed; an exceedingly small aperture, blocked by a mucous film bestrewed with red particles, stagnant. The breadth of the lymph border and the distance of the surrounding vessels was in proportion, the same in this example as during the earlier stages. The part seemed to have undergone no change during the last month, but in all the circulation had become very feeble or rather arterial and small, without colour; and in one, the first, almost suspended; the weather, before unusually mild, having become suddenly very cold, with frost and snow.

The following is a brief recapitulation or digest of the phenomena developed in the healing process.

1. Stasis or actual arrest of the circulation is a direct effect of local irritation, more or less persistent, according to the degree or shock. Thus, if unattended by

injury to structure, recovery from it restores the previous condition, whether inflammation be set up or not. Its local extent, like its duration, will be according to the amount of the irritation. The circulation is oscillatory at the verge of the stasis; beyond this it is preternaturally slow, and yet further from the stationary centre it is, or appears to be, somewhat brisker than natural. The suddenness and completeness of the stasis determine the acuteness of the inflammation; it is slowly formed and imperfect in what are termed congestive inflammations.

2. Contingent upon the stasis is the effusion of serum, or of the liquor sanguinis, the one or the other, according to the nature of the injury inflicted, whether of function simply or of structure. If serum only be effused, the inflammation, if any be present, admits of perfect resolution; not so, if the effusion be of the liquor sanguinis, holding the fibrine of the blood in solution. This is the distinction between the effusions of shock and of lesion, the nervous and vascular, the inflammatory and non-inflammatory œdema. The second results from a more considerable and prolonged action than the first, if both be the effects of inflammation; but whereas the aqueous effusion is often unattended by inflammation, the fibrinous effusion is characteristic,

and proper to it, whether with or without primary breach of texture.

3. The fibrine effused in a state of solution in the liquor sanguinis only becomes susceptible of organization, *i. e.* capable of permanent incorporation with the living solid, when separated from the other constituents of the blood. It is incapable of organization if effused in combination with the blood corpuscles, as in extravasation or hemorrhage. This observation is not contradicted by the appearance of vessels in a coagulum, which serves as a spurious plasma or bed for the reception of the blood corpuscle, and the shootings of the pseudo-capillaries in an arborescent form; and which, whether confined by cellular membrane or a layer of sponge, admits of no further advance towards vital organization, or the attainment of the self-preserving and adapting principle.

4. The effusion of the liquor sanguinis from the arterial capillaries is the first change consequent upon inflammation, either with or without breach; it is in either case limited to the extreme verge of vascular action, or the boundary line of its arrest (complete stasis). In the act of coagulation upon the face and sides of the wound, the contained fibrine separates from the serous portion of the liquor sanguinis, and becomes

a crust or membranaceous stratum, covering in the wound at all points, the sections of blood-vessels, nerves, absorbents, &c. This then forms the intermedium of vascular communication by anastomosis in cases of union by adhesion. It is an effusion entirely distinct from and subsequent to extravasation of blood, and does not take place until after the act of inflammation is established, when the coloured coagulum becomes detached.

I am here strictly speaking of the healing inflammation consequent upon incised wound. In the inflammation arising from some other forms of wound and injury, and especially from constitutional causes, whether upon sound or broken surfaces, the redundancy of the deposit and the disparity of the organizing process are often in contrast, as seen both in the cellular, serous, and mucous textures. And the union by first intention, as it is called, in simple incised wounds, as compared with the slower process of granulation, illustrates the influence of apposition and support in the healing of all wounds, in equalizing and adjusting the processes of deposit and vascularization.

5. The second act in the healing process is the separation of the lymph particle from the blood within the vessel. This is not seen until after some time has

elapsed, for it is not an immediate consequence of the stasis, which may and does continually happen for short and definite periods without this separation, or any effusion of lymph, as in simple irritation or inflammation of a sound texture without deposit. The necessity created by extensive breach, or injury determining such breach, establishes the adhesive action on a scale of extent and duration proportioned to the loss incurred by the injury; and the effusion,—always marginal only,—during the period of stasis, and maintained so much in advance of the active circulation as almost to convey the idea of its being derived from some other source, is now in the form of lymph globule, which has become separated within the arterial coloured capillary, for the special purpose, as it would seem, of supplying the permanent plasma or new solid. Its appearance in the veins is not recognised until the stasis is passed and the circulation restored. Neither is it seen in the newly-formed vessels, but only in the vessels which have undergone the stasis. These are preternaturally dilated; the venous side of the capillary circulation appears to be that most loaded; it is at least most conspicuous. The restored circulation of the part is slow and laboured; the deposit is not only limited to the verge of the wound, but its

progress and the rate of healing bear a steady reciprocal relation to each other. This is of course depending on other circumstances, as the nature and extent of the wound, and the temperament and condition of the animal.

The elaboration of organizable lymph appears to become perfected as it advances, confirming the practical observation, that wounds which heal slow heal sound. It is quite a mistake to suppose that, in wounds with loss of substance, the effusion of organizable fibrine constitutes the permanent material of the new solid. The first deposit effused with the liquor sanguinis is an amorphous exudation, and presents no such regular figure and arrangement as the lymph particle which has been separated within the vessel before deposit. They are, in truth, different in this respect; the first, or that which forms immediately on the receipt of injury, and serves for the intermedium of organization in a close apposition of surfaces (being separated from the liquor sanguinis with which it is effused), would not serve as a base for the new solid; it is soon absorbed, being only a temporary bond or adhesive layer in harmony with the parts, though serving the important purpose of consolidation by anastomosis of the contiguous vessels of opposite sides, or union by the first intention; the

second is not called for in mere divisions of substance, and is not ready if it were; it requires a higher and long-continued inflammatory action; it is a permanent, not a provisional or temporary mean of reparation,—a substantial addition of structure, not a mere conjunction of parts.

6. The oscillation attending the recovery of the circulation seems to be the *punctum saliens*, or first movement towards the formation of the new circulation. From its appearance in the original vessels we may take the lesson of the creative action. It results from the propagated pulses of the heart to the extreme arterial capillaries and their remission in the intervals of the stroke; the backward motion being at first passive, or the result of pure elasticity; then the resistance of an indirect or anastomotic communication with the proper circulating force gradually yields to the propulsive, which is direct and steadily repeated; and thus the progress of the current is determined until the old circulation is restored, and in continuance, until the new channel becomes perfected, and joins or is joined by others, *i. e.* falls into anastomosis, and takes its place as artery or vein, an excurrent or recurrent channel.

7. The escape of the solitary blood corpuscle into the permanent plasma from the contiguous capillary, at se-

veral points of the terminus of the original circulation, is the second marked stage of organization. The intrusion at first of single or pioneer corpuscles, then their advance in close single file up to a point short of the free or interior lymph margin, forms a transparent track or channel, which, however devious, no particle quits; their arrest and agglomeration in a mass, coloured and motionless like an extravasation, is next seen. Many hours elapse before motion is communicated; then a small and scarcely perceptible oscillation commences between the point of separation and the heap, which ultimately disperses by the aid of another transparent track or channel communicating with another vessel. The see-saw now increases in strength, and the track becomes semi-opake, and vasiform; then the jerking onward motion, and no return, is substituted for the see-saw, at first irregular, then becoming steady at measured intervals, corresponding to the derived circulating pulse of the original or parent vessels; and the site of the heap, which is no longer visible, is marked only by the interlacement of multiplied vessels as an anastomotic centre. Frequently two of the new vessels meet at an angle, sometimes traceable to the same parent, but more frequently to distinct coloured vessels: in the former case, an azygos branch starts

from the angle of junction; in the latter, the circulation is continuous in the arch or crescent corresponding to a venous or return capillary, and presenting the appearance of a terminal loop or fork, as the angle is more or less open; the convexity or salient angle being toward the margin. These new vessels next become tinted, and contracted to smaller dimensions than at first, when they looked large and shapeless, their tubular form being then undefined. The coloured circulation then approaches nearer and nearer the margin of the wound; the anastomosis is more and more extended and complete; but the opake lymph margin, so long as it remains, is always free, and in advance of the vessels, even the centre remaining long unvascular when the aperture is obliterated; and when at length hemmed in by the surrounding loops and arches playing around the border, these strike across and anastomose upon the cicatrix. The ultimate process of vascularization (cicatrization) renders the part generally opake for a considerable time; the central or last healed spot therefore discovers itself even to the naked eye long after the healing process is finished, and the surrounding part has partially recovered transparency; and a fantastic arborescent arrangement of the vessels often distinguishes this last vestige of the injury.

