CLASSIFICATION OF BURNS
A HISTORY OF DEVELOPMENT:
WITH COMMENTS FOR TODAY AND THOUGHTS FOR THE FUTURE

A.B. Wallace

A Thesis Submitted for the Degree of PhD
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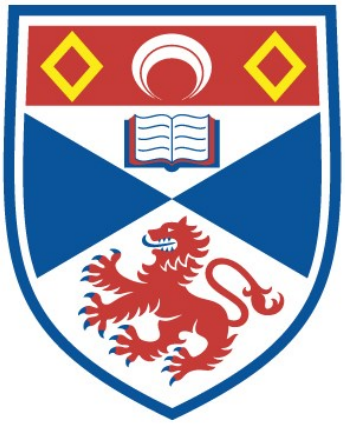

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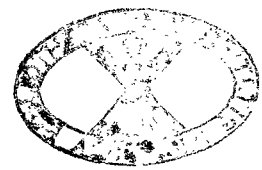

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A History of Development:

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I declare that this thesis has been composed solely by myself and is a record of the work done by me and that it has not been accepted in any previous application for a higher degree.

I beg to submit this thesis for the Degree of Doctor of Philosophy.

I was admitted as a candidate for the degree under Ordinance General No.12 to the Academic Year 1970-1971.

Acknowledgments

The collection of a volume of literature, as has been consulted in this study, was done with the help of many friends, colleagues and libraries.

I would express my thanks to the librarians of St Andrews, Aberdeen, Glasgow and Edinburgh Universities: to the librarians of the Royal Society of Medicine, Nuffield library of the British Medical Association, Royal College of Physicians of Edinburgh, and the Central Library, Edinburgh Corporation, and the Wellcome Institute of the History of Medicine.

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Finally, I acknowledge my great indebtedness to my wife for typing my rough notes, to Miss J. Inglis for typing the first copy and Mrs S. Moyes for typing the final thesis.

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A.B. Wallace

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Introduction

Man, of all animals, according to Greek Mythology, was created last and was therefore poorly endowed with physical attributes. Prometheus, friend and benefactor of mankind, procured fire from the gods on Mount Olympus but this gift has become a two-edged sword by proving both a scourge and a blessing.

In the Encyclopaedia Brittanica fire is described in the following sentences: 'of all discoveries by men fire is one of the most momentous and useful but powerful and dangerous. It is the background and basis of our modern life, domestic and industrial. Traces of fire appear among earliest human relics, even in Paleolithic times'.

SUMNER & KELLER (1927) stated 'it is certain that over the whole earth no fire-less tribe of men has been found ... man is scarcely man till he is in possession of fire'.

Burn injuries have afflicted man from the times of primitive civilization and universally are acknowledged as all too frequent. Most occur in the home to the younger and older age groups and so measured in terms of human sorrow are all the more personal and tragic. Undoubtedly thermal trauma is a major world health issue and in a country like India has become a greater hazard to wellbeing than leprosy.

The treatment of burning injuries has received much attention over the centuries yet results, especially in the more extensive forms, remain uncertain. Traumata from sharp and blunt objects lend themselves to accurate classification and to appropriate measures, but with burns no generally acceptable form of classification has been up to now capable of relation to methods of treatment. What are the difficulties?.

The aim of the thesis is to trace the evolution and significance of the various classifications of thermal injury and to submit a final summary of the attitude of the present and possible procedures for the future.

I am well aware of the problem so well expressed in Ree's Cyclopaedia (1819) that "chronology teaches only the history of dates", and that "in the study of sciences, the only method of impressing the memory with facts, consists in connecting the epochs of them with learned men who have illustrated them".

To form a readable presentation from a mass of information the subject is introduced with an outline of the history of surgery, followed by a short exposition of the burn problem; a section entitled 'the effects of thermal injury' is then presented; the remaining sections are devoted to the evolution of classification by extent and by depth; finally, personal views are offered for consideration with comments for today and thoughts for the future.

OUTLINE of HISTORY of SURGERY

Historical medical books tend to present an uninteresting succession of dates, names, operations, instruments or remedies with little or no reference to the prevailing knowledge of anatomy, physiology, pharmacology, and pathology or of social conditions of the period under discussion.

The history of any branch of surgery - and burns are included/

included - must be seen in the light of surgical development as a whole and in relation to the great names which illumine the years gone by. There are bright or vintage periods alternating with times of darkness or apparent inertia, but all are significant in some way.

An overall picture of progress was painted in the Edinburgh Encyclopaedia (1830). At the times of the Trojan wars, several temples were dedicated to Aesculapius, for his skill in surgery. According to Diordorus Siculus he had been instructed by both Apollo and Centaur, the latter the founder of medicine and surgery. For the next 700 years there was little record of surgical practices, but the classic period of Greek medicine (460-136 B.C.) was adorned by the figure of Hippocrates (460-370 B.C.), a lineal descendant of Aesculapius who gave to medicine its scientific spirit and ethical ideals. His writings were devoted more to medicine than to surgery and by common consent he was worthily termed the "Father of Medicine and the greatest physician of all time". Probably his greatest contribution was the writing of his personal treatises to which he added observations of his predecessors. But in this very act lay a danger to continued progress, well expressed in the words of John Bell, the famous 19th Century Edinburgh surgeon: "most unfortunately for science, Hippocrates wrote with such truth and brevity, with so sound and discerning a spirit of observation, and recited so carefully the signs of danger in all kinds of wounds and injuries, that he has been held in continual reverence and holds an influence over the profession even to the present hour". The art of medicine did progress but that of surgery unfortunately lagged behind. Isolated events however are worthy of record. Herodotus, in the 5th Century B.C., referred to the surgical specialists of Egypt, the oculist and the dentists and the cranial surgeons: in the 4th Century B.C., the great Darius bestowed gifts on his chief surgeon for personal services while/

while in the 6th Century B.C. Cyrus organised medical stations for his armies in the field.

Around 500 B.C. the flourishing Medical School of Alexandria was notable for the introduction of the study of human anatomy. Celsus (1st Century A.D.), a scholar but not a qualified physician, wrote a treatise De Re Medicina which much later in 1478, at the time of the Renaissance, was one of the first books printed. Galen (131-201 A.D.) collected selections of the Alexandrian writings and of Celsus and these along with his own writings provided most of the early surgical knowledge. His descriptions of the qualifications of an operator were impressive. "He must be young or middle aged, have a strong and steady hand, never subject to tremble, to be ambidexter, to have a quick and clear sight, to be bold; and so far void of pity, that he may have only in view the cure of him whom he has taken in hand, and not in compassion to cries, either makes more haste than the case requires or make his cut less than is necessary, but to do all as if he was not moved by the shrieks of his patient". Years later Bichat, the 19th Century creator of descriptive anatomy and army surgeon of the French Revolution, considered two attributes essential to a great surgeon, genius and experience: and certainly in the proper understanding of the many facets of burns these are a great advantage.

With the downfall of Rome came the Dark Ages.

Professor M. Neuburger of Vienna, in his History of Medicine divided mediaeval medicine into four periods: the Monastic (5th to 10th Centuries), the Salernetan (11th to 12th Centuries), the temporary enlightment of the 13th Century, which could be termed Arabic culture, and which became grafted to that of the West and the Pre-Renaissance period (14th Century). But some details of the outstanding men pinpoint the characterеristics of the times.

Paulus Aeginata, so called from the place of his birth, lived in 640 A.D. and practised in Rome and Alexandria. He is said to have invented the operation of tracheotomy. His main claim to fame however is his collection and later publication of all then existing surgical knowledge. His writings remain available to this day. (See Adams, F. 1844-7).

