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## PLASTIC SURGERY.

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THE Surgical Art Formative (*πλάσσειν* to form) boasts of a high antiquity, and was resorted to in remote times, as at present, to repair, remedy, or conceal the ravages and disfigurements of disease, as well as to lessen the deformities produced by the execution of judicial decrees, by natural defects, or by the accidents of personal or general conflict. That branch of this department of surgery which has for its object the restoration of noses, very probably antedated the other branches, as the records of Indian and Egyptian surgical art seem to indicate; but while the subdivisions of the art multiply, as various organs or parts are concerned, the principles governing all plastic proceedings remain the same. The synonyms of this department of surgery are numerous; thus, *Chirurgia Plastica*; *Morioplastice*, from *μοριον* "a part," and *πλάσσειν* "forming;" *Transplantatio*; *Chirurgia Anaplastica* and *Chirurgia Autoplastica*—names preferred by Velpeau and Blandin, and derived from the Greek, the one from *ἀνά* "again," and *πλάσσειν* "to form," that is, to fashion anew; the other from *αὐτός* "one's self," and *πλάσσειν* "to form," to form of, or out of, one's self, or "self creation" (Gross)—whence the words *Anaplasty*, *Autoplasty*; and finally *PLASTIC SURGERY*, or that province of surgery which is distinctively formative.

Among the foregoing appellations I revert to *Transplantatio*, which signifies absolute removal from one part and implantation into another, to point out that such transplantation of larger portions of the body has been designedly accomplished, or an accidentally ablated part successfully reapplied, or blood transfused—all instances of total separation before adjustment, or, in the case of the blood, of perfect abstraction and introduction into the circulatory system of another individual; and that the same end has been mediate effected as in Roux's operation, that of "Autoplasty by successive migrations of the flap." And I would associate with these instances of union of larger surfaces, or multitudes of germs, the modern operation of Reverdin, known as *skin grafting*, by which extremely small portions of integument, and even epithelial elements scooped from the rete, after being totally separated, are implanted or "grafted" upon the surface of tardily healing ulcers, as of burns. Adhesion soon occurs, and is followed by proliferation around the transplanted germs, whether these have been derived from the subject himself, or from another person; whether they are pigmented or otherwise. The transplantation of the spur of the cock, from the leg to the comb, is a familiar example of this mode of procedure, as is also the translated flap of Roux; but in these instances, vitalized adherence terminates the process; whereas, in the case of skin grafting, as practised by Reverdin and

others, the stranger germs are extremely few in each grafted particle, but they form the centres or foci of a cell-formation which gradually but surely spreads and closes over the reluctant surface.

### HISTORY OF PLASTIC SURGERY.

Though we cannot fix the exact period at which plastic surgery was first practised, yet we may be sure that it must have followed with a kindly hand the barbaric use of power and the cruel resentment which were displayed at an early period of the world's history, especially in India, in the mutilation of offenders by the lopping off of ears and noses. And in ancient Egypt, also, Rhinoplasty was known and practised, as Galen declares, and as may readily be believed if we accept as indirectly confirmatory, the Ebers Papyrus, "the Hermetic Book of Medicines of the Ancient Egyptians, in Hieratic Writing," of unknown authorship. And it is also interesting to observe that in the "Secret Book of the Physicians" the science of "the beating of the heart and the knowledge of the heart" are referred to, as taught by the priestly physician, Nebsect. Ebers believes the Papyrus to have been a compilation made by the College of Priests, at Thebes; and assigns the writing to the middle of the sixteenth century, or more precisely to the year 1552 B. C. This date, as is commonly supposed, was prior to the departure of the Israelites, and, according to generally accepted chronology, Moses, in 1552 B. C., was just 21 years of age.<sup>1</sup> The same author, Professor Ebers, of Jena, in an original work "Ouarda," in which he assures the reader that all his statements are based upon authority, besides furnishing evidence of the high position reached by Medicine in the reign of Rameses II., alludes to its division into twenty-one specialties, such as are accepted and practised at the present day, and gives prominence to the thoroughness with which the science and art were studied and practised by the priest-physicians of a great era in Egypt's history. The Roman Hippocrates, Celsus, who lived about one hundred and fifty years before Galen, in the reigns of Augustus, Tiberius, and Caligula, speaks of the restoration of the ears, the nose, and the lips, by the aid of the neighboring skin, and also of reparation of the prepuce. Galen says but little of the treatment of mutilations, and this is copied by Paulus Ægineta and others of his followers. Antyllus mentions coloboma and its repair. And Malgaigne, in his introduction to Paré's Surgery, refers to an Italian family, named Branca, as conservators of the art of restoring noses during the middle ages, and as having invented new methods.

In the year 1597, at a time when learning received a new impetus, appeared the very remarkable and erudite work of Gaspar Taliacotius, entitled "De curtorum chirurgia per insitionem," in two volumes, published in Venice. In this treatise, Tagliacozzi, besides describing minutely the operations for restoring or repairing mutilated lips and ears, gives special prominence to his original method of reproducing noses, in which the flap is taken from the arm, and which has ever since borne the title of the *Taliacotian* or *Italian* operation to distinguish it from the *Indian* or *Oriental* operation, in which the flap is obtained either from the forehead, the cheek, or even the nose itself. The Indian operation was first put in practice in London, in 1814, by Carpue, and afterwards in Germany by J. F. Dieffenbach, who, at the end of the first third of the century, gave great development to the subject, to which he drew attention by the publication of his experiences and of his improved methods. Subsequently, in France, Blandin, Jobert (de Lam-

<sup>1</sup> Charles Rice, in N. Y. Daily Tribune, Nov. 9, 1875.

balle), Serres, Roux, Denucé and Verneuil; in Belgium, Burggraeve and Verhaege; in Germany, Zeiss, Von Ammon, Hoffacher, Baumgarten, Langenbeck and Schuh; in England, Liston, Pollock and Spencer Wells; and in the United States, J. M. Warren, Pancoast, Mütter, Gurdon Buck and others, both by their writings and practice have made themselves deservedly eminent, and, occupying a high position, have placed both the profession and the public under obligation. In reviewing, however, the copious bibliography of plastic surgery, I deem it not unfair to give a well-earned prominence to American Surgeons, whose ingenious and felicitous operations and practical treatises and contributions to science have established the reputation of their authors upon an enviable and enduring basis.

### LESIONS REMEDIABLE BY PLASTIC SURGERY.

The term Plastic Surgery, says Verneuil, "signifies, then,<sup>1</sup> in surgical language, the repair or restoration of an organ changed in form, by the aid of a loan effected in the patient himself, and made at the expense of neighboring or distant healthful parts." "It remedies deformities of deficiency or excess by operations of *anaplasty* by *autoplasty*, which term ought to be restricted to cases characterized by a deficiency of substance as a lesion, and by an organic borrowing from the same subject as an operation. And this double character serves (1) to establish differences between the method in question and the other anaplastic methods, and (2) to distinguish *autoplasty*, properly so called, from *heteroplasty*, which borrows substance from a stranger organism, and from *prothesis*, which replaces lost parts with artificial ones made out of inorganic materials."

It is evident that the occasion for the operations of plastic surgery must arise from congenital defects or deficiencies, from atrophy or wasting after birth, or from actual losses of substance, whether by disease or traumatism. And it is equally obvious that different causes may bring about the same result—deformity—as in the cases of excision of a bone and its congenital absence; the loss by mutilation of part of an organ, as a muscle, and its atrophy from lesion of its tutelary nerve; and the total loss of substance produced as in the cutaneous structures, by traumatism upon the one hand, and by disease upon the other. It is unfortunate that in many deformities, such as arrests of development and total deficiencies of parts, the condition is irremediable; in some, however, plastic surgery alone may make amends; whereas in others this reparative art needs the aid of artificial appliances or substitutes which enlightened surgery must perforce employ. And here, before going further, I would call attention to the absolute necessity for accurate diagnosis; for the positive recognition and determination of the nature of the cause or lesion, and of the actual condition of the part or organ. Whatever be, in general, the need for precision in matters surgical, anticipating operative procedure, there is no department of the art in which a correct appreciation of the causes and consequences of deformity, or lesion, leads to better courses and results in practice.