The lingering of the last healing stage, so constantly remarked in wounds of large diameter, is explained by the proportionate call upon the newly-created vessels to form others; so that for a long period the central circulation is purely, and even remotely, anastomotic.

To conclude: the inflammatory exudations are,—1st, of serum; 2ndly, of liquor sanguinis; 3rdly, of fibrine, or the material of new structure; and the fabricator of the new vessel is the blood corpuscle.

This last shows that no capillary is, as has been supposed, of calibre so small as to be incapable of admitting the blood corpuscle, although it can convey only one at a time, which leaves it transparent; and that the exudations are therefore depending on other circumstances, as the reciprocal attraction between the vessels and their contents, and the change of circulatory motion, which is the result, direct or indirect, of the injury.

The temporary stasis seems to be necessary to the exudation of liquor sanguinis, its continuance to that of the separated lymph particle; and not less the graduated impulse of the returning circulation, to the elimination of the blood corpuscle in single globules for the fabrication of new vessels; for if it were in mass (hæmorrhage) it would destroy instead of promoting organization.

All capillaries, then, may convey either pure serum, or the liquor sanguinis, or the blood corpuscles, severally and distinctly; secretion or separation being, like all the processes of inflammation, a positive action subject to vital laws, not an accidental outpouring, like that from a ruptured vessel.

I greatly doubt if the separation of the lymph particle within the vessel is ever a normal state, *i. e.* unpreceded by stasis, although breach of texture is not necessary to its appearance, as exudation of organizable lymph continually happens without primary breach. The intrusion of the blood corpuscle into the serous capillary is only under the nisus which leads to congestion, or that of inflammatory action. When the last is established, colourless vessels come into view, becoming at first tinted, and then deeply coloured.

The lymph is laid down as the arterial capillary circulation resumes, and always of necessity precedes the generation of new vessels; which process does not commence until after the original circulation, to the extent that is uninjured, is fully restored, as an energy beyond that which exists in the normal state is required. The detached lymph particle is seen in the original veins, but it moves free throughout the coloured circulation, and doubtless acquires a higher vitalizing influence than it

possessed when incorporated with the mass of blood. But ere the organizing action is fully completed it is no longer seen, its appearance seeming to correspond to the necessity for its employment.

Observations on the Constitution and Origin of Pus.

The continuance of the inflammatory action beyond the strictly adhesive stage (so to designate that which terminates short of suppuration) determines the granular form of the fibrinous deposit upon exposed surfaces, and an approximation to it in cavities and sinuses; and upon the free mucous surfaces, in some instances previous to ulceration, but more commonly subsequent to it. The open-mouthed follicles of the mucous membrane are equivalent to granulations, *i. e.* equally secrete pus, in lieu of their proper secretion under inflammation. This shows that the especial form of granulation is not indispensable to the secretion, though it is a form which the effused fibrine more or less affects, when suppuration is set up. The vessel prolonged into the granulation and doubled on itself is more or less tortuous; and so numerous are they as to require a high magnifying power to exhibit their distinctness after successful injection. The appearance of the vessels of granulation, at first almost varicose, and increased while the ulcerative

action prevails, becomes contracted to obliteration as the period of cicatrization approaches.

Pus, I believe, to obtain its characters of consistency, opacity and colour after exudation, and to consist of the superfluous or waste lymph which has been separated during the adhesive stage from the mass of blood, held in solution by the serum, being thus a chemical modification of the constituents of the liquor sanguinis; in short, the latter fluid deprived of its original characters and property of spontaneous coagulation. Pus particles resemble those of lymph seen in the vessels under inflammation, except that they appear broken down and partly dissolved in their texture instead of compact, and of less regular figure; and if, when suspended in a drop of fluid, compared with the elastic blood corpuscle, to which they bear no analogy whatever, utterly inert and devitalized. We never see pus in the blood-vessels but in fatal phlebitis, and if introduced into the circulation by injection, it is destructive to life. Although, therefore, a clean-wiped granulating surface soon presents a covering of pus, it is exuded as a colourless fluid, of a more dense and unctuous consistence than serum. Its appearance is simultaneous with the disappearance of the lymph particle from the veins. The suppurative action being deter-

mined, or, in other words, the separation of the proper lymph particle put an end to by its sufficient deposit in granulation, and the inflammatory nisus still prevailing from the continuance of the irritation—for no imperfect state can be perpetuated—the superabundant lymph particle, at no time coloured, along with the permanent fluid or serum of the blood, is strained off through the pencils forming the terminal loops of the granulation. Thus is obtained the twofold purpose of relief to the loaded capillary circulation, and a bland and homogeneous protecting fluid for the granulation, during the period of its growth up to that of final organization. When the rudimental fibrine is no longer needed for the new structure, it is used, as in nature all remnants are, for a new but not less important purpose, the preservation of that structure. Pus is as necessary to the maintenance of granulation as lymph was to its formation. But a change is necessary to fit it for its new function, and this is provided for by a new arrangement or a new action of the secreting capillaries, and a chemical change, which destroys its vital property and amalgamates the separated lymph globules with the serum of the blood. The precedence of adhesive to suppurative action is sufficient to render presumable a necessary connexion between the lymph separated during the first

process, and afterwards disappearing, and to explain the invariableness of this relation in the order of their appearance. There is no analogy between the effusions of serum or of liquor sanguinis incidental to primary wound or injury of any kind, and pus, yet the ingredients of the two latter are the same; it is by the combinations of a vital chemistry that their appearance and sensible properties differ, and this we are incapable of imitating.

If this theory be admitted, it will explain the appearance of pus in the absence of the especial granular structure or distinct pyogenic membrane, as seen upon mucous, serous and synovial surfaces and canals; and even in the absence of fibrinous exudation, as in certain modes of inflammation, where the habit of the parts or the character of the inflammation render them incapable of carrying on the adhesive action, or that action is by violence interrupted.

Puriform mucus, muco-purulent secretion, are terms in common use, indicating the transition stage witnessed in these cases; so also the modifications of colour, consistence and purity are explained, which are conveyed by the terms sanious, flaky or whey-like, ichorous, &c.; and the improvement of the secretion by elaboration from that of fistulæ and sinuses to the 'pus laudabile' of old authors, concurrent with the improved vitality of the

granulations—meaning a fuller proportion of the lymph particle to the serum—and *vice versâ*, its degeneration in enfeebled and sinking states of the system. Thus also is explained the effect of inordinate and excessive suppuration to superinduce hectic, from the excessive withdrawment of that ingredient, which forms the nutrient and restoring principle of the blood.

The action of a blister in its several stages offers the simplest and clearest illustration of the singleness of character and the reciprocal relation of inflammatory exudations:—1st. The aqueous vesicle of the epidermis, where the cutis heals at once. 2nd. The 'jelly blister,' well known to old nurses, containing albumen and fibrine in abundance, resulting from deeper inflammation, and slow of cicatrizing, as the surface must first be cleared; this is most frequent in weak and diseased subjects. 3rd. Under continued inflammation of the cutis, as when the blister is kept open, pus, or the exudation of the liquor sanguinis divested of blood corpuscles, but often tinged. The supervention of the successive stages of ulcerative and gangrenous inflammation is in like manner demonstrable under continued irritation.

The conversion of the blood corpuscle into the pus corpuscle is a notion altogether gratuitous, and un-

supported either by appearance or probability; and, to my mind, the above is a theory more reconcilable with all the circumstances attending its origin than that which supposes a *de novo* formation of the pus globules. But the wounds of cold-blooded animals* not being subjected to the true suppurative process, nor those of mammalia and birds disposed to free suppuration, there appears to be insuperable difficulty in establishing this theory by actual demonstration.

* The experiments above related were confined to the web of the frog's foot.