Tragedy struck. The barbarians attacked the centres of civilisation from the north and in 641 A.D. Alexandria was captured by the Saracens under Amrou and the famous library was destroyed. The sciences, literature and the arts sank to oblivion for three centuries. In 820 A.D. the Arabs approached the Greek Emperor in Constantinople for access to their literary and scientific manuscripts including those of Galen; the resultant translations reflected the influence of their culture and their pharmaceutical knowledge.

In the following two hundred years the works in turn of Rhazes (800-932), Haly ben Abbas (died 994) and Avicenna (980-1037), the "Prince of Physicians", appeared. Rhazes compiled a great encyclopaedia of medicine, the Continens, Haly ben Abbas the Liber Regius or Royal Book and Avicenna his Canon. The most accomplished however of the Mohammedan surgeons was Albucasis (1013-1106) and the surgical section of his Collections remained in favour till the Middle Ages.

Following the founding of the School of Salerno, some advance took place, and even more in the 11th and 12th Centuries but surgery continued to encounter the barriers of the bigotry and the ignorance of the Dark Ages.

Richerand, the 19th Century French surgeon, wrote of the times: "the universal ignorance; the horror of blood; the dogma of a religion, which shed it in torrents for useless quarrels ... are circumstances which further explain the profound darkness which followed/

followed such empty labours". In the 12th Century the progress of surgery received yet a further set back when the Council of Tours (1163) forbad the ecclesiastics, who shared with the Jews the practice of medicine in Christian Europe, to undertake any operation with the spilling of blood. From this date the separation of medicine and surgery dated and the latter was abandoned to the laity ..... then tragically uneducated and in general of ill-repute. Fortunately a few priests continued to practise a form of bloodless art. Some individual names are worthy of record. Gilbertus Anglicus (1250), the leading exponent of Anglo-Norman medicine, was the first surgical author in England. His Compendium Medicinae was published later in London in 1510. Bernardus Gordon, possibly a Scot, taught in Montpelier from 1285 to 1307. His Lilium Medicinae was published in 1496. John of Ardern (1306-1390), one of the earliest English surgeons, had much experience in the Hundred Years' War. His surgical writings remained popular for many years.

Surgical books from the 11th to the middle of the 15th Century were influenced by Arabian thought and all contain similar statements, procedures and medicaments. With the rise of Salerno and then of Bologna, Italy became leader in medical thought but by the 13th Century first place passed to France. The most eminent surgical authority of the 14th and 15th Century was Guy de Chauliac (1300-1368). He is considered one of the great medical historians and he also took holy orders. Appointed physician to Pope Urban V, his Treatise on Surgery (1363) remained the classical work in France for many years. Paracelsus (1490-1541) was a controversial figure, though Garrison (1968) portrayed him as "the most original medical thinker of the 16th Century".

The advent of Vesalius in anatomy and a few years later of Ambroise Paré in surgery, ushered in a new era. Frenchmen, not without/

without due cause, consider that Paré holds among surgeons the place adorned by Hippocrates among physicians. He was the first surgeon to establish the scientific care of gunshot wounds and was the author of a classic surgical text. Yet his example was not followed by an expected improvement in surgical standards.

In Italy, in 1563, Fallopius, pupil of Vesalius, published a treatise on ulcers while, in 1597, Caspar Tagliacotius, despised by both Paré and Fallopius, wrote his classic on plastic surgery.

In Germany and Switzerland surgery remained in the hands of quacks till the advent of Fabricius Hildanus. Of particular importance was his book De Combustioni which contained a scientific classification of burns, (1607-8).

At this period in England, Wiseman stimulated interest with his Several Surgical Treatises. In France the reign of Louis XIV was one of pomp and ostentation and surgery was discouraged even though both in Paris and Britain the barbers' and surgeons' companies had become incorporated bodies.

The 18th Century opened with an era in surgery of intellectual progress of astonishing proportions especially in France with Petit (1674-1730), Le Dran (1731), Sabatier, Desault (1744-1795), Boyer (1757-1833), while in Germany there were Heister (1683-1758), and Richter (1742-1812). Great Britain too shared in the advance with Cheselden (1688-1752), the Monros, primus (1697-1767) and secundus (1737-1817), Pott (1714-1788), the Hunters - John (1728-1793) and William (1718-1783), James Latta (1793), Benjamin Bell (1749-1806) and John Bell (1763-1820). There can be no doubt however that up to the time of John Hunter the fate of surgery and its standards were largely in French hands.

The 19th Century was for surgery a period of steady advance and the famous Edinburgh school reached its zenith. Antiseptic surgery/

surgery and aseptic principles were developed along with methods of inhalation anaesthesia and new possibilities opened: the surgery of the abdomen, the thorax and the brain; much of this was due to one man, Joseph Lister.

The first thirty years of the 20th Century are difficult to assess, especially in relation to wound care but quotations from a foreword by R. Hamilton Russell of Melbourne, a pupil of Lister, in a book by Halford, Lister Redivivus (1928), are, in my opinion, appropriate. He stated: "Lister, were he to return to earth and see what we have done with the heritage he bequeathed to us, would be bitterly disappointed. The very foundation of his system, the antiseptic dressing of wounds, has disappeared; the antiseptic dressings, at which he worked for years so laboriously, have been discarded, and what is worse, not even understood. The multitudinous triumphs of abdominal surgery ..... seem to have obscured the collective surgical vision. Fully one half of Lister's great achievement lay in the dressing of wounds and the preserving them free from bacterial growth; and the dressing of a surgical wound by Lister was one of the most beautiful scientific procedures mortal eye could witness. But this is an art that is quite forgotten today, and an open wound appears to be a thing that may be dressed by anybody, with anything, anyhow ..... we confide our patients' wounds to the care of nurses, as seems to be the almost universal habit of the present day. But we might realise if we think, how much we lose in confidence and precision, and in actual clinical knowledge of wound behaviour".

How true this is in the Britain of today when surgeons judge their work-load in the main, by operating sessions, ward rounds and out-patient clinics. Few, if any, sessions are allotted to dressings where much danger exists. Is there a reason for this attitude/

attitude of mind?. Hamilton Russell offered this explanation : "As the volume of surgery rapidly increased, the time of the surgeon became more and more subject to increased pressure and gradually the habit grew of leaving the dressing at the end of the operation entirely to the house surgeon. In Lister's practice the dressing was carried out as meticulously as any other part of the operation and was full of method and 'points'. Of course, should the house surgeon have no particular interest in the dressing he, being very busy, may quite naturally depute the dressing to the nurse. The nurse puts some sterilised dressing on the wound and thinks she has dressed it antiseptically - or aseptically; at any rate, she has dressed it".

Such is a brief outline sketch of the general background of surgery against which the evolution of the classification of burns will be viewed.

THE BURN PROBLEM

"Burns and scalds are beyond all comparison the most commonly fatal injuries which occur in civil life; and the liability to this accident appears to have been largely increased of late years by the extended use of steam machinery, the invention and universal employment of lucifer matches and the nature of the modern materials and fashion of female dress. They are also, of all accidents those which invoke the most agonising pain and the most protracted suffering, and they frequently condemn the unhappy patient to a life-long mutilation of the most repulsive and distressing kind". Though written over a hundred years ago by Holmes (1860) the words remain pertinent today.

To quote from American Vital Statistics (1952) trauma is one of the leading causes of mortality and morbidity in all countries of the world and thermal injuries result in a considerable proportion - in fact the mortality is greater than that from gastric and duodenal ulceration.

There followed a statement of considerable account - 'Any step which will lead to improved care is of the greatest importance'.