Plastic surgery deals, then, with deformities congenital or acquired. Among the former are to be ranged atrophies, arrests of development, and infra-uterine mutilations, which latter sometimes involve a part or the totality of a member; and, further, to quote Verneuil, who himself cites Geoffroy Saint Hilaire,<sup>2</sup> as saying that congenital deformities are more frequently met with at the

<sup>1</sup> Verneuil, Art. *Autoplastie*. Dict. Encyc. des Sciences Médicales. Paris.

<sup>2</sup> Tératologie. Paris, 1836.

periphery of the body. "Surgeons may make the same remark." "Arrest of development, atrophy, or mutilation of central parts, compromise life much more certainly than the same lesions affecting the members, the tegumentary folds, the nose, lips, penis, ear, etc." The further remarks of Verneuil upon deformities, considered with a view to their relief by plastic surgery, deserve notice in this place, as also his classification of the lesions to which this branch of the art of surgery "has been most happily applied."

"Deformities by deficiency, compatible with life, may be arranged in three categories, reference being had to their radical cure.

"(1) The absolutely incurable. For example, the total or partial absence of a member, bone, or muscle; marked atrophy in an extreme degree; loss of substance, too deep or too superficial, but very extensive, are cases in which autoplasty can do nothing.

"(2) Cases in which autoplasty can only mask, palliate, or mitigate the deformity without being able to restore both form and function; in which, whatever loss is sustained, absence of the part cannot be compensated for by borrowed tissue.

"(3) The last category comprises those cases in which the loss of substance is of small extent, and affects membranous organs only. Nevertheless, even in these cases, the deformity may be repaired without recourse being had to autoplasty; for example, a vesico-vaginal fistula of the bas-fond of the bladder, in which the margins may be simply united. . . . But things are very different if the loss of substance be great, if the skin be naturally adherent to the subjacent parts, if it have lost its flexibility, its mobility, its extensibility in consequence of disease. Here autoplasty becomes a necessity."

And in this place a general view should be presented of the lesions in which plastic surgery has been more or less happily called upon; but finding the enumeration of Verneuil so apposite, we do not hesitate again to draw material from his admirable article quoted above.

"(1) *Perforations and fistulæ*, which establish a communication between a cavity, a reservoir, or a mucous canal, either with a neighboring mucous organ or with the exterior of the body.

"(2) *Mutilations, total or partial*, of projecting appendices, cutaneous folds, or membranous curtains, which circumscribe the natural apertures.

"(3) *Superficial losses of substance*, not penetrating into cavities, having destroyed a more or less considerable extent of skin or mucous membrane, in a single region, or at the commissures."

And again, the state or condition of the deformities under consideration demands their division into the following categories:—

"(1) Those without tendency to natural repair.

"(2) Those met with or created before natural repair (wounds, the extirpation of tumors).

"(3) Such as present themselves after nature's efforts at repair."

It is evident that in the wide field of action vaguely defined in the preceding pages, surgery has offered to it a great variety of disablements and disfigurements, produced under many conditions, but which may be referred to congenital vices, arrests or absence of development, traumatism *in utero*, or the result of infelicitous use of instruments; to injuries of all kinds; to burns; or to the external manifestations of diseases, and their vicious spontaneous healing with loss of substance, or repair by distorting cicatrices; to gangrene, and to losses produced or provoked by wounds, however inflicted. It is equally apparent that, in dealing with these departures from the normal, the resources of plastic surgery must be taxed, and the aid of artificial substitutes or supports invoked. And not only are these arts exercised upon parts in which disease has done its work, but, as in the rebellious ulcers left

by burns, heteroplasty, manipulating minute flaps or particular masses of germs, attacks by the process of skin grafting, and forces repair in the midst of a tardily granulating surface. Heteroplasty, formation by borrowing from another organism, is also practised in the *transfusion of blood*, by which portions of the blood of man or other animals are introduced into the veins of those who have suffered great losses of the "mother of all the tissues," and who are revived by the refreshing stream. Not only so, but intravenous injections of *milk* have been employed successfully by Prof. T. Gaillard Thomas and others, in cases of very considerable post-partum hemorrhage.

#### GENERAL PRINCIPLES OF PLASTIC OPERATIONS.

When all conditions agree in determining a resort to plastic surgery, no principles which govern this branch of the art should be lost sight of. They are not numerous, but their application under many circumstances of difficulty requires the nicest exercise of judgment, more especially in certain cases in which a plastic operation cannot be repeated. For example, in a case of double harelip which fell under the writer's care, the lateral fissures, on either side of the maxillary bone, extended deeply towards the orbits, and the clefts through the soft parts involved the lip, the cheeks, and the eyelids, and were traced in each eye into a coloboma iridis. In this and similar instances, an error in judgment, compromising much marginal substance, might defeat the present, as it would most probably the final, success of an operation otherwise well devised. The risks, however, of failure in difficult cases, those in which arrest of development has left considerable and intricate spaces, or in which disease or traumatism has produced deformities demanding for their relief an appeal to all the resources of art, are diminished by dividing the proposed operation into a number of lesser operations, or *séances*, so that, like an Alpine mountaineer, the surgeon shall undertake no step forward until abundant security has been obtained for the advance. Thus an original operation, limited in its scope, may be made the foundation of a series of secondary procedures, the success of each of which will render that of its follower less doubtful, and will multiply the chances of a favorable issue for the case.

A comparison of deformities and lesions will serve to arrange them all into two groups, as far as plastic surgery is concerned; the first requiring for its extinguishment or repair simple approximation of parts—widely sundered, it is true, but separated by the unopposed and not vigorous traction exerted by the physical properties of some of its elements, and the vital property of others; the second necessitating a borrowing from the immediate or remote neighborhood, and the localization and interpolation of new flaps or pieces. It may be claimed as self-evident, as it is also shown in practice, that the frequency of fortunate results in the former group is in accordance with the lack or low degree of tension, and with the analogy, or rather identity in nature, of the tissues restored to their original relation, or even, urged a little farther, made to bridge over a gap left by a minor loss of substance. In the latter group, the same absence of stretching or tension must mark the adjustment of flaps, and the same analogy of tissues must be preserved in the selection of pieces to be permanently transposed. Besides all this, it is requisite and necessary that the flaps should be well provided with nutrient vessels, whether they be destined to retain their continuity with the mother tissues, or to lose their original basal attachment by severance as soon as they shall have acquired sufficient adhesion in their new position. It must also suggest itself to the surgeon that hairy parts should not, if possible, be repaired with

bare flaps, and that hairy flaps should not, upon pain of ridiculous disfigurement of the patient, be translated to regions normally devoid of hair. The end of a re-made nose would be an undesirable termination of that organ, if it were made to bear a tuft derived from a well-covered scalp.

Another circumstance tending towards the successful ending of a plastic operation, is recognition of a due proportion between the size of the gap to be filled or bridged over, and that of the flap. And it must be well borne in mind that, as by cicatrization a "natural autoplasty" (Verneuil) is accomplished by the simple traction of the cicatricial tissue, it may be necessary, under different circumstances, to employ a flap smaller, the size of, or much larger than the space to be covered. A flap borrowed from situations in which the tissues are lax, ought to be many times larger than the opening or chasm; for, by the natural elasticity of its elements, the flap is greatly reduced in size, and, inasmuch as it will not bear tension, scantiness of material may lay the foundation of failure in the operation by rendering firm union between the freshened surface and the borrowed piece impossible, and by inviting and producing inflammation and gangrene. Of course, such a condition of things would be a misfortune, since positive and extensive loss of substance in the flap, or destruction of its totality, is usually repaired with difficulty, if even the damage thus occasioned should not preclude the possibility of a repetition of the operation. Wherefore the surgeon must assure himself of the just proportions, as well as of the form, of the proposed flap, making due allowance for shrinkage as well as for ulterior atrophy, which sometimes follows a perfect union. But even here, it may be added that flaps of sufficient thickness, as well as size, and abundantly provided with bloodvessels, are much less liable to ulterior atrophic contraction.