CHAPTER X.

OF ULCERATIVE INFLAMMATION.

Is ulceration a negative process, a mere defect of nutrition, as they assert who consider the adhesive deposit simply a plus of nutriment from an alteration in the quality and quantity of the circulating blood? or is it a special action of the vessels, whose office it is to remove superfluities and redundancies, and regulate the growth of parts? Every practical pathologist will, I believe, answer the last question in the affirmative. In truth, it would be difficult to conceive how any modification of the secreting action which furnishes the deposit should explain the removal of parts from their innutrition; a loss of consistence and cohesion even to disorganization is what may rationally admit of such explanation.

That the veins which ultimately receive the absorbed matter or waste parts should in certain circumstances

employ their capillaries in this action is more intelligible; but the provision of an express system for this purpose, the universal communication of arterial and venous capillaries, and the single and sufficient end of their formation, with the special exception of the portal vein, make it highly improbable that this function is assumed by the capillary veins, except vicariously, under forced and extraordinary circumstances. I am disposed to think that the experiments brought in proof of the absorbent action of the capillary veins present such circumstances. Veins are amply supplied with lymphatic absorbents, and such results as are taken in proof of venous absorption in entire textures are open to this source of fallacy. But the ulcerative action is confined to breach of structure: the anatomy of disease presents phenomena peculiar to itself; its physiology is exclusive. It may be that the capillary veins acquire a new and important function in the state of solution of texture or breach of continuity.

Pus and morbid matters, and also coloured injections, are found in the second order of veins: they are supposed to have been absorbed by them, in the first case, from a breach; in the second, from a sound surface; in the former they are rendered patent from partial discontinuity, and the excrementitious matters may thus be

admitted direct into the circulation; but in the latter case the surface is defended by its integrity, supplied with sound absorbent vessels. It is as contrary to the simplicity and perfection of all natural mechanism and to the analogy of order in nature, to employ more causes than are competent to effects, as it is to the spirit of philosophy to admit an exception without adequate cause.

I therefore infer, that to the artificial conduct of experiments this seeming contradiction is to be referred; which explains the supposed cases of venous absorption, refers both to a yielding of the surface, natural or violent, and constitutes them morbid or artificial phenomena. The finding such matters in the veins, or the translation of them into the system, or their deposit in a remote part of it, does not constitute the veins the agents of ulcerative inflammation. They become carriers of the *débris*, or the morbid secretions with which the blood is loaded, after a dissolution of the structure of which they form a part; and then, if the suppurative inflammation has existed, they may convey pus; or if bile, or urine, or foreign matters have been effused, they may convey these fluids with their blood. We know that it is germane to their function to circulate blood loaded with the general refuse of the system, *i. e.* the

blood spoiled by the circulation, or, in certain circumstances, the excrementitious fluid, so that the whole difference resolves itself into the veritable absorbent action of the venous capillaries under artificial pressure, or in an altered and exposed state of the surface.

Some modern pathologists have taken exception to Mr. Hunter's theory of ulceration, and go so far as to deny that the absorbents are concerned therein. First, they say that there exists no direct proof. To this it may be answered, that it is common to see the absorbents of the mesentery loaded with pus in the abscess of its glands, and also in dysentery, which is considered proof enough of their share of the work as applied to the chyle in nutrition; that if we correctly ascribe to this order of vessels the office of removing the *débris* of sound structure, the proof of their not being so employed in broken structures will fall upon the recusant party; that if they do not deny to the action of these vessels the removal of a piece of metallic iron, or a fragment of opake crystalline, or a flake of blood or of lymph effused, which have undergone the degree of solution necessary for absorption, it is for them to show that the same agents are not employed in the removal of parts and surfaces disorganized by violence or inflammation.

I shall state briefly the several objections, and reply to them.

Objection 1.—*Ulcers spread most rapidly during inflammation, when absorption is diminished.*

This statement requires some modification. It has the common speciousness of a hasty generalization. The error consists in a confusion of the several modes and stages of inflammation and the several conditions and necessities which give them birth. An ulcerative inflammation and an adhesive inflammation differ diametrically, this being the morbidly increased action of the depositing, that of the absorbing vessels.

It is correct to say that absorption is in proportion diminished during the first stage of inflammatory fever, *i. e.* inflammation of the system, idiopathic or sympathetic; but very contrary to facts to say, that absorption is at all diminished in the after stages, and especially in that mode of inflammation proper to ulceration, viz. secondary or hectic fever. Common observation gives a flat contradiction to such a statement.

Ulceration, *i. e.* ulcerative absorption, cannot exist unpreceded by inflammation, more than adhesion or suppuration. Even in whole structures, when we would procure absorption of lymph or serum that has been effused, we increase the activity of the capillaries of the

part by local frictions and stimulants, because we calculate upon the increased activity reflected upon the absorbents by the ordinary sympathy of their actions; and we administer mercury to excite artificially an irritative fever, that finds relief and subsides in an excessive action of the absorbents*.

Objection 2.—*The tissues best supplied with absorbents do not ulcerate so readily as others inferiorly supplied. Thus bone, which is quickly absorbed before an aneurism, does not ulcerate so readily as cartilage, which is very slowly absorbed.*

This again is a palpable confusion of the two modes, the interstitial and the ulcerative absorption, and an argument which I should infer does not come from a surgical pathologist.

We are incompetent to speak of the comparative supply of absorbent vessels in firm textures. The supply of absorbents is generally in proportion to the supply of blood-vessels, and the smoothness, firmness and compactness of structure in the cornea and cartilage, and their close transparent covering membrane, render the minutest points of ulceration in those textures conspicuous. Ulceration, as regards the cornea, commences more frequently in the interlamellar cellular texture than on either face.

* See preliminary positions.

The process of wasting, interstitial absorption, is quite independent of inflammation.

When a bone or cartilage disappears without ulceration, it is an atrophy, *i. e.* either a cutting off of the nutrition, the absorbent action continuing the same, or simply an excess of the absorbent action. A part therefore disposed to atrophy is less prone to ulcerate, *i. e.* the non-inflammatory anticipates and supersedes the inflammatory process. Thus the interstitial cartilages waste, while the vertebræ are carious and their substance removed by ulceration: the body of the testis wastes much more frequently than it ulcerates. The cornea presents both states, but is prone to ulcerate; the proportion of ulcer to conical cornea being at the least as 100 to 1. The articular cartilage of joints, also subject to waste, more frequently ulcerates. But all these textures are exposed to both modes of absorbent action in common with others; and unfortunately for the argument, the two textures, skin and mucous membrane, which, it will not be denied, are of all most plentifully supplied with absorbents, are of all most liable to ulcerate.

It is the mode and degree of irritation that determine whether a part takes on interstitial absorption, or ulcerative inflammation.

An aortal aneurism, or an œsophageal tumour pressing upon the spine, produces caries of the vertebræ; upon the sternum and the ribs it operates to remove the superjacent textures by that interstitial disintegration and absorption, preceding inflammation, which Mr. Hunter has termed progressive absorption.

Objection 3.—*The state which favours ulceration is one adverse to absorption, either by lymphatics or veins.*

By this is meant a state of congestion or slow and difficult transmission of blood.

I should say, that to healthy absorption a stagnant circulation was unfavourable, whereas it so strongly disposes to a breach of texture by inflammation, that we entertain the apprehension of this result as almost a certainty, sooner or later, where we find it established. Suppuration, the action of the inflamed blood-vessels, is followed by ulceration, the sympathetic action of the absorbents. Every tyro knows the effect of moderate and equally diffused pressure to quicken absorption and preserve texture by promoting the activity of the circulation, and its effect to produce ulceration, viz. morbid absorption when partial and excessive.

Objection 4.—*Absorption is a slow and ulceration a rapid process.*

This objection, stated indefinitely, displays only the

weakness of the argument. Both processes exhibit, in different instances, all the varieties of progress.