For the purpose of comparison and study, mortality figures are available in many countries but never morbidity statistics, so important for a true picture of social conditions and the adequacy of education, preventive measures and care. Figures of resultant scarring or disfigurement, reduction of movement, deformity or limited function, loss of tissue, psychological disturbance to patient or family, loss of man or woman hours, pulmonary or renal complications, disturbance in general health, etc., do not exist. Much can be gleaned however from a review of the practices and statements of earlier surgeons, their judgments and assessments. With these in mind I quote from a poem of Clowes (1591), the greatest of the surgeons of the Elizabethan period in England. His essays were/

were described by Norman Moore as "the very best surgical writings of the Elizabethan age" (Garrison, 1968). He began:

"Certain Precepts meet for young students in Chirurgerie, gathered chiefly out of Guido Decaulisco, by William Clowes:

"I read that Aristotle the wise and grave Philosopher,
Wrote an Epistle, unto noble King Alexander;
Saying, choose your servitors, by their good and comely face,
For such men are most meete, to be about your grace.
Of the same opinion, the best learned sure are still,
That the countenance doth betray the manners good or ill.
Therefore faith Guido, you shall in no way choose
Any such deformed person, Chirurgery to use,
But one that is ingenious and apt for the demise,
New remedies for new griefs, as daily they do rise.
With a cunning, speedy handsome handling of the grief,
By the third part of Phisick, procuring safe relief.
The things that a good Surgeon, ought chiefly to know
Are naturall, not naturall, against nature also.
Yet they that have learning without practise in the Art,
Do oft more hurt, than help, unto the grieved part,
So practise without learning, ye ought not to admit,
These two may not be separate, that are so duly knit.
There must be a dexterity, and a finesse in working,
A quick remembrance, and a ready understanding.

The poem concluded thus -

A Surgeon would not take in hand any cure or maladie,
The which is past all help or hope of his recoverie,
And he that setteth a day, when his patient shall be cured,
Is but a childish surgeon, you may be well assured.
Hippocrates in his Aphorisms, as Galen writeth sure,
Saith/

Saith four things are needful to every kinde of cure,
The first, faith be, to God belongeth the chiefest part,
The second to the Surgeon, who doth apply the art,
The third unto the medicine, that is dame nature's friend,
The fourth unto the patient, with whom I here will end.
How then may a surgeon appoint a time, day or hour,
When three parts of the cure are quite without his power.
All these things should be observed by surgeons as their homes:
I wish we all could follow this, finis William Clowes".

The last ten lines remain salutory advice to all physicians and surgeons, especially those working with burned patients. There exists no doubt in my own mind that a review of the evolution of the classifications of burns will help towards a greater understanding of the development of knowledge of thermal injury and one is reminded of an Egyptian proverb (Ptah Hotep)* : "the counsel of former days, it is profitable to him who hears them, it is a loss to him who shall transgress them". As one looks back over the years one point becomes clear, that any discussion of classification cannot be separated entirely from that of early therapy and that of healing, but at the same time intelligent classification in theory begets intelligent care.

Why has classification assumed an important role?. Comparison of results of varying treatments are of value only if the burns are of similar nature. Comparison of mortality figures alone is of little value, morbidity figures must also be obtained. Derganc (1971) believed the main advantages of an internationally acceptable/

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*PTAH HOTEP. The God of Medicine was worshipped in ancient Egypt till well into the Christian era.

acceptable classification lay in the avenues opened for mutual interchange and comparison of results which would lead in turn to improvements in care. He also enumerated the reasons for abandonment of the classifications in vogue as inadequate, deficient and ambiguous and emphasised the need to find a common language so that suitable treatments can be more readily planned and introduced.

Though these remarks referred to classification by depth, they could be applied to classification in general. Thermal injury, whether from scalding or burning, can be grouped in several ways : by the extent and depth, by clinical appearance and by the resultant pathology.

Additional factors may influence both the picture and the progress: sex, age and health of the individual, duration of application, portion of body involved, clothing worn, locus of accident, treatment instituted and the absence or presence of complications (including infection).

The divisions of burn classification to be discussed are extent, depth and severity. Interesting observations over one hundred years ago by Holmes (1860) were : "the estimation of extent, a matter which necessarily eludes a formal classification" and "the essential question of the depth or degree".

Though much has been written, classification by extent, depth and severity is by no means a straightforward exercise, not least by reason of the conformity of the human frame, the inherent difficulty in estimation of the volume of a three dimensional lesion, the irregularity and varying proportions of the constituent elements of the skin, epidermis, dermis and appendages and the varying opinions of what constitutes a minor, moderate or severe burn.

The significance and also the problems of classification can be fully appreciated only after a careful study of the response and/

and later effects of the application of heat to a body surface.

EFFECTS of THERMAL INJURY

(Mainly local - primary & secondary)

LOCAL CHANGES. Galen was aware of the inflammatory reaction produced by heat, but not till the first half of the 19th century in Britain were studies carried out in the experimental pathology of burns. John Thomson (1813) described the responses of the blood vessels of the frog's web to irritants. Hastings (1820) continued experimental studies on burns and demonstrated the early contraction of vessels, followed by accelerated blood flow and then dilation and retarded flow. Cameron (1945) in a comprehensive review referred to prior work of Philp (1839), Addison (1943), Travers (1844), Wharton Jones (1850) and Lord Lister (1857).

From experimental work on guinea pigs Mendelssohn and Rossiter (1944) found that irreversible changes took place in epidermal cells at temperatures between 45 and 52°C. and concluded that the living elements of the skin do not differ from other body tissues in their ability to withstand heat.

The significance of acute changes in an area of burning and the evolution of their appreciation have been well described by Sevitt (1957) and by Foley (1970).

Though Lister (1858) did not write much directly related to the subject of burns, several of his experiments were concerned with inflammatory responses and pertinent to the present discussion.

Lister's approach to any surgical problem was along fundamental lines. In one of his early papers "On the early stages of inflammation" (1858) he stated : "It is with the first deviations from health that the essential character of the morbid state will be most unequivocally stamped and it is therefore to the early stages of inflammation that attention must be chiefly directed

in/

in this inquiry". There then followed a description of a friction injury which gave a perfect picture of thermal trauma of the epidermis with involvement of the dermis.

"If the palm of the hand be chafed by long continued friction, as for example in a rowing boat, the first thing that will be observed, when attention has been directed to the part by a feeling of uneasiness, will be that the skin is redder than natural, implying that the vessels are abnormally loaded with blood, and if the irritation be continued, the cuticle will be raised in the form of a blister. If now, the loosened epidermis be artificially removed on the earliest occurrence of effusion, a scarlet raw surface will be exposed; and on pressing the tender dermis firmly with the finger, and suddenly removing the pressure it will be seen that while the redness for the most part have momentarily disappeared, there will be many minute red points from which the blood cannot be expelled. This shows that while the blood is in part still free to move, there are some minute vessels completely clogged with it. Again if dry heat be made to act upon a part of a frog's foot, there will result, in proportion to the elevation of temperature and the duration of its action, undue redness of the vessels, from accumulation of the blood corpuscles; and if the burn has been sufficiently severe, vesication will soon take place as in the human subject. It occurred to me that if instead of the powerful irritants commonly used in these investigations, some exceedingly mild stimulants were employed ..... The material which appeared most suitable for this purpose was warm water ..... the foot of the animal being stretched under the microscope upon a glass plate ..... It was found that the result of the warm application was constriction of the arteries to absolute closure, generally lasting for several seconds and then giving place to dilatation beyond their original dimensions/

dimensions, to which they afterwards gradually returned. The dilation differed in different instances, being generally more decided and more permanent when the water was hotter and longer applied ..... If the warm water had acted for longer periods, another class of symptoms began to show themselves; the corpuscles passing on less freely than the liquor sanguinis through the capillaries, and lagging behind so as to accumulate in abnormal proportion to the plasma, and stagnating completely when the force of the heart was partially taken off through contraction of the arteries, though passing on again when the vessels dilated ..... It was perfectly clear that in these experiments the stagnation of the blood depended on something more than were contraction of the arteries; and it also seemed impossible to account for it satisfactorily as a result of their dilatation.