#### CLASSIFICATION OF PLASTIC OPERATIONS.

From what has been said, it will readily be admitted that all plastic operations may be arranged in five categories. The *first* comprises all those in which the borrowed piece is obtained *from a distance* and transferred directly to the seat of its future residence, retaining, however, for a time not determinable with precision, its connection by means of a pedicle with the tissues of its original site; to the *second* belong those cases in which the autoplasty is accomplished, after the method of Roux, by "*successive migrations*" of the flap, from a point more or less remote; the *third* includes all operations in which the flap or flaps are derived from the neighborhood, and are moved into place by *gliding*, or made to assume proper relations by *stretching* or by *lapping over*, as when a periosteal flap is made to cover the end of a severed bone after amputation; the *fourth* embraces all those operations of simple *approximation*, as after the V-shaped piece is removed for the relief of ectropion, or for the attempted cure of epithelioma of the lip, or, more primitively, when the freshened "*vivified*" edges of a vesico-vaginal fistula are brought into contact, and maintained in apposition with more or less tension. Under the same caption may be inscribed several of the methods for bringing about adhesion in ununited fractures of the bones, the broken ends being, under some circumstances, vivified, and made adherent to one another by means of silver wire, or of a screw or screws of the same metal. Lastly, the *fifth* category comprehends all *readjustments* of totally severed parts, as a nose or a tooth, authentic instances of which species of repair are not sufficiently infrequent to be wonderful. In this category are also to be enumerated the famous skin grafting by *greffes épidermiques*, or *dermo-épidermiques* of Reverdin; the grafting by larger bits, or *anaplasty*, of Sée,

Ollier, and Poncet; the transplantation of particular or greater morsels derived from a stranger organism, *heteroplasty*, whether that be human or animal; and, finally, transfusion of blood.

#### GENERAL RULES FOR PLASTIC OPERATIONS.

In the majority of the operations and methods enumerated, immediate union, or union by the first intention, of the newly juxtaposed parts, is the aim and hope of the surgeon, although sloughing or gangrene to a small extent may not wholly defeat the intention of the operator. But a scrupulous attention to the general condition and surroundings of the patient, the adoption of a carefully studied plan of operation and observance of its minutest details, and a sagacious and watchful after-management of the case, are circumstances which lead to if they do not insure success, and which must be had in view and closely followed out if success is to be the issue. Among the evil consequences of an unwise disregard of detail, may be mentioned gangrene, as depending upon a poverty of the nutrient supply of the flaps, whether by reason of its attenuate pedicle, its thinness, the scantiness of bloodvessels in the pedicle, or their choking by excessive tension or twisting, or upon want of protection. The manner of making the sutures, the choice of proper material for them, and the distance from each other at which they are placed, will and must influence the mode and time of union of the wedged parts, and bring about, or not allow or favor, union by first intention. And thus portions along the line may fail to heal, and suppuration may permanently interfere with a union which, in other situations, is firm enough. And a disregard for the quality of the air in which the subject of the operation lives, as loaded with the miasmata of fever or erysipelas, or the prevalence of the latter disease as an epidemic, may not only set the operative skill of the surgeon at naught, but may open a door in the patient's body for the entrance of a fatal complication.

In this connection, a very important circumstance ought to be made conspicuous, and this is that the hiatus left by the forced loan imposed upon an innocent feature, must itself be the subject of the same interest which attaches to the locality benefited. It may sometimes be left to cicatrization and ultimate shrinking of the scar, but not unfrequently adhesive straps invite or force approximation of separated margins, with or without preliminary loosening of the integument and connective tissue done with a view of facilitating approach, or linear or crescentic incisions may be employed to transfer deformity to unimportant situations, by promoting instant adhesion of tissue margins separated by loss of substance. It was with this intention that the writer, after removing, by a long elliptical incision, a considerable melanotic tumor from the front of the thigh of an itinerant Methodist preacher, who made his circuits on horseback, practised on either side of the longitudinal gap a deep incision parallel with the neighboring margin, dissected up the bands lying between the incisions and elliptical space, and brought the margins together in a line on the convexity of the thigh. Immediate union occurred along the whole extent of the line, while the lateral cicatrices were so placed as to escape friction from clothing or other matters which the front of the thigh was called upon to bear.

But loss of substance, if it be of limited extent, may not always require the translation of a flap, or may not call for any further abstraction of tissue. Thus for freshening the margins of some buccal fistulæ, experience has shown the advantage to be derived from the employment of the actual cautery, or the thermo-cautery of Paquelin, applied at a dull-red heat and at

several sittings, the operator relying upon the cicatricial contraction produced by the healing of the successive burns, for the extinguishment of the distressing and unsightly aperture.

Among the interesting documents which bear upon this subject, I would refer the reader to one by J. R. Marinus,<sup>1</sup> entitled "Considerations upon Heteroplasty or Autoplasty by Heterogeneous Transplantation," a compendium of remarkable cases of parts restored and replaced. This author quotes Reissiger,<sup>2</sup> as being the first who proposed to replace an opaque human cornea with a healthy one derived from an animal [an operation which has been, of late years, successfully resorted to in several instances]; and afterwards Mæsner, and subsequently Dieffenbach, who both attempted "keratoplasty" upon animals, but whose experiments led them to the conclusion that, since the cornea when nearly separated did not reunite, transplantation to another eye offered still fewer chances of success. And, on the other hand, Marinus assures us that Rudiman reports that in India belief is so strong as to the possibility of reunion of a cut-off nose, that the executioner is commanded to throw the piece into a brazier, to prevent readjustment.

In this country, as is well known, plastic surgery has been much cultivated, and practised with remarkable success. The operations and most valuable contributions of Prof. Joseph Pancoast are guides and texts for surgeons, and the work and practice of Mütter are monuments in this department of the art of surgery, but we would regard this notice as incomplete without reference being made to Prof. Gilbert,<sup>3</sup> among whose successful cases may be mentioned the construction of two noses by the Indian method; to Dr. Gurdon Buck,<sup>4</sup> whose triumphs are familiar in the department of restorations; and to Dr. Detmold,<sup>5</sup> to whom both the profession and the public owe so much.

#### SKIN GRAFTING.

Under the *fifth* caption we have grouped, and therefore associated together, a number of facts which acquire relationship by reason of the complete separation of the parts re-applied and fixed by restitutive autoplasty, as of the *nose*, of which Hoffacher, officially present at duels with rapiers fought at Heidelberg, reports several successful cases, and notably one in which the organ lopped off was seized by a dog, but being rescued, although cold and moist, was, after careful cleaning, re-attached. Bits of fingers, lopped off, have been known to adhere vitally after replacement, and teeth also have taken hold when transplanted; indeed transplantation of these ornaments of the mouth was, within a century, a fashion in some countries, in which, it is said, sound front teeth of fresh country girls were purchased by fading belles to replace their own carious incisors or canines. It is remarkable that with such experiences, which, perhaps, were not confined to the later centuries, surgeons so slowly recognized the facts, *first*, that portions of the living body might be sundered from it without immediately losing life; and, *secondly*, that these portions, so removed, could contract vital adhesion with another part of the same individual, or with some part of another person or creature. But, like the discovery of the circulation of the blood, the separate anatomical and physiological truths of which were known even from the time of Galen, the

<sup>1</sup> Annales de la Société de Médecine d'Anvers, 1842.

<sup>2</sup> Baier'sche Annalen, 1824, Bd. 1., Stück 1, S. 209-215.

<sup>3</sup> Med. Examiner, new series, vol. vii. Philadelphia, 1851.

<sup>4</sup> Bulletin of the New York Academy of Medicine, vol. iii., and elsewhere.

<sup>5</sup> Bulletin of the New York Academy of Medicine, vol. iii. Paper upon Plastic Surgery.

discovery of the phenomena of germination of anatomical particles when transplanted, was reserved for very modern times, although glimpses of the real significance of the process of healing of wounds and ulcers had been enjoyed in early ages.