Objection 5.—*Granulations ulcerate more rapidly than cicatrices, though they cannot be better supplied with absorbents.*

A granulating ulcer is an unfinished stage; all the operations upon which restoration depends are in full activity: they depend for their existence and changes on the action of absorbents as much as blood-vessels: a cicatrix on the contrary is a finished and complete state. It is a comparison of the house with the scaffold. Compare the absorbing powers of the sound surface, either cicatrix or original, with those of a granulating ulcer, by applying to them mercury or arsenic, opium or nux vomica, either in powder or solution. The absorbent endowment of actual finished cicatrices is, like the vascular, very slender, of which their stationary condition is a convincing proof.

Objection 6.—*A part must become fluid to be taken up by minute lymphatics; if so, why may it not pass off with the discharge?*

It may be admitted that the part absorbed must be reduced to a pulpy or fluid state, but this is surely an argument for its absorption.

In open ulcers we know that much does pass off with the discharge; but is this always sufficient to account for

the deficiency? What becomes of the discharge in extensive caries of bones, where the bodies of three or more vertebræ have disappeared, and how are large collections of matter disposed of, having no connection with the surface? I have seen cases in which pints of matter have been taken up in psoas abscess, and the parietes recover without breach.

Objection 7.—*Injections of ulcers show dilated veins, but no extraordinary development of the lymphatics.*

This objection, if it proves anything, proves too much; for it will not be asserted that the lymphatics are unemployed because ulceration exists, if they be not the instruments of ulceration; and the congested, and consequently inert state of the veins, plainly indicates the more active employment of another order of vessels, and that they (the veins) are not directly concerned.

The rapid and extensive occasional action of the absorbents in cases of inflammation without breach, as the removal of the serum in local dropsies, the lymph in iritis, &c., is as incontestable a phenomenon as their continual action to regulate the adjustment of solid and fluid by removing useless and decayed parts in the healthy economy; and when inflammation is attended with breach, constituting ulcerative inflammation, they are the sole organs of the removal of parts, and no animal structure is exempt from their operation. They

do not take the initiative in inflammation, but act subserviently to prior changes. Ulceration, when it occurs, is consecutive to adhesion and suppuration, in almost all cases; and although suppuration may now and then pass without ulceration, in the same manner as adhesion prevents suppuration, yet the frequent case of ulcerative inflammation succeeding to abscess, and the very rare existence of ulceration without pus, constitute the ulcerative, third in order, of the processes of inflammation.

We have shown the secretion of pus to be depending upon the deposition of lymph, and its organization for that purpose more or less perfect, as it approaches to or recedes from the form of granulation, the organ which the adhesive provides, in the first instance, for the suppurative action; in the second, for the renewal of structure. Pus confined in a cavity is in effect analogous to a foreign body: how is its liberation effected? is it peculiar and unlike that of other foreign bodies? Ulcerative inflammation is the instrument by which it is brought to the surface, and this is opened for its discharge. The most powerful stimulus to absorbent action is pressure; it operates upon sound parts, reducing their bulk by what is called interstitial absorption—the process of attenuation conservative of form and structure—but under inflammation it sets up the

ulcerative absorption, or that mode which, acting superficially, first gradually destroys, and then removes solid structures. Both modes are employed in bringing tumours and morbid collections from the interior; the first, the interstitial, taking precedence; but in acute suppuration, the ulcerative action advances rapidly and anticipates the interstitial, which is a chronic process that frequently exists independent of inflammation.

Whether the tendency of matter to the nearest surface, external or internal, the outer or inner integument, as the case may be, is due to the more yielding structure of parts in the direction of the nearest surface, or to the operation of a physical law, as the increased amount of pressure upon the increased area of the summit over the base, I cannot determine. Mr. Hunter, following out his constant view to a direct provisional or conservative agency in the animal operations, in disease as in health, attributed a relaxing process to the skin, concomitant with a progressive and ulcerative absorption, to explain the invariable tendency of matter to the surface.

If the absorbents acted only at their ordinary rate of action, the presence of foreign bodies or excreted fluids would rouse them to an increased activity; but the ulcerative absorption never occurs but as an inflammatory process, and the action of the absorbents in this

process is therefore exclusively a morbid one, and generally partakes of an increase proportionate and corresponding to the opposed action of morbid secretion. Thus a slow abscess has a slow discharge; nay, the ulcerative process is so torpid, that months may pass before the inflammatory action of the part to be removed is set up. A foreign body escapes quickly, or the reverse, according as its size, figure, &c. irritate to inflammation, or create little disturbance; and as large collections of fluid in natural and morbid sacs and cysts often remain without exciting inflammation, consequently no ulcerative action occurs. But if from any cause inflammation is set up, it superinduces active suppuration in these chronic sacs, and then ulceration, *i. e.* disintegration and removal of the containing and resisting parts, commences in its order. So a gangrene, when not the result of acute inflammation, exhibits the utmost indisposition to separate by the ulcerative process, which can only be roused by strong stimulants to suppurative inflammation.

The texture of the part to be removed is opened, loosened, and softened, prior to ulceration, by preparatory interstitial absorption, resulting from a loss of the due balance of circulation, proper to inflammation, quickened by continued pressure from distension; and

upon this partially disorganized condition it is that ulcerative absorption supervenes. This, which has been termed the softening process, is often witnessed in broken down and dissolved parts in the vicinity of chronic abscess—parts about to be removed as unfit for use, and prepared for undergoing absorption or removal—in the formation of external ulcers, and especially in morbid changes of the firmer textures of cartilage and bone. The continual contact of pus was formerly supposed to induce "erosion," the term then given to ulceration of bone; but the perfect innocence of pus in the parts in which it is secreted, when not in a state of putrescence, as by the admixture of air in cavities, is now established beyond controversy.

The ulcerative, being a purely vital action of the absorbents proper to the part affected, goes on progressively, either by perforation of the substance, or by an encroachment on the surface, or by undermining and separating parts prepared by disorganization or actual death for being cast off. The texture of the part determines which of these modes of action is employed. The cornea, the cartilage, and bone present the penetrating and circumscribed, foveolous or fossulated ulcer, a pit or chink; the cellular membrane presents the hollowing and undermining process, as in the

sinuses and pouches of abscess in cellulous parts, and on the margin of indolent ulcers, also between the articular extremities of bones and their cartilages; the spreading or superficial ulceration is best exemplified in the skin. But it is always by the absorbents proper to the inflamed surface that this action is carried on, as we see in the ulceration of granulations, the one-half or two-thirds of an ulcer healthy, *i. e.* the granulations upstanding and florid, while the remainder are removed or marked out for removal by decay, and a fresh and clean surface presented in their place at the end of forty-eight hours. So that both the depositing and organizing, and the absorbing actions, are those of the contiguous capillary and absorbent vessels, indispensable to the nutriment, form, and vitality of the part affected.

The ulcerative process thus stands between the life and death of parts subjected to its action, and administers to either, according to the circumstances of the case; being the instrument of reparation in the suppurative and adhesive inflammation, and of separation and removal of the waste and decayed, in the suppurative and gangrenous. It is the agent of granulation in the former, of sloughing in the latter case; suppuration being the common link by which these extreme processes are connected. Without granulation ulceration

is a wasting process; with it a repairing one. In like manner, ulceration without suppuration is a devastation without means of control or repair. The formation of granulations, and the establishment of healthy suppuration, promote the two great objects of a barrier against further destruction, and a permanent basis for the new solid.

After this explanation, it is almost superfluous to say, that the detachment and the removal of parts are the special service of the ulcerative inflammation; the cleaning, levelling, and dressing of the granulating surface for the final process of cicatrization or healing, being the natural action of the absorbent vessels of the new structure, a distinct function, well denominated by Mr. Hunter "modelling" absorption. The same normal function performed by the absorbents of new organizations, regulating their growth and figure as those of original structures, has of course no necessary connexion with the ulcerative process, although always indispensable to that of granulation, which alone can repair the breaches caused by ulceration.