"If the foot of a frog which is under the influence of chloroform be covered entirely with wet lint, except a small area of one of the webs and a red hot cautery iron be held for a few seconds about half an inch above the exposed part, inflammation will be excited in the area in proportion to the time of the action of the dry heat upon it; but on removal of the lint, the circulation will be found perfectly healthy in the surrounding parts. In the severe cases stagnation is universal in the exposed area, and the epidermis becomes eventually raised by the exudation of serum beneath it; but in milder cases nothing more than accumulation of slowly moving corpuscles is produced, and I have observed this state of the part to continue for hours after the heat was applied. ..... the effect on the blood was ..... not due to the direct action of heat ..... but to some changes which it had effected on the tissues of the part ..... in most cases one of the earliest abnormal appearances is that of the white corpuscles adhering in large numbers to the walls of the arteries, capillaries and veins ..... the adhesiveness is limited to the/

the part irritated.

"Inflammation is sometimes brought about in man in a way strictly analogous to that on which we induce it on the web of a frog's foot, viz. by the immediate operation of some noxious agent from without, as when boiling water is poured on the skin".

Such were the straightforward basic observations of Lister.

Cohnheim (1873), a pioneer in experimental histology and pathology, first demonstrated vascular changes with fluid exudation and leucocyte migration, and also that erythema, the first visible sign, was followed by local stasis and an accompanying faint cyanosis.

Many years later, Lewis et al (1926) demonstrated that water at 51-52°C., when applied to the skin, produced blistering although the subcutaneous temperature did not rise above 42°C. Simonart (1930) in burning experiments on animals found an almost immediate dilatation of capillary and a general increased capillary permeability with in addition a haemoconcentration after a few minutes.

FLUID AND HEAT LOSS. The first use of the term 'Shock' applied to the resultant clinical picture following severe injury is of some interest. Devised from the French 'choc' the word appeared in English in the translation of Le Dran (1743) : 'the bullet thrown from the gunpowder acquires such rapid force that the whole animal participates in the shock'.

John Thomson (1813) described how patients with extensive burns, however superficial, were liable to be affected by cold shiverings which were greatly exaggerated by exposure and by the application of cold.

An editorial in the Lancet 1881 entitled 'Blood changes in Burns' stated : 'in each case the blood was noticed to be remarkably viscid ..... . This condition of the blood naturally led to an estimate of water in the tissues ..... the amount of water was normal. There/

There was here, then, a condition quite different from that met with in cholera ..... . It is not difficult to see that one source of loss of water from the blood after burns is by exudation and evaporation from the burnt surface.

Tappeiner estimated that the loss of less than a kilogramme of water would be difficult to produce the altered composition of the blood found to exist ..... a quantity quickly provided by the extensive exuding surfaces often met with. To show the extent of this exudation, he found that from the reddened burnt skin of a rabbit, thick drops of fluid could always be pressed ..... The question at once suggested itself why, when the blood was thus deprived of water, the tissues did not compensate its loss by yielding up their water. To this Tappeiner gives a twofold answer. First the fall in blood pressure ..... the exudation was not a simple loss of water. No fact in surgery was more familiar to all than that the fluid of the blisters in burns was richly fibrinous and quickly coagulated : that indeed it was not serum, but liquor sanguines. An exudation of liquor sanguines does not of course alter the composition of the fluid part of the blood, but the absorption into the blood of fluid from the surrounding tissues depended upon the difference in density of the two fluids, and therefore after a burn the rate of direct absorption will not be materially altered. The conclusions deducible, therefore, are that after extensive burns so great an exudation of blood plasma occurred from the burnt surface that the blood was concentrated, and the relative proportions of corpuscles and plasma modified even to a fatal extent ; that, owing to a fall in the blood pressure, the flow of lymph into the blood was slackened ..... and direct absorption of fluid through the capillary walls not increased and the loss of fluid was not compensated.' (Tappeiner, 1881).

The first real appreciation of the importance of fluid loss in/

in burns was shown in the work of Underhill, Kapsinow and Fisk (1930) who demonstrated in animals that the capillaries of an area burned became permeable to methylene blue and trypan blue and that in a burn of 16.5 per cent of the body surface the local oedema fluid was equal to 70 per cent of the total blood volume : an important observation when related to fluid replacement therapy. In addition they showed that the capillaries in a burned area became permeable to protein and led to an oedema which attracted further water, salt and protein from the plasma volume and also from the uninjured interstitial parts and from the rest of the body water.

Mitchiner (1935) considered that early serum loss in the first few hours after a burn was excessive but almost ceased at the end of twelve hours. Loss in animals, he stated, had been shown to be greatest in deep burns and to amount to over 70 per cent of the blood volume where one-sixth of the body surface was burnt. As an illustration he cited that a man weighing 65 kilogrammes with one-sixth of his body surface involved would lose in the first twelve hours after injury 3,500 c.cs. of serum from a total blood volume of 5,000 c.cs.

McClure (1936) published interesting practical suggestions : 'The amount of fluid lost from the body owing to an accidental burn may now be calculated : a burn of one third of the surface of the body (female of 91 kg.) with rate of evaporation increased to 1835 Gm in twenty-four hours, the blood volume might be decreased at most by the difference between the normal rate and the rate after injury, or 600 Gm.'. He commented 'Water that leaves the blood probably remains in the body in the spaces in various tissues. Restoration of the normal distribution of fluid, then, depends on vascular and other readjustments within the body'.

Cope & Moore (1947), contributed to a clearer understanding of/

of the biochemistry and volume of burn oedema and showed that much of the fluid loss was inside the body. Plasma loss was shown to be rapid in the first eight hours from burning while the increased capillary permeability persisted to some extent for forty-eight hours. As fluid loss bore a relation to the area of burning, estimation of burn extent became a necessity for guidance to therapy of oligaemic shock.

Moore and Ball (1952), and Moore (1970), stressed the importance of early external fluid shifts and that injured tissues contained fluid unavailable to the rest of the body in large volumes and which could with advantage be classed the third space if the intracellular fluid was termed the first and the extracellular fluid the second physiological compartment. He contended that the third parasitic collection depleted the others and led to internal dehydration. In composition its contents resembled those of extracellular fluid.

Cope et al (1953) pointed out that the hypermetabolism following major thermal trauma was more marked than in any other injury and suggested that this was a response to heat loss.

Lieberman & Lanshe (1957) reduced the metabolic rate in animals by blocking evaporation from burned surfaces.

Moyer (1962) considered the increased metabolic rate to be due to the greatly increased insensible water loss since each gram of evaporated water removes approximately 0.580 K.cal. of heat from the body. Hardy et al (1955) made interesting observations on insensible fluid loss a few years before and found it greatest during the early days of a burn. They found also a correlation between 'loss' and the per cent of body surface burned. They concluded that 'insensible fluid loss' constituted much clinical significance to the fluid therapy of burned patients.

In 1962 Moncrief & Mason demonstrated the considerable evaporation/

evaporation loss in burned patients while in 1963 Fallon & Moyer produced evidence to show that a dry burn eschar transmitted water to the air 75 times faster than normal skin.

Harrison, Moncrief, Duckett & Mason (1964) studied the relationship between energy metabolism and water loss from vaporization in severely burned patients. Among their conclusions were : heat production increased as evaporative heat loss and severity of injury increased : the response appeared to be linear and statistically was highly significant. Total water losses indicated a higher requirement than was recommended for fluid resuscitation during the end of the first or the second week post burn.

Cohen (1966) in addition showed an increased water loss from the normal shown in the early eschar phase. In a very comprehensive article Moncrief (1969) described that 'in thermal injuries, the protective layers of the skin are destroyed and in full thickness lesions the normal vapour barrier of 35 mm of mercury is totally eliminated and so body water evaporates at the same rate as from an open dish of water. In partial thickness destruction the loss of vapour barrier is proportional'.