Perhaps Prof. Frank H. Hamilton, of New York, may be regarded as the first who attempted to generalize upon the experience of the past, when, in his clinique at the Dispensary of the Geneva Medical College, in January, 1847, he proposed to a boy of fifteen years a plastic operation, with the view of planting upon the *centre* of an ulcer a piece of new and perfectly healthy skin, taken from the calf of the other leg, and not intending to cover over the whole sore, but, perhaps, two or three square inches, which he believed would be enough to secure the closure of the wound in a short time.<sup>1</sup> And the reporter affirms that this proposition had been made to the lad two years before. Dr. Hamilton's earliest operation of the kind was not done, however, until January 21, 1854, upon Horace Driscoll, in the Buffalo Hospital of the Sisters of Charity. An account of this operation, contained in a paper entitled "Old Ulcers treated by Anaplasty," read before the Buffalo Medical Association, June 27, 1854, was published in the *New York Journal of Medicine* in September of that year. In the summary, the following remarkable sentence forms the *fourth* of six propositions: "If [the graft be] smaller than the chasm which it is intended to fill, the graft will grow, or project from itself new skin to supply the deficiency." The *fifth* proposition refers to a probable *expansion* of the graft, and the *sixth* asserts that "in consequence of one or both of these two latter circumstances, *it will not be necessary to make the graft so large as the deficiency it is intended to supply.*" In this we observe the declaration of a principle, not new in fact, but original in its direct suggestiveness, implying a knowledge of the strength of *border growth* of new skin in an ulcer, of the weakness of the *middle part*, and also of the means likely to repair, or capable of remedying, the deficiency. The fact was known long before, and is still familiar in the text-books of surgery, as we find Erichsen saying, "Indeed, if the ulcer be large, there may not be enough [new skin] for the cicatrization of the centre." What Hamilton accomplished, and no doubt intended, if his words mean anything, was the establishment of a new basis of skin-formation where it was most needed, and his credit does not rest upon the performance of a simple anaplasty.

The generalization of the idea which guided Hamilton was made by Dr. J. L. Reverdin, *interne lauréat* of the Hospitals of Paris, in 1869, for on the 8th of December of that year he presented<sup>2</sup> before the Society of Surgery a patient who belonged to the service of his "excellent master," Dr. Guyon, and on whom he had practised a new experiment, for which he proposed the name of *epidermic grafting*. It consisted, to use his own words, "in transporting to a granulating wound little bits formed out of the superficial parts of the integument."

"This experiment had been suggested to me," he says, in an admirable article published a few years later,<sup>3</sup> "by having observed little epidermic islands which formed spontaneously in certain wounds; I asked myself if, by a graft, we might not obtain the formation of similar little islands of cicatrization, and thus hasten the cure; therein was a double interest, physiological and practical. The result was such as I dared hardly hope; not only did the little morsels continue adherent to the granulations, but presently they began to extend and form an island of cicatrization." And then the author, surveying the field likely to be covered by skin grafting, reproduces a part

<sup>1</sup> Buffalo Med. and Surg. Journal, Feb. 1847, p. 508.

<sup>2</sup> Bulletin de la Société de Chirurgie, 1869; Gazette des Hôpitaux, Janvier, 1870; British Med. Journal, Dec. 10, 1870.

<sup>3</sup> Archives Générales de Médecine, 1872, t. i. pp. 276, 555, 703.

of his communication to the Société de Chirurgie, and concludes with these words: "Finally, I shall have to study, as much as possible, the histological process. Is there here the simple effect of contact, or vicinity? Is there proliferation of the transplanted elements?" During the progress of experimentation, many questions, of course, arose, which have not yet all been answered; but after the adherence of the grafts was accomplished, and epidermis was observed to form around them, Reverdin came to the conclusion that "the epidermis by itself, but still the living epidermis, that of the deep layer, would alone be necessary for the success of the grafting." And again, "the adherence of the graft is, therefore, effected by the epidermis; the welding of the dermis is but secondary and accessory; the part played by the dermis in the properties of the formed islets is, therefore, completely null." But the grafts remain, and are not absorbed; yet, as Poncet<sup>2</sup> expresses the idea, "The cutaneous graft not only is not re-absorbed, but it possesses all the properties of the skin."

The views entertained by Reverdin with regard to the epidermis seemed to him to find confirmation in "a little fact" which was that, in some cases, he found upon the strips of plaster grafts which, put in place the evening previous, had failed to unite, but which, upon being replaced, "took" perfectly.<sup>3</sup> We shall see, further on, that Georges Martin,<sup>4</sup> in his thesis "upon the duration of the vitality of the tissues and of the conditions of adherence of cutaneous restitutions and transplantations," ascertained, through observations of his own, that some separated bits of human skin maintained their vitality, when exposed in free air, for ninety-six hours, and others in a confined space for one hundred and eight hours, at a temperature of nearly zero, C. [32° F.].

Hamilton failed to perceive that, without peduncular attachment, his little flap might adhere and grow; but Reverdin saw this, and so earned his honors. He communicated his discovery to the Société de Chirurgie on the 8th of December, 1869; the commission to which it was referred, consisting of MM. Guyon, Chassaignac, and Desprès, made a report; and Guyon, in whose service the experiments were made, presented the subject verbally, and provoked a discussion hardly favorable to skin grafting. But Verneuil declared himself in favor of the method, which he believed was calculated to render service in many departments of surgery. Gosselin, Guyon, Alphonse Guérin, and Duplay offered encouragement, and extended facilities;<sup>5</sup> and Marc Sée dispelled the bad impressions remaining by presenting, six months afterwards, a patient who bore evidence of the success of the operation,<sup>6</sup> in which Sée had been aided by Reverdin himself.

Grafting now became the fashion; M. Vulpian<sup>7</sup> presented before the Société de Biologie, in the name of M. J. M. Phillipeaux, a case of transplantation of the spur of a young cock of forty days upon the comb of the same animal, in which the spur became incorporated with the skin, formed no adhesion with the cranial bones, but surpassed in length its non-transplanted fellow. Some grafted the skin of the white man upon the negro;<sup>8</sup> or took grafts from moles or parts stained with India ink;<sup>9</sup> or borrowed skin from amputated members;<sup>10</sup> or even supplemented, in the case of a large ulcer after a burn in a little girl, some three hundred grafts from the patient herself,

<sup>1</sup> Loc. cit., p. 707.

<sup>2</sup> Lyon Médical, t. xiv. pp. 293, 294, 1873.

<sup>3</sup> Loc. cit., p. 709.

<sup>4</sup> Georges Martin, Thèse, Paris, 1873.

<sup>5</sup> Archives Gén. de Méd. 1872, t. i. p. 277.

<sup>6</sup> M. Sée, Gazette Hebdom. de Paris, Juillet 20, 1870; J. Ustariz, Sobre los Injertos en general, etc. Anfiteatro Anat. Español. Madrid, 1877; and E. T. Easley, Am. Med. Weekly, Louisville, Ky., 1876, vol. iv. p. 353.

<sup>7</sup> Comptes rendus des Séances et Mém. de la Soc. de Biologie, t. II. 5e Série, Année 1870.

<sup>8</sup> G. T. Maxwell, Philad. Med. Times, 1873, p. 37.

<sup>9</sup> J. T. Hodgen, Cell or Skin Grafting. St. Louis Med. and Surg. Journ., 1871.

<sup>10</sup> B. Anger, Sur l'Hétéroplastie. Comptes rendus hebdom. des Séances de l'Acad. des Sciences, t. lxxix. p. 1210. Paris, 1874.

with a score of others derived from a young pig.<sup>1</sup> Animals, also, were made the subjects of experimentation; indeed, some years before 1869, with regard to animal grafting it was proposed to "unite," or "glue together," two animals by their cutaneous envelopes, and even animals of different species.<sup>2</sup> Some, like Reverdin, preferred small grafts; others, as M. Ollier,<sup>3</sup> thought better of larger ones, even reaching the dimensions of eight square centimetres, or, as Donnelly,<sup>4</sup> employed those of a diameter of a quarter of an inch. Savrey, quoted by Georges Martin,<sup>5</sup> asserts that "two Swedes, to give each other a durable remembrancer, exchanged a bit of skin of the inside of the forearm;" but the most remarkable graft ever applied was one of which we find the account in the discourse of Ustariz already referred to. It is as follows:—

"Armaignac says that, in the seventeenth century, there is seen a light glimmering in this direction, quoting a case, related by an ecclesiastic named Kraeminkel, of a soldier who had lost a large part of the hairy scalp and of the bone beneath it, the surgeon closing this opening with a portion of bone and skin, of the same form and dimensions, taken from a dog which he killed for the purpose. As it appears, the Church being apprised of the matter, there were launched against the poor surgeon all the anathemas and furies of which that institution is capable; and it became necessary for his return into the communion of the faithful that he should practise a new operation upon the unfortunate soldier, ridding him of that unclean spoil of dog which had become strongly consolidated with the adjacent parts, and, as Armaignac facetiously remarks, subjecting him to a treatment more conformable to the Christian character."