The office of the absorbent vessels, and the appearances presented by parts upon which they are or have been at work, have endowed them in imaginative minds with a sort of intelligence directing the choice of their

food, and their plan and course of operation. Their appetite varies with circumstances; no more. In ulceration they follow the course which the previous inflammation and consequent spoiling and softening of texture point out. This is generally influenced by the direct operation of pressure from within or from without; but neither does pressure produce ulceration in the absence of inflammation, nor does ulceration occur only when pressure operates, nor always cease when pressure is taken off. The soddening effect of immersion in pus has been supposed to loosen the texture of surfaces exposed to it, but the secretion, which is sheathing and protective to the new texture, can scarcely be despoiling of the old, and the softening process is evidently depending on an interstitial, not a superficial change. This is either such as disqualifies the part for function simply, or for life: the former admits of maintenance, and may be wholly independent of inflammation; a change of consistence due to imperfect nourishment, an interstitial atrophy; the latter determines the suppurative and ulcerative inflammation for its removal by breach. It is in this way that hard structures are removed; the animal part of bone is already so far atrophied as to leave the earthy part a friable substance, or the earth, deficient in its supply, renders the animal part a jelly; but the ulcera-

tive absorption is only employed when inflammation has occasioned breach of texture. The ulcerative process is, indeed, best illustrated in the processes of caries and exfoliation of bone, the former being the suppurative and ulcerative, the latter the gangrenous and ulcerative action.

When the thinning and absorption of parts covering an abscess has destined them to destruction, which happens, notwithstanding the relief of a partial discharge by the natural opening, where the abscess has attained size, and also where the artificial opening is deferred, or insufficient, an ulcer is the result. This may form, under other circumstances, as from external lesion or removal of the parts, forcing suppuration to the extent of the injury, without abscess; it is enough that the parts have been, whether directly or indirectly, irreparably spoiled, to determine, as the only mode of restoration, the adhesive, suppurative and ulcerative inflammation. This must happen equally as regards all three, whenever so large a portion of substance is removed as renders insufficient, or prevents the first and direct adhesive process; and even in many instances, where, by mechanical contrivance, clean cut parts are brought into contact, the suppurative and ulcerative processes still ensue. But in the case where the abla-

tion of a part is so inconsiderable, or so provided for by the preservation of the sound integument as to render it equivalent to simple division of parts, the suppurative action is not called up, and still less the ulcerative. The suppurative, based upon the adhesive, is sufficient for the healing by granulation, in cases where the removal of parts is small and the surrounding texture sound, *i. e.* uninjured and uninflamed.

But if abscess, as often happens, supervenes upon wound, or a wound involves parts previously injured or inflamed, the suppurative and ulcerative actions are unavoidable, because such parts are incapable, not only of the adhesive action, but of self-preservation. Whenever the detachment of parts is required, ulceration is set up. If the adhesive action did not previously exist and set a limit to it, it would spread, as we see it do in poisoned sores and erysipelas, until we can procure this action to serve as a barrier; but the parts and the constitution being previously healthy, and especially, the injury being casual, or from without, the adhesive action always takes precedence. As the suppurative may in certain cases precede the adhesive, so in others the ulcerative may for a time stand alone, anticipating both; but this is an inversion of the order of their natural and ordinary course, for in no case, consistent with the

life of the parts, can the ulcerative action progress unchecked by the adhesive; and the suppurative, as we have shown, is indispensable to the healing by granulation.

An ulcer is a patent and familiar illustration of the pathology, not only of the ulcerative, but of all the processes of inflammation; and as it is that vital action by which not only the dead are separated from the living, but the living are removed, which have undergone such organic changes, or lost so much of their vital power as to be incapable of resisting absorption, it may be regarded, as before observed, as an agent for life and death, and if in one case "the natural surgeon," in another the natural destroyer.

Although "ulcer" is a comprehensive name for sores formed by the ulcerative inflammation, in many states and phases of their existence such sores exhibit no ulcerative action, as when that mode of inflammation is arrested. The interstitial absorption is the process by which what is called a healthy (healing) ulcer is dressed, and levelled and prepared for skinning; and it is only when this natural, not morbid, action has superseded the ulcerative, that the healing process is fully established. No sore can heal while ulcerative absorption (the inflammatory process) continues either upon the

edge or the centre. This mode of inflammation is so directly opposed to the adhesive, and so adverse to healing, that, being arrested, the hindrance to healing is removed. To put an end to it, therefore, is the surgical indication. This is done by constitutional and local treatment jointly; in some cases the one, and in some the other plan avails most.

To know the character of ulcers and treat them accordingly, is a subject of the first importance to the practical surgeon, and well worthy of his science, though often not so regarded. They admit of a general classification, but present many varieties and anomalies. The great distinction is the presence or absence of the ulcerative inflammation, *i. e.* the morbid condition and action of the absorbents, by which the ulcer was formed. An inflamed is an ulcerative ulcer, so is an irritable, and more or less so is also an indolent or callous ulcer; in the gangrenous or sloughing ulcer, ulcerative inflammation is, as in gangrene, a necessary remedial agent for the purpose of separating the dead from the living parts, thus clearing the surface for sound granulation, and the edge for skinning. It is not necessary that ulceration should have existed prior to granulation, although granulation must succeed to ulceration; an ulcer has no other means of repair. The adhesive, then, is

the curative termination of ulcerative inflammation; and if for any reason the part is incapable of this action, disorganization and death is the consequence. Cicatrization is the finished adhesive action, that which completes the purpose, and therefore terminates the existence of granulation.

It is, as we have shown, by ulcerative following suppurative inflammation, that matter and foreign bodies are brought to the surface and extricated, and that preternatural openings of communication, fistulæ, and sinuses are formed. But happily the adhesive action has gone before in the majority of such cases, and consequently, both external and internal openings and passages are defended by it, and the ulcerative process guided and circumscribed. Thus abscesses point, and effusions of the secreted fluids are prevented, and preternatural communications of the viscera with the surface are walled off and shut out from the system. If sudden injury or a cachectic state of the body anticipate this adhesion, and the ulceration is undefended, the worst consequences ensue. The secretions, healthy or morbid, as the ulcer is occasioned and situated, overflow and are diffused through the visceral chambers, or the cells of the connecting membrane, and destructive inflammation or gangrene follows. The

precedence and guardian superintendence of adhesive inflammation is necessary, not only to the efficiency of the ulcerative process, but for the preservation of parts and often of life; and for their restoration, even to the last finishing stroke. Where it has been anticipated by ulceration or by gangrene, the safety of parts and life depends—next to the non-fatality of the extravasation, or the non-importance to life of the parts destroyed—on the capacity of the system for the adhesive inflammation to arrest the progress of the mischief and to accomplish the repair. The knitting together of preternatural openings, the obliteration of sinuses, the formation of granulations on parts separated by the disjunctive ulceration, soft and hard, are only to be attained by the adhesive action. This is still more strongly exemplified in gangrenous inflammation, the subject presently to be considered.

CHAPTER XI.

OF CICATRIZATION.

Skinning is the last or finishing stage of the adhesive process which ensues upon breach of surface, or, the completion of the process of granulation. It is rapid in proportion as the diameter of an ulcer is small and its surface level, and follows upon the cessation of the purulent secretion. If this secretion be promoted by circumstances or by treatment, it is retarded. Thus a sinus or covered way very slowly cicatrizes, because the secretion of pus is maintained by it, and because, also, the extremities only of the sinus are in communication with skin; these cicatrize, and the centre remains raw. Another reason is that proper granulation is prevented, which forms immediately upon laying open the sinus, and then prepares for skin and speedily cicatrizes.

Is this constant and remarkable effect owing to the

operation of the atmosphere upon the raw surface, or the change of form which it assumes? The cylindrical or tubular form subjects the part to be either collapsed or distended, and this state to be alternated, which is equally an impediment to healing by apposition and by granulation; and the centre of the sinus is too remote from the extremities to be within the sphere of action of the vessels of the surrounding skin; the larger the sinus, therefore, the slower or more intractable to heal. When such a sinus ceases to secrete pus, it is obliterated by shortening, and the gradual apposition and incorporation of its sides forming a central line of union, as after small abscess; it is incapable of producing granulation or skin. The dilatation changes the action for skinning by converting it into ulcer; and this difference in the actions of healing of abscess by contraction and adhesive coalition, and of ulcer by granulation and skin, is, I believe, the real and only answer to the question. It is a slow, spurious, and often insecure union by adhesion; the parts having never granulated, fall back upon the adhesive process on the cessation of suppuration, by the mere force of contraction maintaining permanent apposition. Compare the depression or puckering of a naturally healed fistula or sinus with that of one freely dilated, or either with that of an

abscess where the early and free opening has allowed none to form. The mode of healing of abscesses and sinuses, when they occur, is the same, viz. by the condensation of the opposite sides, and the gradual reciprocal intercourse (anastomosis) of vessels upon a central line, which is long afterwards detectable by a cord-like induration; and if large, a more or less superficial depression, corresponding to the axis of the cavity or sinus, where the cellular structure has undergone obliteration. But neither proper granulation nor proper skin are formed in such cases.