To illustrate the importance of these facts Moncrief stated that whereas an uninjured person lost by the insensible route (mainly respiratory tree) 15-21 ml/hr/ sq. metre of body surface, an adult with a flame burn of 40 per cent surface area, lost by the same route (but mainly from burnt surface) 100 ml/hr/ sq. metre body surface.

In addition to the water loss, the body lost 560 K calories of heat with the evaporation of each litre of water and so the metabolic demands on such patients were considerable.

Gump and Kinney (1970) likewise emphasized the considerable calorie and fluid losses through the burn wound surface and that early assessment of extent was of much significance in care. They considered/

considered that discrepancies between fluid intake and urine output in burned animals focussed attention on the properties of burned skin and so the terms sensible and insensible loss had been replaced simply by evaporative fluid loss. Gump and Kinney reviewed the physical characteristics and functions of the three major parts of skin and chose the stratum corneum for special mention as they considered that its importance had been misinterpreted and that it formed a tough resilient membrane resembling a fine sheet of semi-transparent plastic which consituted a vapour barrier. When removed or destroyed there was a marked increase in the rate of cutaneous water loss. This comparatively recent new field of observation, related directly to extent, has led to several freshening forms of therapeutic approach : modification of evaporative losses, thermo-regulation, etc.

EFFECT ON SKIN STRUCTURE AND HEALING. Barnes (1933) defined a burn wound of the skin as a solution of the vital but not necessarily of the physical or mechanical continuity. This naturally leads to consideration of the effects of heat on skin structure. Normal skin consists of a cellular or epidermal layer (epidermal in origin) and the dermis or connective tissue layer (mesodermal in origin) with capillaries and nerves, embedded hair follicles, sweat and sebaceous glands. The hair follicles and glands may terminate in the subcutaneous fat.

A burn may involve or may destroy the epidermal layer but leave the corium intact. If the lethal effects penetrate deeper the results are more difficult to determine. This arises for several reasons. First, inadequate knowledge of the histology of skin in different sites, age groups, occupations, race, colour and sex. Little if known of the varying vascular patterns of skin throughout life and of the phasic activities of the skin appendages. Little also is known of the considerable 'gel' composition of the dermis in the baby and/

and its response to thermal injury.

Once histological and histochemical knowledge is increased a greater appreciation of the healing processes will ensue and classification will become easier.

An interesting early description of healing was given by Roser (1862) : 'burns heal just in the same way as other destructions of the skin ; the common opinion that their cicatrices contract to a peculiar extent is without foundation. Such contractions to an extreme degree were found in practice to be almost always the result of burns ; hence the conclusion was too hastily drawn that great contraction is a special quality of the cicatrices after such injuries ; the real reason being that the skin is rarely destroyed to a great extent except by burns.

As influenced by the depth of the burn, four principal methods of healing may be distinguished :- 1st, simple reproduction of the epidermis, often in a very short space of time, in cases where the deeper layers of the skin have been uninjured; 2nd, formation of granulations, of a net-like appearance, by the superficial layer of the skin, followed by a rapid formation of epidermis; 3rd, formation of granulations by the deeper layers of the skin, followed by very slow cicatrization; 4th, formation of granulations and cicatrization by the subcutaneous cellular tissue, the healing being much promoted through dragging in of the surrounding skin by the contracting cicatrix. The second form occurs where the deeper layers of epidermis or epidermis-producing tissue are not destroyed, and may be recognised by the peculiar net-like appearance presented by the surface after removal of the slough, little red granulations projecting from a whitish or yellowish ground. Cicatrization is rapid in such cases because the epidermis has thousands of points from which to spread. The third method of healing is the slowest; the epidermis only/

only spreads from the margins, and there is little or no diminution of the wound by contraction of the cicatrix'.

I find this early description of a superficial, deep dermal and deep burn, fascinating.

A clear up-to-date description of the histological changes during healing has been given by Sevitt (1957) including the partial skin loss (in two) grades, deep partial skin loss and whole skin loss burns.

Mention should be made at this point of the tendency of the scars which tend to become hypertrophic or keloidal during or following the healing of partial skin loss burns. These are found most often in children or young people, less common over the age of sixty, and frequently on sites carrying lanugo hair. Mowlem (1951) and Glucksmann (1951) have written on this considerable problem.

One of the few papers on the overall histological structure of skin is by Gonzales-Ulloa et al.(1957). These authors believed no systematic study of the thickness and histological characteristics of skin had been made. In summary, their findings were that the epithelial covers varied in thickness in the following order - male (adult), female (adult), senescent, and newborn but there were in addition regional variations. Two other conclusions in this paper are pertinent :

(a) The existence of the epithelial cells at variable depths in the dermis should be proved if spontaneous healing of a destructive lesion of the skin is to be considered.

(b) Many factors influence the thickness and histological character of skin : age, genetic background, health, work, mechanical friction/

friction, exposure and pathological influences.

This knowledge is essential before any study of classification can be complete.

Another stimulating study and one seldom referred to is that by Hartwell (1955). In a discussion on burns he wrote : "Only a few articles, and those have mostly been published quite recently, have dealt in a practical way with the histopathology of the burn wound". He proceeded : "The continued existence of the normal epidermis is dependent largely on the maintenance of certain physiological conditions in the underlying dermis. Likewise, the continued life of epithelium which has covered over a wound in the underlying dermis will depend upon those same physiological conditions being present in the underlying scar tissue which becomes a sort of substitute dermis".

Injured dermis heals by collagenous fibrous tissue which after maturation produces a scar. This fibrous healing is distinctive to mesoderm yet is influenced by the process of epidermal healing. The two processes together result in a healed wound but existent pathology in either can disrupt the harmony.

Hartwell stressed a point which to my mind is not sufficiently appreciated by many who treat burns. "The number of living epithelial cells determines the time of healing". As cell-increase plays so little part in primary epithelialisation, cognizance of the number of epithelial cells available to take part in an outward growth extension must be taken. This work of Hartwell supported the contentions of Gonzales-Ulloa. Moncrief (1969) is one of the few writers to infer the importance of the histological picture : he pointed out 'the varying thickness of skin with the atrophy of appendages in old age and their delay in development in the young'.

The possibility that the local destruction of tissue in partial skin loss burns might be progressive has been appreciated, from/

from progressive venous congestion or thrombosis, from progressive oedema, from mechanical and chemical trauma and from super-added infection.

There is no doubt that local applications have over the years done untold harm, well depicted by Dunbar (1934) in a table to illustrate mortality statistics of burns and scalds in the Glasgow Royal Infirmary from 1833-1934. The criticism applied however to some medicaments is not fully justified and this applies specially to tannic acid of which I personally had much experience. Sevitt (1957) wrote that tannic acid may possibly transform a partial skin-loss burn into one involving the full thickness of the skin and quoted Cannon and Cope (1943), Cameron, Milton and Allen (1943) and Brush, Larn and Ponka (1947).

Davidson (1925) in his original paper postulated that the protein constituents of the injured surface cells formed a stable compound with the tannic acid and that further penetration into the deeper lying protoplasm was prevented by this action and the true astringent effect was limited to the most superficial layers of tissue.

Wilson (1929) following painstaking studies reported : in Edinburgh a consecutive series of 117 cases treated by the method (tannic acid) showed a death rate of only 10.5 per cent instead of a former death rate of 38.7 per cent in another large series as closely similar as possible treated by other methods. The conclusion must be that the tannic acid method for the treatment of burns is one of the most important recent advances that have been made in modern therapeutics.

On the other hand Allen and Koch (1942) wrote : 'if there has been loss of only a partial thickness of the skin ..... rapid re-formation of the covering epithelium takes place ..... if the remaining epithelial elements are not fixed and rendered inert by

a coagulating agent.