The whole matter of skin, or, as Reverdin calls it, epidermic grafting, was liberally treated by that author in the *Archives Générales de Médecine* for the year 1872. His method, exceedingly simple, may be expressed in a few words. Taking usually his little bits from the inner surface of the leg, he rendered the skin tense over the flat surface of the tibia, and introduced the point of a rather large venesection lancet parallel to the bone, and to the depth of a half millimetre; then pushing it forward so that the point should emerge three or four millimetres further on, the little piece was cut loose by the edges of the instrument. "The little wound," he adds, "is the seat of a fine sanguineous dew." "I apply," continues the author, "my lancet, bearing the graft, upon the granulations which I have selected, and slide it upon them with the point of a pin. It is thus in relation with the granulations by its deeper face, and I ascertain, by a motion from side to side, that no part of its edge is rolled up, for it is necessary that it should be completely spread out. This result once obtained, and all my grafts in place, I cover them with strips of diachylon plaster, which are not removed for twenty-four hours." Sometimes the grafts were furnished by the subject himself; at other times they were successfully borrowed from a different person; now they were obtained, as at Guy's Hospital and at St. Bartholomew's, from limbs recently amputated; or, again, they were derived from the cadaver, soon after death, as by M. Prudhomme.<sup>6</sup> One fact, says Reverdin, would be of great importance "if it were perfectly demonstrated." Dobson and Laroyenne<sup>7</sup> found it necessary and advantageous to borrow grafts from young subjects to implant upon aged patients. But, from his own experience, the inventor of the process does not "venture to draw a definitive conclusion" upon this point. We learn also

<sup>1</sup> Thomas F. Raven, *British Medical Journal*, London, 1877, vol. ii. p. 623.

<sup>2</sup> P. Bert, *Exp. et Consid. sur la Greffe Animale*. *Journal de l'Anat. et de la Physiol. normale et path.*, t. i. pp. 64, 87. Paris, 1864.

<sup>3</sup> Ollier, *Sur les Greffes Cutanées ou Autoplastiques*. *Bull. de l'Acad. de Médecine*, Paris, 1872, pp. 242, 246.

<sup>4</sup> Donnelly, *New York Med. Record*, 1872, p. 572.

<sup>5</sup> Georges Martin, *op. cit.* p. 14.

<sup>6</sup> *Lancet*, May 20, 1871; Thèse de Colrat; Reverdin, *loc. cit.*

<sup>7</sup> *Med. Times and Gazette*, Oct. 29, 1870; Colrat, *op. cit.*; Reverdin, *loc. cit.*

from Reverdin's memoir that grafts were taken by himself and others from negroes; that little bits derived from different animals could be successfully grafted; and also that Czerny and others had transplanted pieces from the mucous membranes.

We have, so far, traced in brief detail the method of the pioneer himself, and reproduced his views at some length, for the reason that his observations were so exact, and his practice so sure, that those who followed him made but little change in the plans proposed, found few opportunities for new applications of the practice, and emitted not many original views as to the plans of operating, the mode of attachment of the bits of tissue, or the general laws of physiology applicable in the mass of cases, or in particular instances. But real progress was, perhaps, determined by the recognition of the elements upon which proliferation depended, and of the fact that the marginal cicatrix was formed from all the borders of the grafts; although N. C. Dobson<sup>1</sup> had declared, as early as 1870, that the growth of cicatrix was not unlimited, and that no one island exceeded the dimensions of a sixpence. And the same may be said with regard to the conditions necessary to success, for, as all ulcers tend towards or must be brought to the form of the common or typical ulcer in the process of healing,<sup>2</sup> so must all ulcers, for a favorable reception of the grafts, be already covered with willing granulations, or be made to be covered with them. To express the same idea in the words of Reverdin, "the end to be attained when we wish to prepare a wound for grafts, is to obtain [a surface of] granulations as well defined as possible." And it is here of interest to record the fact that, in speaking of the growth of the little islands, as determining the rapidity of cicatrization, Reverdin informs<sup>3</sup> us that the observation of a case of ulcer in which the formation of pellicle advanced from spontaneous "ilôts," gave him the first idea of "*la greffe épidermique*."

But rapidity, although promoting a prompt cure, was found to be associated with solidity, and this latter quality with permanency. For a time, says Reverdin, the cicatrix due to the grafts is a little prominent, but eventually becomes depressed "as an umbilicus;" then around the grafts is formed a whiter, thicker, and more solid cicatrix, and one which resists relapses.<sup>4</sup> And although his facts were few, still results seemed to point to the conclusion that "cicatricial retraction and vicious cicatrization" were opposed, rather than favored, by the new process.<sup>5</sup> "I can now conclude," says Reverdin, "(1) That by grafting we may prevent the adhesion (*soudure*) of two neighboring granulating surfaces. (2) That as for retraction, reasoning and certain facts demonstrate that it can be prevented, at least in part, by means of grafts. (3) That the applications [of grafts] made for the cure of certain deformed cicatrices have given good results; these results should be verified by time."

There remains to be briefly noticed Reverdin's view with regard to the part taken by certain elements in the formation of a cicatrix, and to do this I will reproduce his language, premising the quotation with his statement that, "on account of pain and possible accidents, small grafts are preferable."<sup>6</sup> Thus: "The epidermis by itself, but the living epidermis, that of the deep layer, is alone necessary for the success of the graft."<sup>7</sup> "The adherence of the graft is accomplished, then, by the epidermis; the union of the dermis is only secondary and accessory."<sup>8</sup> And finally, the opinion is expressed that we can greatly facilitate the cure of rebellious wounds of which the duration bears no relation to their extent.

<sup>1</sup> Med. Times and Gazette, Oct. 29, 1870, p. 500; Reverdin, loc. cit.

<sup>2</sup> Paget, in Holmes's System of Surgery.

<sup>3</sup> Loc. cit., p. 555.

<sup>4</sup> Loc. cit., p. 564.

<sup>5</sup> Loc. cit., p. 571.

<sup>6</sup> Loc. cit., p. 711.

<sup>7</sup> Loc. cit., p. 707.

<sup>8</sup> Loc. cit., p. 708.

A. Poncet, in the previous year, 1871, had reviewed the whole matter, method and all, in a paper entitled "Des greffes dermo-épidermiques, et en particulier des larges lambeaux dermo-épidermiques,"<sup>1</sup> taking up the same texts. In a discussion upon the subject,<sup>2</sup> participated in by Letiévant and others, the former says, speaking of animal grafts, "I call these grafts zoo-epidermic, in opposition to human grafts which I distinguish under the name auto-epidermic or hetero-epidermic, according as the grafts are gathered from the subject grafted or from his neighbors." Then the means employed to secure the grafts are referred to, the lancet of Reverdin, the scissors of Pollock, the cataract-knife of Ollier—all effecting the lifting of the epidermis and of the superficial layer of the dermis. But even with the weight of testimony in its favor, Letiévant felt called upon to oppose the remark "that the practice of skin grafting should be rejected as hurtful, and that it led to neglect of the important indications of the treatment of wounds," and at the same time undertook the defence of zoo-epidermic grafts, from the dog for example, because auto-grafts were painful, and caused new wounds in the patient. M. Christôt promptly denied that he had declared grafting to be useless, but did not avow himself a partisan of the process; and with this denial further opposition to skin grafting seems to have ceased.

We have presented with some liberality the views of Reverdin with regard to the process of his inventing, frequently quoting his own words. It is here interesting to compare or contrast the ideas entertained by Poncet with those of the master, following upon the discovery of Reverdin, although antedating in publication the formulized expressions of the latter.