Where an ulcer is formed, as often happens, upon an ancient cicatrix, both granulation and cicatrization are materially retarded, for two reasons; first, from the deficiency of free cellular membrane, owing to the previously existing adhesion consequent upon the ulceration; and secondly, the comparatively imperfect power to heal of secondary and adventitious textures. The first circumstance prevents the surrounding textures from lending themselves, by their natural pliability, to the formation of granulation; and the second prescribes a limit to the proper force and freedom of the local circulation, upon which skinning or the completion of the new vascularization depends.

The cessation of the secretion of a granulating sur-

face is not the only condition necessary to the act of skinning, for an ulcer may have its secretion morbidly arrested and turn dry, in which case it scabs and skins slowly beneath the scab, provided it be unirritating and undisturbed. But if not suffered to fall, if rubbed or compressed, or from its size, harshness, and duration irritating the ulcer, it inflames, and ulceration instead of cicatrization follows.

In the ordinary normal process the surface and margin of the ulcer must correspond for the production of skin; no ulcer can heal which has a loose hollow margin, or a thick perpendicular edge, or one inverted or everted; nor while either of these conditions holds does the ulcer cease to secrete, however unhealthy the secretion. It is common to see a part of the circumference of an ulcer prepared, and on the same side the surface ceasing to secrete and almost ready to heal, cicatrization having actually commenced, but it is partial, simply narrowing the area of the ulcered surface on that side. In such case the ulcer is cachectic, not healthy. In the latter, the skin is fixed and bevelled down to the granulation level, and presents a fine white line of union, like the ciliary ligament of the eye, at every point of the circumference: the granulation is uniform and smooth, and looks as if covered with a transparent pellicle; its

colour, now less vivid than when in full secretion, of a pale rose tint. Around and beyond the marginal line fine radiating lines or gathers may be discovered converging towards it, the result of an equal contracting process. In this stage the formation of the skin, *i. e.* the opacity and consequent whiteness of the cicatrix, is almost synchronous with the cessation of secretion.

It has been a question whether skin is formed from the margin by the vessels of the skin, or upon the surface, by the vessels of the granulations. This I have no difficulty in answering. Certainly by the surrounding skin; for, first, we see it gradually advancing from the margin, and equally reducing the diameter of the sore from day to day; secondly, we never see the skinning process without the described preparation of the border, and the process is quicker or slower in proportion to the distance of the skin from the centre; thirdly, the insular patches frequently observed upon the bed of an ulcer, especially unhealthy ones, may always be traced to a corresponding portion of undestroyed skin, thus confirming the fact. Lastly, the cicatrization beneath the surface, as of abscesses and fistulas, is not, as before observed, by the formation of skin or of proper granulation, but by an adhesive process, which tacks the skin to the subjacent cellular texture condensed by

inflammation, drawing it inwards into folds and puckers; in short, a process similar to that which we see in the obliteration of cysts by pressure, and in the formation of solid tumours, to which the skin becomes adherent during their growth. It is very common to see these folds and indents of skin over scirrhous and other tumours, having so precisely the appearance of cicatrices after an abscess or an operation, that we are erroneously led to believe one or other must have taken place.

The principle of analogous textural structure in the repair of breaches is exemplified in the serous and fibrous membrane and skin, as in bone and tendon. Cellular membrane, muscular fibre, cartilage, mucous and synovial membrane, together with the composite organs, present exceptions to this property of the adhesive process, which specially identifies the vessels of the new structure, and their function, with those proper to the original structure. A breach of muscle is supplied by tendon, cartilage by bone; deficiencies of synovial and mucous membrane are permanent, their cicatrices being formed by the covering, subjacent, or contiguous texture. In no instance is the new structure identical; the cicatrix of the common integument being divested of its cellular bed by condensation with the subjacent structure, and therefore incapable of

infiltration in emphysema or extravasation; also of blush and of transpiration, and opake. Its vital properties are so unequal as to render large cicatrices especially prone to ulceration. The cicatrix is incapable of admitting an injection of its blood-vessels, at least such as holds any comparison with that of the original sound texture, and neither its organic nor its sentient properties approach to the standard endowment of the original tissue.

The extraordinary rapidity with which an ulcer sometimes forms skin, compared with its usual rate, conveys, with other circumstances, the not incorrect impression of the vessels of the surface indirectly aiding its formation. This is resulting from the contraction of the vessels of the granulations, in their union and levelling, giving a glazed appearance to their surface as the secretion ceases, and the (quasi) pellicle begins to form. But the act of cicatrization consists not in any fresh deposit; it is simply the last stage or completion of vascularization which renders the transparent lymph surface nebulous or opake, and this always commences from the margin whence the vessels are derived, and is progressive from the circumference to the centre. The actual form of membrane is never accomplished, such as could be separated by fair dissection at any stage, from a cicatrix; it is a permanently opake unsecreting surface, a condensation of the

new lymph with the cellular texture beneath or surrounding it, serving the negative purpose of a semi-organized covering, viz. protection to the part. Like all other new structures, it is a copy, and differs, as all copies do, whether of nature or art, from the original.

CHAPTER XII.

OF GANGRENOUS INFLAMMATION, AND GANGRENE.

I DO not employ the term "mortification," because it is not technically explicit, and has been vaguely and indiscriminately used. Nor shall I use the term "sphacelus," because gangrene is a sufficient synonym, if the term gangrenous inflammation be accepted, which presents the stages of recoverable and irrecoverable, threatened and devitalized texture. A gangrened part is never restored. By the arrest of gangrenous inflammation the gangrene may be circumscribed, and by the supervention of other processes, the dead may be cast off and the living part repaired with more or less loss of substance. The special use of the term sphacelus has been to designate a state of utter death, in which the part becomes subject to chemical changes, as if severed from the body, and such meaning I affix to the substantive term "gangrene."

I shall first consider the characteristic signs and appearances of gangrenous inflammation.

The signs of pain, heat, redness and swelling are present in the inflammation, which from its outset announces the disorganization and death of the parts affected by it. But the pain is more rapid and intense than in other modes of inflammation, and in proportion short-lived; the heat, augmented only in the commencement, and little perceptible externally, in comparison with the burning sensation often expressed by the patient; the surface of a peculiar dusky red, often mottled, turns purple and then black; and the swelling, diffused and soft to the touch, presently becomes inelastic or doughy, and next emphysematous. Vesicles of various size appear, filled with a sanious fluid. In the course of a few hours the pain and sense of burning are at an end, and the colour is changed to a pale ash or a buff hue by desquamation of the cuticle, and greatly shrunken in volume from the free discharge of a fetid sanies. Such are the appearances of acute, also called, humid gangrene.

If the inflammation occupies a circumscribed space, it is generally consecutive upon and defined by the adhesive inflammation: if it appears in several contiguous spots or patches, the whole of the intervening surface,

and more or less of the subjacent and surrounding part, partakes of the inflammation and is marked for destruction; if, as often happens, it is of irregular size and shape, and the surrounding margin darkly discoloured, tumid and painful to the touch, it is spreading, and rapidly travels along a continuous surface without check, to the destruction of texture and generally of life.

The depth to which gangrenous inflammation penetrates beneath the integument is subject to great variety. It is sometimes superficial, and at other times involves the entire diameter of the part; a toe, a finger, the foot or the hand; the cellular membrane only, or in addition, the muscles, blood-vessels and bone.