The misconception could have originated from misdirected enthusiasm. Mitchener (1935) for instance stated : 'better to try to prevent drainage of serum by coagulation of the damaged vessels and their contents, a process which can be carried out only by a coagulant capable of penetration through all damaged tissue and not merely able to coagulate the surface of the injured area, As will be seen, tannic acid in weak solution is ideal as a penetrating coagulant.'

Medawar (1942) was the author of a seldom quoted article 'Chemical Coagulants in the treatment of Burns', several sections are worthy of quotation : 'burns differ from other traumatic lesions not merely because they involve an extensive superficial loss of skin but also because of the persistence of a zone of dead tissue within the lesion itself ..... coagulation therapy may be thought of as an attempt to solve two problems which are directly related to these properties of burns : to form over the lesion a surface seal or "tan", to restrict external fluid loss and to exercise a general protection and analgesic function : and to make dead tissue at all events physiologically external to the body, by converting dead tissue from being part of the lesion to being its most immediate dressing..... Certain chemical coagulants can form compounds with tissue proteins which are stable to the mechanical action of body fluids and totally resistant to digestion by proteolytic enzymes.

A second important factor regulating the choice of coagulants for application to burns is their penetrative power, for on this depends their ability to penetrate tissue far enough to coagulate it, but not so far as to cause significant new damage on their own account.'

From experiments Medawar stated 'the results suggest that tissue fixed by tannic acid is stabilised to the action of body fluids and that in burns coagulated tissue layers must be split off as intact/

intact sheets since they cannot be digested away'. These points of themselves are most instructive but under the heading 'Penetrative power of Coagulants' Medawar wrote 'since coagulants automatically destroy any living cells with which they come into contact, the second set of factors influencing the choice of coagulants for application to burns is that bound up with their penetration power.

Tannic acid and gentian violet are outstandingly the most feeble penetrants of tissue among the range of coagulants examined. Tannic acid may be a violent reagent, but to describe it as a violent coagulant (see R.S.M. Discussion on Burns 1940) is misleading.

Tannic acid and gentian violet are distinguished from the majority of coagulants by a combination of two distinct properties : excessively feeble penetrative power, and the ability to fix tissue'. Medawar prefers the term 'fixation' to 'tanning'.

The final summary stated 'facts suggest that tannic acid and gentian violet cannot cause new damage on their own account when applied to burns : and that the tissue they fix is completely stable to the action of body fluids, and is to be thought of as a wound dressing rather than as part of the lesion itself'.

Wallace (1955) pointed out the value of release incisions to reduce vascular compression and to encourage survival of dermal epithelial remnants. Meade (1958) published an evaluation of tissue destruction in burns in relation to a) the primary injury and b) from secondary vascular effects. He favoured release incisions or surgical decompression. Bennett and Lewis (1958) advocated similar procedures. Derganc (1962) writing on the subdivision of partial skin-loss burns listed the factors in favour of regeneration as the absence of secondary thrombosis in the vascular dermal network, the absence of infection, with cool and dry local conditions. Janzekowic (1968) considered that the majority of burns were deep dermal in type and/

and must therefore be recognised to allow of prompt and adequate treatment to reduce morbidity.

Experiments by Hinshaw (1963) suggested that in some instances in the early stages tissue destruction following thermal injury was progressive, whereas in others the damage was reversible. The ultimate death therefore of some burns might be dependent on the promptness and adequacy of care.

DETERMINATION OF DEPTH. Deep dermal involvement is often difficult to determine, both clinically and cytologically. Loss of sensation as a test was mentioned by Dupuytren (1836) to determine destruction of skin.

Patey and Scarff (1944) appreciated that healing in burns was related to epithelial cell survival in areas of dermal injury and to help in the early recognition suggested for the use of van Gieson's stain (picro-fuchsin). Dingwall (1943) for the same purpose suggested intravenous injection of fluorescein and examination of fluorescence under ultra-violet light. From their studies Patey and Scarff concluded that there were all degress of coagulation necrosis of the dermis in burns and that even with only superficial damage the follicular and glandular epithelium could not re-epithelialise the raw area until the slow separation of necrotic material was completed. They considered this problem had not been adequately studied.

Some tests have been based on vascular adequacy of dermis. Dingwall (1943) used intravenous fluorescein while Gibson and Brown (1945) used Kiton fast green. The pyroscan which takes infra-red photographs, "thermographs", gives promise for early recognition of adequacy of skin vascularity but the initial output is expensive. Jackson (1953) in a comprehensive review considered the pin-prick test as useful a guide as was available.

Hinshaw (1963) considered the difficulty in diagnosis of depth existed for several reasons : the variation in the thickness of/

of skin in different parts of the body and the variation in appearance of flash burns, scalds and contact burns. He upheld a test of sensitivity of the area as an aid to distinction : that a loss of sensation indicated deeper burns, but in experiments on rabbits he found that neural degeneration had only partly developed four hours after injury but was nearly complete in twenty-four hours.

Bennett and Dingman (1957) fully aware of the many variables, sought an answer to evaluation of depth by experimental use on pigs of radio-active isotopes. They found that the differentiation of deep partial thickness burns from full thickness was not dependable within the first twenty-four hour period because of the varying oedema associated with full thickness burns.

Sevitt (1957) in respect of biopsies recorded : 'the difficulty arises when the biopsy has been removed within a few hours of burning, at a time when nuclear and cellular disintegration may have subsequently developed. Similar histological criteria in biopsies excised more that twenty-four hours after burnings may be safely regarded as evidence of a partial skin loss injury'.

Following further studies, Hinshaw (1961) enumerated reasons for misjudgment in diagnosis of burn severity. He stressed several important points : that the number and depth of hair follicles varied greatly from one area to another and with age, and that the surface appearance depended not only on depth of injury but also on the causal agent.

Hinshaw's conclusions can be listed in the following order : that burns produced by very short exposure to very high temperatures (flash burns) appear deceptively severe; that burns of long exposure to lower temperatures appear deceptively mild; that the number, size and depth of hair follicles vary from one part of the body to another; that in the very young, burns may appear deceptively mild/

mild (the injury need not involve the full thickness of the dermis to destroy all of the hair follicles); that in the aged, hair follicles are often small, sparse and shallow; that pin-prick sensation can be misleading. (A useful guide might be painless extraction of a hair from its follicle.)

Other tests have been applied. Tempest (1961) used disulphine blue while Forage, Bouton and Johnston (1963) attempted histological estimation of the depth of burning which they considered to be the most accurate method of early assessment but they found it had no great practical value. Forage (1964) also developed a test to distinguish differences of surface temperatures of burns of different depths. Goulian (1961) published a method of early differentiation between necrotic and viable tissue in burns with the use of intravenous Evans Blue dye. He included also a review of other diagnostic aids.

Williams and Cade (1964) found that infra-red methods using fast scanning machines for producing thermal images could have a number of medical applications and since this period thermography has been used to help to differentiate deeper from superficial burns.

In spite of all suggestions, Moore believed that deep dermal burns defied exact anatomical and histological definition.

CHANGES IN THE BLOOD. These can be of considerable significance in extensive and in deep thermal trauma. In 1862 Baraduc of Paris described the haemoconcentration so characteristic of severely burnt patients and deduced the cause was loss of serum into the blisters.

Schultze (1865) published work on the effects of high temperatures on red blood cells, and stated that corpuscles at 52°C. became indentated and then became split up into larger and smaller spheroid bodies. Wertheim (1867-9) carried out experiments on dogs and confirmed the work of Schultze but demonstrated also a tendency for/

for the red cells to run together. There was also a deposition of haemoglobin or its derivatives in the tubules of the kidney, evidence of thrombosis, and hyperaemia of viscera. Wertheim ascribed death to the sudden loss of red blood cells. He also reported on the presence of leucocytosis.