At the end of the discussion just referred to, Poncet<sup>3</sup> took occasion to recommend the practice of Ollier in the employment of large and numerous grafts, stating at the same time that he had failed with epithelial grafts alone; and continuing his discourse he goes on to say that "as to the proliferation of the epithelial elements, it is a simple action of the presence of the mucous layer of the epidermis, determining at times the epithelial transformation of the elements of the embryonal tissue, to which it is united. . . . In the seam of junction of the granulations with the morsel transplanted, the same phenomena are observed as in the union of the margins of a wound by first intention. The extension of the graft has not seemed to us to be owing to a proliferation of the mucous layer. It must act by its presence upon the embryonal elements directly in relation with its margins, and thus determine their epidermic transformation." In the same connection we refer to the opinions already advanced by Reverdin, and we propose to adduce those of Coste, as expressed in a conference upon epidermic grafting held on the 31st of May, 1873, at the *École de Médecine*.<sup>4</sup> "How," asks the distinguished professor, "is the adhesion brought about? How is proliferation accomplished? That is very simple. The transplanted epidermis determines by its presence, by its contact, the transformation of the embryonal cells of the granulations into epidermic cells. This, according to Reverdin, Colrat, and Poncet (de Lyon), is the most probable, and even the only possible theory."

On the other hand Mr. Bryant gives utterance to a directly opposite doctrine. In notes from the Wards of the Cork Hospital,<sup>5</sup> communicated by Mr. Martin Howard, we find the following: "The question was asked whether the skin graft was an excitor of skin action, or were the cells proliferated? Mr. Bryant declared that the grafts grew, the skin being prolonged from the graft, and that the border also threw out a growth. This he proved in the following ingenious way. He had a white man under his care, suffering from an ulcer on his leg, and on this ulcer he grafted a portion of the skin taken from a negro in the hospital. As the ulcer decreased in size, the piece of black skin increased considerably." However satisfactory this experiment may have been, the observation is at variance with those of Reverdin and of Coste, the latter of whom expressly declares<sup>6</sup> that "grafts borrowed or obtained from a negro and implanted upon a white person, rapidly lose color and bleach out entirely, from the effect of the progressive absorption of pigment. "I saw," says this author, "a remarkable example of

<sup>1</sup> Lyon Médical, t. viii. p. 494, 1871.

<sup>2</sup> *Ibid.*, p. 520.

<sup>3</sup> Lyon Méd., p. 564.

<sup>4</sup> Marseille Médical, 10<sup>e</sup> année, No. 7, Juillet, 1873.

<sup>5</sup> Dublin Journ. of Med. Science, vol. lxi. p. 388.

<sup>6</sup> *Loc. cit.*, p. 398.

this, a few months ago, at the Hôtel Dieu, in Paris. Besides which I note the rarity of pigment in cicatricial epidermis." M. Coste finds it necessary to preface his remarks with the observation that "in spite of the identity of terms, the animal graft bears no resemblance, either in its course or in its definitive evolution, to the vegetable graft; a radical difference separates the two. What," asks the professor, "is a vegetable graft? It is an individual, or a part of an individual, transplanted upon another individual, which in some way serves as a soil for it. In this soil it lives as a parasite, the transported individual develops and lives a life which is its own, meanwhile preserving its autonomy, its individuality. It is quite different, in the double point of view of theory and practice, with regard to the animal graft. This, borrowed from the individual himself or from another, has essentially for its object the filling up of a loss of substance. The borrowed part and that to which it is united, after reciprocal modifications and influences, coalesce, the one with the other; they end by becoming confounded, by being identical, by living a common life. There is, therefore, no analogy between the animal graft and the vegetable graft; these two grafts resemble each other in name only." We will not follow Coste further, but merely state that he reviews the experiments of Bert, especially the "*greffe Siamoise*" of that observer, the "*rat sur rat*," which tests his own views upon the same subject.

Again, in 1872, M. Reverdin insisted upon the manner of adherence of the grafts, and of their effect on granulating surfaces—for he laid his grafts upon the surface—and declared<sup>1</sup> that he saw grafts from the negro, or black cat, lose color and become altogether white. And in a note upon epidermic grafting, presented by M. Claude Bernard to the Academy of Sciences, at the meeting of November 27, of the same year, Reverdin says: "There results from this histological examination (1) that the adherence of the graft is effected, in the first place by the epidermis, and only secondarily by the dermis; (2) that the epidermis acts by action of contact (catabiotic action, Gubler), in determining the transformation of embryonal elements into epidermis." In the same volume, page 326, may be found a note of M. Ollier, presented by M. Claude Bernard at the meeting of March 18, containing the following, bearing upon the subject before us, namely, the aim and action of the transplanted or transported germs: "As for myself, in transporting large cutaneous morsels I seek to reduce, as much as possible, the natural *épidermization* of the granulations. My aim is to change, upon a more or less extensive surface of the wound, the process of repair. I replace the epithelial layer of new formation with a cutaneous, fleshy, thick layer, stable in its fundamental elements, and destined to fill the rôle of a true skin. It is, therefore, an autoplasty which I perform."

While not attempting a complete history of skin grafting, I have nevertheless followed the idea from mind to mind, and developed, although not at great length, the opinions entertained by the originator himself, as well as by those of his countrymen who stood, so to speak, around him, concerning the part performed by the germs transported and transplanted. The preponderance of testimony seems to weigh in favor of the view that the epithelial germs grow in or upon their new soil, but that a more remarkable phenomenon, to be observed after the transfer, is to be found in the influence which they exert in determining by their presence and contact the transformation of the embryonal cells of the granulations into epidermic cells. And this power does not appear to be limited to the immediate neighborhood of the grafts, but seems to be communicated to the sluggish borders of the wound or ulcer.

Reverdin presented his first case and announced his discovery on the 8th of December, 1869. In England, the value of "epithelial grafting" was at once appreciated, and as early as May, 1870, Mr. G. D. Pollock, of London, had put Reverdin's method in practice, and had tested it in four cases, which, with a number of others, were made the subject of a paper entitled "Cases of Skin grafting and Skin Transplantation," read on November 11, 1870, and

<sup>1</sup> Bulletin de Thérapeutique, t. lxxxiii. p. 71, 1872.

published in the Transactions of the Clinical Society of London, for the year 1871. At first he made a slight incision in the granulations, and imbedded the piece of skin; but afterwards he followed Reverdin closely, laying the graft on the granulations, or surface of the ulcer. He found no difference in the results; but he ascertained it to be essential that the patient should be in good health—a condition which appeared to lie at the foundation of success. With regard to the process of cicatrization itself, I prefer to adduce the words of the author, for it will be observed that, while agreeing to some extent with Bryant, already quoted, in his explanation of the phenomena occurring after, or induced by, grafting, he differs altogether from Reverdin, Coste, Poncet, and other French authorities, and, in differing, presents some new features in the case.

When, as Pollock expresses himself, a graft is successful, there appears a fine, thin, delicate membrane, and in this membrane may be seen a beautiful network of red vessels. Shortly the membrane becomes white, and the vessels disappear. "The membrane is, as far as I can judge, the deeper layer of epithelial cells which possessed the greatest amount of vitality and youth." And, he adds further on, the wave of new pellicle stimulates the margin of the original ulcer, and induces cicatrization. Mr. Pollock's first case was that of a child of eight years, who, her dress taking fire, was burned in both thighs. The left had healed at the time of her admission into St. George's Hospital, but the right thigh presented an ulcer extending from above the trochanter down to the outer surface of the knee. On the 5th of May, the grafting was done, and on the 26th of November, of the same year, the healing was complete. In the second case there were two ulcers; in the third, a chronic ulcer of the right leg; the fourth was one of ulcer over the tibia, from a kick; the fifth one of chronic ulcer of the leg; the sixth, a case of large sore on the chest, from a burn; the seventh, eighth, ninth, eleventh, twelfth, and fourteenth, cases of ulcer of the leg; the tenth, one of serofulous ulcer of the forearm; the thirteenth, one of contraction after a burn, in which, after dividing the cicatricial bands, the gap was grafted, no success following the operation; and the fifteenth and sixteenth, cases of syphilitic ulcer, in both of which the process proved a failure.