In some rare instances gangrenous inflammation takes possession of an entire structure, as, for example, hand or foot, or even a limb up to its connection with the trunk and beyond it; and the indication is the sudden subsidence of agonizing pain, change of colour to a pale bluish hue, loss of temperature and of sensation, so that the limb looks and feels like grey or clouded marble. I have seen in two cases the upper and lower extremities of the same side so affected in the same patient. The rapid dissolution of the vital principle in such instances anticipates the march of disorganization: such cases are generally depending on nervous prostration from injury

or operation, attended by peculiar circumstances of aggravation, or yet more frequently, peculiar temperament.

Functional defect of circulation, depending on the deteriorated quality of the blood or other cause of defective innervation, gives rise to the gangrenous inflammation of the extremities, the lower especially, which are the seat of chronic ulcer, or abraded by superficial wound or sore; and when so arising in aged, debauched or much debilitated persons, partakes of the nature of chronic inflammation in the slowness of its progress, and is now and then susceptible of arrest by a supporting treatment, and even of healing after slough or amputation.

The chronic gangrene, properly so called, is generally an idiopathic affection, *i. e.* independent of injury; I have never known it to be traumatic. It does not bear the semblance of inflammation, though this may succeed to it. It affects only the extremities, and more frequently the lower than the upper. It is frequently insulated, confined to a single toe; in other instances it extends to all the toes of one foot; sometimes, but not often, affects both feet, rarely the hand or fingers. The main distinction between this and acute gangrene is, that from the first the part thus affected, losing its temperature and colour, becomes dry, tough and shrunken in-

stead of moist, soft and swollen, and takes on a yellow or blackish-brown appearance, nearly resembling that of a mummy. It is also called dry gangrene. In general it is without pain or contiguous inflammation; in some instances the burning pain, on the contrary, is continued, and so intense as to be almost insupportable, although the neighbourhood shows no sign of inflammation, nor does the pain when present arise from that source. In almost all these cases the arterial circulation, root and branch, is more or less impaired and defective from organic change.

Gangrenous inflammation may be primary, *i. e.* no other mode of inflammation going before it. The circulation of the part and neighbourhood becomes stagnant, and the vessels, both arteries and veins, are choked with broken and semi-solid coagula. Is it due to the vehement intensity of the local inflammation and consequent exhaustion of the nervous life of the part? or to a constitutional condition, which renders the solid or fluid elements incapable of entertaining the functions of the part, on which depend its temperature and principle of resistance to external agents, in other words, its life? In all cases not produced by external injury, and in many that are so produced, I believe that the latter is the true explanation.

The death of the branch is due to the impaired vitality of the trunk; the blood has undergone a change, and with it all the organs concerned in its distribution and depending on its influence. Inflammation is in such circumstances an extraordinary effort, incapable of being supported, yet instinctive to every form and mode of vitality threatened with dissolution. It is the lighting up before death which the part, like the system, actually exhibits at such an epoch.

Although gangrenous inflammation is never inseparable from constitutional causes, and when primary, is to be especially referred to them, it is in many cases directly originating from the severest forms of local injury, or consecutively to diffused inflammation, as for example, erysipelas, supervening upon the injury. Where the injury is slight, that has given rise to gangrenous inflammation, it has generally been preceded by this species of inflammation, which opposes no check to its progress.

The operation of heat and cold, and their sudden intertransitions, the operation of stricture and ligature, and various chemical agents may be productive of gangrenous inflammation, but the state of gangrene, or disorganization produced by the complete and sudden

arrest of the circulation, is distinct from gangrenous inflammation, and is not often followed by it. The distinction consists in the latter being a purely local casualty, finding the constitution capable and disposed in most cases to throw it off by the processes of adhesive and ulcerative inflammation. But to this there are exceptions. When the gangrene falls upon a part necessary to the ordinary functions of life, as the intestine, the adhesive and ulcerative action have not time afforded them for completing the separation of the gangrene, owing to the direct fatality of the obstruction, from whatever cause arising. Or if the gangrene occupy a large portion of the body, or its surface, as in burns, the powers of the nervous system are so prostrated, that even before inflammatory action can show itself, death ensues.

The injuries to which gangrenous inflammation succeeds are generally violent and complicated, and such as loosen all the connecting textures, whether crushing mutilations, bad compound fractures and luxations, or such deep and extensive effusions as compress and annihilate the internal circulation of a part. Thus, I have seen a subfascial effusion, following a severe strain of the fore-arm, producing a spreading gangrenous inflammation of the extremity to within a hand's breadth

of the axilla; and similar cases, of suppuration between the deep-seated muscles of the thigh, I have known terminate suddenly in gangrenous inflammation of the entire limb to the groin. Injuries of nerves particularly, are liable to be followed by gangrenous inflammation: of this I have also seen some marked examples. Baron Larrey found reason to attribute the gangrene of the foot following the operation for popliteal aneurism to the nerve having been injured, or included in the ligature. Yet complete paralysis, interception of sensation and motion, may exist without a tendency to gangrene. The surface, however, is deprived of its protecting power; and where exposed, as on salient points, to pressure, artificial heat, &c., it inflames, and the inflammation is gangrenous.

Gangrenous inflammation, in the larger number of cases, is secondary to intense cutaneous and cellular inflammation, and so common is this association, that the term "gangrenous erysipelas" and "carbuncular abscess" are in practical use to denote these combinations, and the distinction of gangrenous from adhesive and suppurative inflammation. It is an acute inflammation directly disorganizing, because the resisting power of the parts affected by it is inadequate to sustain the circulation; this becomes stagnant and

imperfectly coagulated in the larger vessels, for the blood loses the coagulating principle as it dies, while a non-vital transudation of their fluid contents loads the surrounding cells with sanies, with which pus is intermixed, where the suppurative process has preceded the gangrenous; and the whole texture perishes and putrifies. That it is a substantive mode of inflammation is shown by its occasionally idiopathic existence, as well as its distinctly marked primary characters; by its supervention in decayed or diseased habits on very slight forms of injury, and especially by its tendency to spread along the neighbouring sound parts from the extremity towards the centre.

The arrest of the circulation is the proximate cause of gangrene. Now this may be sudden or gradual, whether the occasional cause be external or from within; from chemical, mechanical, or vital agencies. Heat and cold, chemical and mechanical disorganization, stricture and ligature, are all capable of acting instantly and completely, or indirectly and imperfectly. If their action be instant, the after-condition of the part destroyed is that of dead animal matter, *i. e.* it is delivered up to the action of the atmosphere, and decomposed by putrefaction. If it be gradual, the changes are compounded of a remnant of vital action and the action tending to its destruction; or

in other words, the local circulation, though circumscribed and crippled to the last degree, is not annihilated. Inflammation in the first case (instant arrest) can only be a consequent, and bounded, of course, by the line of life in the contiguous parts; in the second case (gradual obstruction) it may be the forerunner and accelerator of the gangrene, for wherever there is circulation there is susceptibility of inflammation. Suppose the case of a ligature as it is applied in phlebotomy, and a tourniquet screwed home as at the moment of amputation, and each left untouched: in the one we should have gradual swelling to distension with heavy burning pain, then ecchymosis, and phlyctenæ or sanious vesicles, particoloured and changing hues, soddened surface, and crepitating integument; in the other, an universal livor or blackness would be followed by direct loss of temperature and sensation, collapse or shrinking, and dissolution of texture. Even the fetor of dying is distinguishable from that of dead animal matter, until putrefaction assimilates them.

Or suppose the case of a loop of gut violently protruded and girt as if with a string (as we tie a nævus or a pile), so as to preclude the entrance of blood, and another portion gradually strictured by congestion, as, for example, in the large irreducible herniæ that stran-

gulate themselves. Both are discoloured and collapsed, perhaps rent. But in the last we have the broad ash-grey spots upon the claret-coloured ground, tags and patches of dead lymph, and sloughs or ulcerated holes, indicating that inflammation has supervened upon increasing congestion, and speedily become gangrenous.

In the first, then, of either of these cases, the part dies independent of inflammation; in the second there has been a life-struggle; there is evidence of inflammation, but it is gangrenous.