In 1868 Klebs described blood pigment in the urine following severe burns. An editorial in the Lancet 1881 read : 'We recently noticed some observations of Hoppe-Seyler (1881) on the condition of the blood in cases of extensive burns, which went to show that there is no marked destruction of, or change in, the blood corpuscles to account for the striking general symptoms. Professor Tabheiner of Munich has followed up these investigations by others more numerous and elaborate, from which more definite results have been obtained, to which it seems worth while to draw attention. His first observations were made on the blood and tissues of four young adult males, who died in from six to seventeen hours after burns extending over about two-thirds of the surface. In three cases a small amount, varying from .5 per cent to 2.5 per cent of the total colouring matter of the blood was found in the serum - a result in agreement with Hoppe-Seyer's, and confirming his conclusion. But in each case the blood was noticed to be remarkably viscid; and on estimating the amount of water, it was found to be notably deficient in relation both to the number of corpuscles and the absolute amount of haemoglobin'.

Maragliano (1887) described methods for estimating injury to red corpuscles and Schlesinger (1892) showed the increased specific gravity of blood following burns was from serum loss. Silbermann (1889-1894) by use of these tests found the damage to the blood after extensive burns to be greater than had been thought. Bardeen (1899) however in a summary stated : on the whole it seems improbable that the body suffers very severely from the numerical loss/

loss of the erythrocytes in burns.

The Practitioner (1895) referred to an article 'On the theory of death from burns' by Silbermann of Breslau in which the author referred to the possible absorption of a variety of poisonous products but he stressed the extensive destruction of red corpuscles and the deposition of corpuscular debris : Von Wetti (1899) he stated confirmed the changes in the red cells.

Brooks, Dragstedt, Warner and Kinsely (1950) described an additional feature in burned animals, a clumping into smooth masses of 25-50 diameter of the erythrocytes which was termed sludging of blood. They suggested that this characteristic led to slowing of the blood stream, stasis of vessels and pseudo-thrombi.

An appreciable number of patients with burns of more than 20 per cent of the body surface were shown by Cope and Rhinelander (1943) to excrete blood pigment in the urine, the amount related to the extent and depth of the wound. The pigment according to Shen et al (1943) and Brown (1945) was derived from red cells in the peripheral area of burning. Anaemia occurring in patients with extensive burns has been recognised for many years but the exact cause has not been determined with certainty. Impaired red cell formation was suggested by Cope (1947). In large burns, Wilson considered that around 30 per cent of the circulating red cells could be destroyed. (quote from Wilkinson (1955). Davies and Topley (1956) however believed that the red cell loss amounted to only about 5 to 10 per cent of the red cell volume and that there must exist an internal unexplained cause which can exist from eight hours from injury and extend for many weeks. Muir and Barclay (1962) gave a detailed account of the development of knowledge on the subject and concluded that the loss of red cells during the shock period fell into three phases. 1) at the time of burning. 2) those/

those injured at the time of burning but not destroyed, and removed within a few hours by the reticulo-endothelial system, and 3) from causes unknown. The loss in this stage bore no relationship to the size of burn but to the extent of deep burn. On rare occasions a massive red cell destruction occurred (Muir 1961).

Arturson (1970) has carried out work on the variations in severe burns of the oxygen releasing capacity of haemoglobin.

Alexander, Dionigi and Meakins (1971) have shown that a burn injury affected adversely the anti-bacterial function of neutrophils.

BIOCHEMICAL CHANGES. Following thermal trauma, the corium composed largely of protein material, becomes altered and in extensive injuries much biochemical and enzymatic action is stimulated.

Peters (1945) postulated that biochemistry could elucidate some of the vexing problems. He indicated that the term "biochemical lesion" was first used by Gavrilesco & Peters (1931) to describe the state in brain tissue caused by lack of vitamin B. Peters suggested that following thermal injury two zones were created : zone 1, commonly central, of complete heat-coagulation : and zone 2, commonly peripheral, surrounding 1 on all aspects, of partial heat damage. He considered zone 2 potentially dangerous from damaged cellular elements, such as enzymes and skin proteins, which could be absorbed into the circulation.

MORBIDITY AND MORTALITY. The terms are defined in MacNalty's British Medical Dictionary (1961): Morbidity - the state of being diseased or conducive to disease : Mortality - 1) the condition or quality of liability to death or 2) death rate or mortality rate : the number of deaths registered in any one year per thousand of population.

Morbidity has also been described as to include any departure from normal health.

Most/

Most deaths from burning were at one time attributable to shock and acute circulatory failure. More patients with extensive lesions survive the early danger period and succumb to the complications common to large surfaces of skin loss. Among other complications are hyperpyrexia, acute respiratory distress and renal failure.

Morbidity in thermal trauma is a vast problem and includes almost 100 per cent of persons burned. The term includes scarring and discoloration, loss of hair or excessive hair and skin tenderness or irritation of any kind : crippling or loss of movement or power : loss of parts : personality changes : domestic upsets : problems of school or of work. There is probably no other form of injury with a more extensive morbidity problem.

A survey of general prognosis is relevant. Pack (1926) writing an etiology of burns remarked that forty-five per cent of the deaths occur during the period from birth to fifth year. Pack (1926) in an article on 'Prognosis in Burns' stated that all burns covering one-third of the body surface are extremely serious, if not immediately fatal, while all burns involving one-tenth of the body surface should be considered serious.

Christopher (1928) expressed Davidson's (1925) view that all burns of first degree are fatal if two-thirds of the body surface are involved and all burns of second degree are fatal in adults if one-third of the body surface is involved, and in children if one-seventh is involved. Berkow (1931) believed that the influence of extent of injury was prognostically "greater than that of depth".

In prognosis, however, several factors have to be considered. Bull and Squire (1949) believed that the two factors which required to be standardised to allow of general comparison were the age of the patient and the severity of the lesion and, for the/

the latter, suggested measurement by Berkow's method.

A useful guide of "estimation of severity", or prognosis, which employed age and extent, was used from 1950 in my unit and termed the "Boyd Index". Dr W.H.F. Boyd, my anaesthetist, found a measure in the correlation between age of the patient and the percentage surface area involved. He deduced that if the addition of those two values exceeded 80, the chance of survival was slender. The guide was simple and popular though, with improvements in anaesthetic techniques, operative timing and after-care and probit analysis, the method is seldom employed.

There is general agreement today that severity should include age, site, extent and depth, and also take into consideration the causal agent and pre-existing disease in each patient.

However, Phillips and Cope (1960) found that in fatal minor burns of less than 25 per cent surface area the survival time was determined by factors other than extent; and, further, that in major burns of less than 90 per cent the survival time varied surprisingly little with extent, while in those of over 90 per cent no patient survived more than one day.

On the other hand Farmer (1960) believed that in children, while the incidence of death rose rapidly for those with second degree and third degree burns with over 25 per cent of body surface involved, there was nevertheles an appreciable mortality and much morbidity below this critical level. He considered that all second and third degree burns of over 10 per cent surface extent in children should be regarded as major injuries.

EVOLUTION of CLASSIFICATION by EXTENT

It is generally presumed that the more extensive the area of thermal trauma the greater is the danger to life; that area is proportional to shock and area plus depth relates to mortality.

However, early references to extent are rough and ready :- more often an inference than a direct statement of fact. Rhazes (860-932), in his Continens for instance, and others, employed the terms 'extensive' burns and 'severe' burns (Paulus Aeginata, Book IV) to indicate extent and depth. Guy de Chauliac (1363) also referred to 'extensive' burns while Heister (1742), the great German surgeon wrote : "we shall also consider the extent of the burn ..... before we can form a true judgment of the consequences that will attend", and continued : "when the whole surface of the body is burnt - or scalded - though the injury considered in any particular part shall be looked upon as a very slight one, yet by being spread to great in extent, it is a disorder of the last consequence. And this is the case more particularly in infants".