The practice of skin grafting soon found favor in England, in spite of misgivings more or less distinctly expressed, and cases were presented to various medical societies. Among the many, we may refer to the cases of Mr. Pearse,<sup>1</sup> in his account of which the author advocated the employment of small pieces, and making a wide gap; and to that of Mr. Raven,<sup>2</sup> who supplemented insufficient grafts from a little girl, with "zoö-epidermical" grafts from a young pig.

The method was adopted in Germany, in which country Dieffenbach had given such development to plastic surgery; into Italy it speedily found its way; in Spain, and other European countries, it became the accepted innovation, as, for example, in Constantinople, in which city Zebrowski published, in 1873,<sup>3</sup> an essay upon skin grafting—"Sur la greffe épidermique"—basing it on observations made upon eight successful cases. In fact, to use the language of Martin Howard,<sup>4</sup> in his communication already referred to, "In the journals will the work of the grafters be found;" an evidence of the lively zeal with which the profession tested and approved of the practice.

It will presently be seen that skin grafting became immediately active in America, reaching almost synchronously the United States, Canada, and Mexico; but we prefer, in order to preserve the autonomy of the subject, to revert to the two questions which arose in the country of its origination, and which have an important bearing both upon the theory and the practice of

<sup>1</sup> Practitioner, vol. viii. p. 36-39. London, 1872.  
Gaz. méd. d'Orient, t. xvi. pp. 136, 137.

<sup>2</sup> Loc. cit., 1877.

<sup>4</sup> Loc. cit., p. 386.

the operation. The first of these refers to the *persistence of vitality* in the grafts; and the second to the size of the particles or pieces translated; questions which, as may be supposed, commanded the attention, not of French observers only, but also of those of other countries, without excluding the members of the medical profession in the United States. Not that these questions were absolutely disposed of in France, but that they were presented in a very formal manner in several papers of note.

The first of these, by Paul Bert, antedated skin grafting, so called, and had for its title "Experiments and reflexions upon animal grafting,"<sup>1</sup> and entertained the proposition "of the preservation of vital properties in parts separated from the body;" and declared that "transfusion of blood, animal grafting, restoration, constitute but one single and immense order of facts, which are properly studied simultaneously, and which might be comprehended under one common formula." Then follow his divisions, (1) animal graft; (2) "marcotte," by slips or shoots; and (3), grafting by approximation of animals of different species. Under *marcotte*, Bert ranges the "Indian method, in which the flap is never for a moment separated from the body." It will be observed that Bert treats of anaplasty and autoplasty, and the same may almost be said of Ollier,<sup>2</sup> of Lyons, who, at a later period, discussed the whole subject of animal grafts, giving preference to larger pieces instead of the minute morsels recommended by Reverdin, approaching the boldness, but not quite equalling the venture, of Hamilton, of New York. Paul Bert's remarkable experiments in animal grafting<sup>3</sup> gave as results the following; of less value from the fact of the adhesion of the tails of rats, than from the length of time which had elapsed since their amputation before they were applied to a stump. Thus tails of rats, separated from the animal for 3½ hours, adhered when grafted, and so did others after a lapse of 7½, 16, 26, 48, 62, 64, and 72 hours, although failure ensued in other cases. And Ollier<sup>4</sup> adduced instances of periosteal flaps 24 hours old, obtained from a rabbit, which adhered when applied to another animal of the same species.

Georges Martin, in his Thesis already referred to, upon the duration of the vitality of tissues, etc., brings together 343 grafting operations, which form the object of 60 personal observations, and, in detailing these, records very surprising experiments and their results; and he quotes Baronio, Gohier, Wiesmann, Dieffenbach and others, and their variable success. But the most worthy of attention are his original experiments and observations, as to the limits of vitality, with cutaneous and dermo-epidermic grafts in the human subject. It would appear that none of his grafts lived and were effective after 108 hours' exposure "in free air" at a temperature of nearly zero, C. [32° F.], but that when kept in tubes, or confined air, under the same circumstances, the grafts were successful. Another experiment, the temperature being nearly at zero, C., was successful after 96 hours, the morsel having been preserved in free air; in another, the temperature being 6° C. [42°·8 F.], the limits were 82 and 96 hours, under the respective conditions of free and confined air; when the temperature was 12° C. [53°·6 F.] they were 72 and 84 hours; when 15° C. [59° F.] the figures were 60 and 72; when 20° C. [68° F.], they were 36 and 36; and, finally, a last experiment, at 28° C. [82°·4 F.], showed the limits of vitality to be 6 hours and 7 hours, in free and in confined air respectively.

M. Martin laments that we have no medicament capable of prolonging cellular life, but he asks the question, whether certain alkaline solutions may not afford the means. In this connection he quotes M. Caliste, as having proved that muscular irritability continues for a long time in a weak solution of potassa, while distilled water destroys it rapidly, and M. Pélikan, who saw frogs' muscles, plunged in these solutions, remain intact after fourteen days. Finally, M. Brown-Séguard noticed contractility of the iris for sixteen days, and accounted for the phenomenon by the residence of the membrane in the alkaline media of the eye. Besides the conditions referred to as favoring adhe-

<sup>1</sup> Journal de l'Anat. et de la Physiol. normale et pathol. de l'homme et des animaux, t. i. pp. 69-87. Paris, 1864.

<sup>2</sup> Bulet. de l'Acad. de Médecine, t. i. 2e série, pp. 242-246. Paris, 1872. "Sur les greffes cutanées ou autoplastiques."

<sup>3</sup> Thèse, 1863. See also Coste, Marseille Médical, 1873.

<sup>4</sup> Traité sur la régénération des os, t. i. p. 417.

sion of the grafts, or "success" as M. Martin calls it, he declares that "longevity is inversely as the mass." Of course, the conditions of the persistence of the life of the graft receive careful attention, and temperature, hygrometrical state, and volume, are referred to as the agents which chiefly influence its duration. Cold, says M. Ollier, favors the success of transplantation; and "elevation of temperature," in the language of Bert, "is one cause of a shorter duration of vitality." Moisture hurries decomposition; and smaller masses live longer than the larger. And, finally, the bit of living tissue to be preserved must be maintained at a low temperature, and in a vessel hermetically closed. Among the conclusions reached by M. Martin, we may give prominence to the following, which bears upon large and small grafting alike; "a separated part preserves its vitality for several days, during which it is apt to contract adherence." "The surgeon, therefore, will always be called in time to replace an organ; besides, he may employ for the reconstruction of a separated organ a bit of tissue some time removed." So that, in preparation for a plastic operation, "tissues may be collected in an amphitheatre immediately or soon after death." It is almost needless to add that the condition of the part receiving the graft, as well as that of the graft itself, must be suitable; for, in order to procure adhesion, the mutual concurrence of the plasmatic cells of the piece transported, and of the breach, is indispensable.

From the foregoing experiments we are led to believe that parts separated from the body retain their vitality for a very considerable time; and, granting that the experiments could be repeated, the surgeon need find no difficulty in appropriating, as has been done, flaps from amputated members, or even borrowing particles or bits of tissue from the cadaver.