The difference of these cases is that between the open artery and the obstructed vein in one, and the non-admission of blood into the vessels in the other: the latter we may dismiss from further consideration. But opposed to the former, we may have the obstruction on the arterial side, the veins being free. Thus the interrupted or imperfect action of the heart from disease of its walls or valves, or contraction of its orifices, may induce gangrene; and ossified and aneurismal arteries, as well as the varicose state of both orders of veins, severally predispose to it, and may equally become causes of gangrene.

The dry gangrene is that which we commonly see associated with diseased heart and arteries. The venous trunks are rarely the seat of varix; and with the vari-

cose condition of the superficial veins, considering the frequency of the case, it is rare to see this form of the disease coincident. It is by signs of accumulation on the venous side, and of the imperfect change of the blood in the lungs, that gangrenous inflammation, the acute form of the disease, is marked from its commencement, and varicose ulcers of the legs in old people not unfrequently inflame and turn gangrenous.

Pressure from tumors and morbid changes of structure may obstruct either the contiguous trunk of artery or vein, one or both. Infiltration, from effusion into the cellular membrane of the secreted fluids, natural or morbid, acts diffusedly to produce stagnation, then strangulation and gangrene, independently of any acrimony of their quality, though this may of itself be a sufficient cause. The resistance formed by an unyielding texture, as a strong fascia under excessive distension, or even an unyielding bandage, has often led to the same result. I have seen an enormous mammary abscess, and other similar unrelieved collections of deep-seated matter in cellulous parts, as around the anus, involve the whole neighbourhood in sudden gangrene. It is indeed by a circumscribed or partial gangrenous inflammation that large tumors and abscesses, left to nature, effect their openings.

On the other hand, enervation from age, starvation and exposure, or even from shock, is competent, without any organic change of the vascular apparatus, to originate the same morbid condition.

The grades and shades of inflammation liable to be produced by mechanical obstruction must vary as the obstruction varies; therefore, if in place of the mechanical, we calculate the varieties of obstruction from internal or vital causes, and at the same time remember that all inflammation has its origin in capillary obstruction, we may not only allow for the several varieties of gangrenous inflammation, but understand how all the processes of inflammation throughout the entire range stand related, and how a part threatened with, or on the verge of gangrene, may recover its healthy circulation and uninjured texture, as sometimes happens; how an adhesive, suppurative, or ulcerative inflammation may turn gangrenous, or the system be rescued from destruction by the gangrene and separation of a part. These considerations, as it appears to me, simplify the problem of gangrenous inflammation.

The fever of gangrenous inflammation is as strongly distinguished from that of adhesive and suppurative as the actions are dissimilar; and this also marks the difference of acute and chronic, or, as they have been

termed, moist and dry gangrene; especially of a purely local gangrene, or the casual death of a part, from gangrenous inflammation. Acute and cold abscess are not more distinguished in this respect.

The fever of gangrenous inflammation is one very early marked by powerlessness of the circulating system. The pulse has at no time the full and firm swell, nor the hard and contracted stroke of fever in other modes of inflammation. It is increased in frequency, and diminished in diameter and force; in many cases irregular, and in some intermitting. A peculiar anxiety of expression appears in the physiognomy, and a remarkable livor overspreads the face, the features of which, the nose and lips especially, are contracted and pinched. The anxiety is soon exchanged for a hebetude of expression, as if the patient were under the influence of alcohol or opium; involuntary movements and tremors affect the hands and fingers, and frequent sighings are observed, which are broken by occasional hiccup. The inclination for food fails totally, the surface of the tongue is coated with a brown fur, harsh and dry, leaving the edges and tip free, but without moisture. As the case advances, the entire tongue, fauces and lips, become dry to incrustation, so as to require constant moistening, but with small quantities of fluid, for swal-

lowing is slow, and attended with difficulty. The skin, which in the onset was dry, opens to a copious but clammy perspiration over the whole surface. It parts sensibly with its temperature, and feels cold as well as damp. The mind, at first irritable, then, after the total subsidence of pain, stupid, wavers and becomes subject to illusions, chiefly of a passive and transient kind, expressed by half sentences, with a thick and broken articulation, and accompanied with startings and momentary gleams of insane excitement.

In traumatic inflammation of this species, the age and constitution being previously in its full vigour, this low delirium is exchanged for fits of active and wild frenzy, accompanied with loud cries and vehement efforts, requiring a powerful and continual restraint; and this continues, with occasional intervals from exhaustion, for hours together, and subsides, often suddenly, in prolonged coma and apoplectic death. Whether the exhibition of alcohol and stimulants, with which the patient is plied, has to do with this symptom, or in what if in any degree, is doubtful; but I believe neither medicine or cordial has any permanent influence over this state. I never saw a case of idiopathic gangrene, or a gangrenous inflammation, unpreceded, as in hernia or enteritis, by nervous shock, attended by this sym-

ptom. Neither do I remember to have seen it in burns, which are open to the operation of shock, though of a different description. In erysipelas affecting the head the delirium is generally passive, and extends only to incoherent talk, except when preceded by concussion or severe injury. The more advanced symptoms of dissolution, as the death-like coldness, the clammy sweat, the small, indistinct and flickering pulse, and the cadaverous expression, no one who has seen them can fail to recognize. In this state a patient will sometimes lie totally insensible, and unable to articulate or to swallow, for eighteen or twenty-four hours, and die without a groan or struggle.

The condition of local gangrene from casualty, widely distinguished from that of gangrenous inflammation, exhibits the powers of the system roused to resistance and self-preservation, by the setting up of adhesive, suppurative, and ulcerative inflammation, and in a considerable proportion of cases with success. In very aged and enfeebled persons, the gangrenous inflammation follows upon these local disorganizations, and then generally proves fatal. But these are exceptions; and the contrast is the more marked between the local and the constitutional character of the cases respectively, showing how the previously exhausted or collapsed state

of the system determines both the idiopathic and traumatic gangrenous, or typhoid inflammation.

The conversion of simple acute into gangrenous inflammation in certain cases, as after the apparently timely relief of strangulation in hernia, and after traumatic erysipelas, from slight abrasions and such minor injuries, in aged people, *i. e.* the easy access of the febrile condition or constitutional state peculiar to gangrene, not only determines and explains the existence and frequent fatality of gangrenous inflammation, but the generally successful issue of the cases of frost bite, stricture, and other examples of casual and local gangrene.

Gangrenous inflammation, therefore, is to be regarded as essentially of constitutional origin in all circumstances: its local termination is the same disorganization as follows from the work of destroying agents; in this extreme result alone do the inflammation of gangrene and the state of gangrene touch and analogize. When we speak of an inflammation passing into gangrene, we convey that the system is the medium through which such a change is expected or effected, and that thereby the whole character of the action is changed. For the process of sloughing (separation or disjunctive ulceration), to the extent necessary to clear a wound of

spoiled textures, is a local process indispensable, and which excites no reasonable alarm, if the surrounding inflammation is of the adhesive kind, and the ulceration confined to the adhesive line, accompanied by a free suppuration. These are indications of tranquillity of system and consequent power of the parts, whether the destruction is of the extent of a caustic issue or involves the hand or foot. But if the spot of acute gangrene, idiopathic or from injury, be surrounded by the gangrenous inflammation, which spreads rapidly and kills as it spreads, without provision for its arrest or its separation, we turn with well-founded alarm to the system of which it is a part, taking no comfort from the small extent or perfect reparableness, in other circumstances, of the mischief hitherto inflicted; we feel that so indicated, the failure of constitutional power is the fearful odds against which we have to contend, and this is corroborated by inquiry into the constitutional symptoms, and the pre-existing state of the patient's health and habits.

To conclude: gangrenous inflammation, always originating in weakness, whether violence be combined with it or not, is never a process conservative of structure; and in this regard stands contrasted to all other inflammatory processes. It is by the promptitude and

activity of these that its destructiveness is limited, and its mutilations, as far as possible, repaired. The absence of hemorrhage, owing to the coagulum of death, which chokes all the vessels far above the line of separation, is the temporary stay to its fatality; the adhesive process taking the lead, as has been shown, of the ulcerative, converts this into a permanent safeguard, and, with the additional aid of the suppurative, not only follows up and repairs the line of breach, but assists to remove the rubbish.

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