As we have already remarked, skin grafting speedily had its claims acknowledged in America; indeed Bernutti<sup>1</sup> refers to the statement of Spautigati as to the communications of Reverdin and of Frank Hamilton, of New York, having been sent in December, 1869, to the Société de Chirurgie, of Paris, but adds that there is in the Bulletins of that Society for 1869, no record of Hamilton, whom Spautigati makes co-author with Reverdin. One of the earliest notices of skin grafting by a writer on this continent, was contained in a paper, published Dec. 12, 1870, by Sr. D. Luis Muñoz, of Mexico,<sup>2</sup> in which the subject was carefully presented; and this was followed by another, accompanied with four cases, by J. M. Bandera, which appeared the following year, in the same Journal. In the same year, 1871, Prof. J. T. Hodgen contributed to the St. Louis Medical and Surgical Journal<sup>3</sup> articles upon "Cell or Skin Grafting," giving cases, and explaining the methods of procuring grafts employed by himself. These were three in number: (1) By snipping off bits of human skin and epithelial layer; (2) by scratching off scales of epithelium; and (3) by removing sheets of detached portions of epithelium. And he grafted also from parts stained with India ink, and from moles. Hodgen was successful in his grafting; but it is remarkable that he obtained results with pigmentary grafting quite at variance with those of Reverdin, Coste, and others in France, although he found them in correspondence with those of Bryant, already referred to in this article. The American author says that when cells of the deep layer of the epithelium are used, the pigment also grows with the growth of the graft, but that when old dry scales are grafted, no pigmentary deposit takes place. It is curious to contrast with the experience of Hodgen that of Maxwell,<sup>4</sup> who, to fill a gap produced in the face by a gunshot wound, resorted to an anaplastic operation, engrafting the skin of a white man upon a negro patient, with

<sup>1</sup> Giorn. della Reale Accad. di Medicina di Torino, t. xxxvii. pp. 35-55, 1874.

<sup>2</sup> Gaceta Med. Mexico, 1870.

<sup>3</sup> St. Louis Med. and Surg. Journal, vol. viii. N. S., p. 289, 1871.

<sup>4</sup> Phila. Med. Times, vol. iv. p. 37, 1873.

the consequence of finding, after three months, that the white skin had lost its distinguishing character, "and that the whole surface of the wound was of uniform blackness." Many experiments were subsequently made, from time to time, in colored skin grafting, but we need refer only to those of J. H. W. Meyer, who reported two cases in 1877.<sup>1</sup>

Skin grafting was now practised in all parts of North America. In Canada, in 1871, in the proceedings of the Medico-Chirurgical Society, of Montreal, we find that Dr. W. H. Hingston evoked discussion upon a paper on skin grafting, accompanied with cases.<sup>2</sup> In Baltimore, Prof. J. J. Chisolm<sup>3</sup> practised skin grafting publicly, and advocated the employment of grafts obtained from the deeper parts; in California, Prof. H. W. Toland recorded a case of skin grafting practised by him in 1873;<sup>4</sup> and in 1874, Prof. D. Hayes Agnew,<sup>5</sup> of Philadelphia, published cases and remarks upon ulcers and skin grafting, reported favorably upon the process, and proposed to supply skin from a portion of the body corresponding to the diseased part, as promising more success.

It were invidious, almost, to withhold the names of the surgeons who made early application of the new process of inducing cicatrization, but the limits of this article forbid the enumeration. We may, however, refer to Dr. Howard's<sup>6</sup> investigation of "muscle grafting," which he believed to disprove the "epithelium theory;" to Dr. M. Donnelly's<sup>7</sup> paper, with cases, on skin grafting as practised in St. Vincent's Hospital; to that of Dr. W. F. Cheney,<sup>8</sup> with cases, in 1872; to the paper and cases of Dr. E. L. Wemple<sup>9</sup> in 1873; to the contribution of Dr. J. W. Trader,<sup>10</sup> in the Medical Archives of St. Louis, relating to a railroad injury in which, after sloughing of the crushed foot, skin grafting was happily resorted to; to the Bellevue Hospital report,<sup>11</sup> in 1873, of the method of setting grafts, referring to the setting of two thousand grafts; to a case of Dr. B. M. Cromwell,<sup>12</sup> with comments, reported in 1875; and finally to Prof. S. G. Maclean's successful treatment of a large ulcer by simple measures and skin grafting.

Before concluding this article, I purpose to briefly review the opinions entertained with regard to the preferable size of the grafts, and begin by stating, on his own authority, that Reverdin always adhered to the small grafts with which he inaugurated his system, and that Mr. Pollock was, in the main, likewise minded. Nevertheless, we find M. Ollier,<sup>13</sup> in 1872, saying that, instead of grafts, little morsels of two, three, or four millimetres square are preferably used, "as is practised by M. Reverdin." And further on, Ollier adduces his favorable experiences with grafts of large size, of four, six, or eight square centimetres, involving the entire dermis, and constituting "a veritable autoplasty;" and expatiates upon the necessity of immobility in the parts submitted to operation, adding that this is best secured by a silicated apparatus. At first he employed epidermic grafts, then dermo-epidermic grafts of one or two centimetres' extent, and finally grafts of skin and cellular tissue; all in one patient, to procure cicatrization after a large burn. He observed, how-

<sup>1</sup> Chicago Med. Journal and Examiner, vol. xxxiv. p. 320, 1877.

<sup>2</sup> Canada Med. Journal, vol. vii. p. 495. Montreal, 1871.

<sup>3</sup> Richmond and Louisville Med. Journal, vol. x. p. 353, 1870.

<sup>4</sup> Western Lancet, 1874.

<sup>5</sup> Med. and Surgical Reporter, Nov. 1874.

<sup>6</sup> New York Med. Journal, Sept. 1871.

<sup>7</sup> New York Med. Record, vol. vii. p. 572, 1872.

<sup>8</sup> Trans. Med. Society of California, 1872, pp. 106, 108.

<sup>9</sup> Pacific Med. and Surgical Journal, vol. vii. p. 381, 1873-4.

<sup>10</sup> Med. Archives, vol. vi. p. 257, 1871.

<sup>11</sup> New York Med. Record, vol. viii. p. 538, 1873.

<sup>12</sup> Atlanta Med. and Surgical Journal, vol. xiii. p. 641, 1875-6.

<sup>13</sup> Bullet. de l'Acad. de Méd. Paris. 1872. 2e serie, pp. 244, 246.

ever, that after four, five, or six days the epidermis fell away, and left the graft bare as if it had been blistered; and concluded, from what had occurred, that "perhaps grafts, called *epidermic*, succeed only when containing a lamella of *dermis*." And that these procedures were successful, may be inferred from the fact that, in 1873, Poncet gave in the *Lyon Médical*<sup>1</sup> an account of the "presentation of a patient bearing autoplasmic cutaneous grafts introduced a year before by M. Ollier." In America also, in 1872, Dr. M. Donnelly, in a paper already referred to, advocated the use of grafts as large as a quarter of an inch, claiming such to be superior to smaller ones; and declared that he regarded the source of supply as indifferent, except that the graft should be taken from a point of least motion, as the insertion of the deltoid.

In conclusion, we may summarize what is known as to skin grafting as follows:—

I. It affords an admirable means of accelerating and facilitating cicatrization.

II. The pellicle produced by its aid is less prone to contraction, and contracts less than an ordinary cicatrix.

III. The deeper layer of the epidermic elements are the chief factors of growth.

IV. The growing cicatrix is formed at the expense of the embryonal cells of the granulating surface, stimulated into activity by the presence of the living cells of the graft.

V. This stimulus, first showing energy in and around central islands of new growth, induces similar activity at the hitherto dormant margin of the ulcer.

VI. Grafts may retain vitality and be effective long after separation from the body.

VII. Small grafts, of the size of millet seeds, for example, are, in general, preferable to larger ones; although larger grafts, as of one-fourth inch square (Donnelly), or even eight square centimetres (Ollier), have had their advocates and successes.

VIII. Grafts should be obtained from the patient himself, if possible, but in all cases the danger of specific inoculation ought to be present in the mind of the surgeon who borrows grafts from one subject for application upon another, or who practises heteroplasty.

IX. Grafts furnished by the aged are less disposed to adhere than those procured from the young, and oftentimes fail entirely.

X. Grafts obtained from one race of men may be successfully used on individuals of another race; and animal grafts may be transplanted upon human beings, adhere, and provoke cicatrization.

XI. Foul surfaces, or those of persons in bad health, will refuse to accept good grafts; but with improvement or establishment of the health of the individual bearing an ulcer, and the appearance of healthy granulations, a favorable result of skin grafting may be anticipated.

XII. Finally, the great benefits accruing from successful skin grafting far outweigh its drawbacks, which are the pain of the operation, and, unless amputated limbs be utilized, the consecutive pain in the parts yielding the grafts, whether, of course, these be autoplasmic or heteroplasmic.

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<sup>1</sup> *Lyon Médical*, t. xiv. p. 293, 1873.