John Hunter (1835), on reflection from his studies on the early response to irritants, wrote : "the operation of the body termed inflammation requires our greatest attention for it is one of the most extensive in effects". Van Swieten (1745) of Leiden but later of Vienna, referred to the danger of "the more extensive burns especially if a large part of the body has been injured". Latta's (1794) opinion was that "in all cases of burns, the danger to the patient is exactly in proportion to the extent of the injury". Latta referred to a popular belief that "a burn spreads for nine days before it discovers the least inclination to heal". Bell (1795) recorded that "when the surface of a burned part is extensive, the effects of this inflammation are not confined to the spot which has more immediately suffered".

There/

There were other references to extent in writings of the 18th Century but in the 19th Century they were legion. Lawrence (1829) remarked; "prognosis, however, turns chiefly on the extent"; while Liston (1831,1840) stated : "Burns are in general the more serious, yet scalds though not injuring the skin deeply give rise to the most alarming symptoms when a large extent of the surface is affected". Another example was by Schmidt (1835) : "The danger for life", he wrote, "depends far less on the degree than the extent. I have not lost a fourth degree burn if it has not been extensive and I have not saved one if it involved two-thirds of the body surface even if it was first degree as so much of skin function had been destroyed". Gerdy of Paris, in 1853, recognised the importance of extent rather than degree in relation to prognosis. Spence (1868) recorded that in scalds as in burns, the danger to life depended partly on the extent of the surface affected and also on the part of the body injured. The first effect noticed from a burn or scald was the shock or collapse which was very great when the injury was extensive. I refer again to Holmes (1860) who considered that a reasonably accurate method of estimation of extent was not available. Lister (1868-1869), in his lectures to students, remarked that an extensive first degree burn or scald could lead to death from shock. Billroth (1877) declared : "As regards the danger to life, the extent of the burns is of the greatest importance, entirely apart from their intensity. It is generally assumed that if two-thirds of the surface of the body are involved in a burn of the first degree only, death will soon occur in a manner which has not as yet been physiologically explained".

Thomson and Miles (1904) observed that extent frequently proved greater than the first estimate, while Sneve (1905) assessed the mortality rate for burns of one-third of the body surface as nearly/

nearly 100 per cent. Macleod (1918) following considerable experience in the First World War concluded that in both burns and scalds the gravity was proportionate to the extent rather than the depth of the injury.

ASSESSMENT OF BODY SURFACE AREAS. Methods of assessment of the area of involvement are of comparatively recent times. Funke (1858) covered the skin of a cadaver with adhesive material and then measured squares of paper were pasted over to obtain estimations. Meeh's (1879) studies were painstaking and time consuming but his results set a standard. Parts of the body were marked out in geometrical patterns and were then traced on transparent paper to get total areas. The eventual formula of area elaborated was based on a mathematical law that the surface of similar solids were proportional to the two-thirds power of their volumes.

Fubini and Ronchi (1881) marked out the anatomical regions of the body and assessed the areas geometrically.

Bonchard (1900) adopted a similar approach while he in addition referred to a method of M. Roussy, who employed a cylinder with a revolution-counting device which was applied to the surface of the body. Roussy also described a method employed by d'Arsonval of calculating the surface areas electrically, first clothing the person in silk tights then charging the body as one would charge a Leyden jar and then applying a metal plate of known area. Lissauer (1903) on the other hand covered the skin of each of 12 dead babies with coloured adhesive, then applied silk paper and finally measured the total area geometrically or with a planimeter.

Weidenfeld (1902) provided data for assessment of surface areas of different portions of the body but little was done to establish his method.

Howland and Dana (1913) appreciated that in babies and young/

young children proportional relation in surface area determination was most important and they evolved a simple formula in infants with weight as the only variable.

Du Bois and Du Bois (1915, 1916) employed clinical calorimetry to measure surface areas in man and stated : 'the methods of determining the metabolism have been greatly improved, leaving the surface area the doubtful factor. The number of formulae for surface area determination is large, the number of individuals whose area has been measured is small'. Their method was as follows : 'first a mould of the surface was made by pasting paper over tight fitting underwear and then the area was determined by cutting the paper in pieces, printing a pattern on photographic paper, cutting out and then weighing the pieces of the pattern. To establish the area of each part of the body by linear measurements alone a formula was devised from length and breadth measurements. From further work a formula was evolved incorporating weight and height, area = weight $^{0.425}$ x height $^{0.725}$ x 71.84.

Berkow (1924) did much to clarify an important but somewhat confused picture and placed available knowledge in proper perspective when he declared that it was impossible, practically, to determine the actual extent of a lesion but continued : 'what is of greater value, is an estimate of its extensiveness relative to the body surface' Berkow also stressed the importance of the changing proportions of infancy, childhood and adolescence. In the newborn infant the head represents approximately one quarter of the total crown to heel length, while in the adolescent it is one-seventh. The infant is short-limbed with a relatively large head and thick trunk (Ellis, 1966).

Monafo (1971) quoted Meeh and advanced the following formula: Surface area $(cm)^2$ = weight $(kg)^{0.425}$ x height $(cm)^{0725}$ x K (71.84).

ESTIMATION OF THE EXTENT OF THERMAL TRAUMA. Berkow (1924) was very conscious of the importance prognostically of the extent of burns and did much to evolve a ready and more accurate method of estimation. In view of the importance of his papers direct quotations are presented : "It is impossible practically to determine the actual extent of a lesion. But, what is of great value, its extensiveness in relation to the body surface can be readily estimated. To express such relationship, the lesion must be compared with factors on the body surface which - (1) represent the total surface area of the body; (2) maintain a constant relation to each other and to the total body surface; and (3) must be such that the relation between the lesion and the factors can be readily devined and expressed.

"Such factors are the proportions between the surface areas of numbers of the body and the total body surface.

"Disproportioned people are few".

In summary, Berkow's method of estimating the extent of injury was founded on the ratio between head, trunk and upper and lower extermities and the total body surface. He stressed repeatedly the importance for study purposes of careful recording of the surface area involved of all burns and scalds.

In a second article based on further clinical experience, Berkow (1931) reiterated much of his previous findings but in addition stated "(1) the surface area proportion principle is of great help; (2) the prognosis relative to mortality is dependent on area of unburned and functioning skin remaining; and (3) burns of over 48 per cent surface area in adults and 30 per cent in children are most often fatal". The importance of accurate surface area injury assessments became steadily more appreciated.

Tauber (1926) considered estimation of extent important in relation to early therapy and offered this advice : "Always remember to/

to add about 20 per cent additional to an estimate as about that area of adjacent burned tissue is for the time being unable to function properly and is completely out of commission. So this additional amount must be estimated in the aggregate of burned tissue. It has been our custom for a long long time to state as a dictum that adults cannot survive with one-half of the integument burned and children under ten years with one-third of the integument, and children and infants under two years of age with one-quarter of the integument. As there is in infants less resistance established from other infections which occur as we grow older".

Christopher (1928) thought in similar fashion regarding extent and wrote : "fatal outcome is apt to follow erythema burns involving two-thirds of the body surface or blister burns affecting one-third of body surface in adults, or one-seventh in children. All burns covering one-third of the surface of the body are extremely serious".

A.B. Wallace (1941) modified the Du Bois and Du Bois (1916) method for use in recording extent in his burnt patients.

Most methods of estimation of surface areas of burns employed today are based on the publication of Lund and Browder (1944) who confirmed the conclusions of Berkow but considered that the adult table when applied to children could lead to considerable danger. New tables and diagrams were evolved which were thought could be employed in over 99 per cent of cases without serious error.

Over the years further modifications, simplifications and applications have been suggested and without doubt will continue to be advanced.

Postnikov (1949) published work on the measurement of burnt surfaces in adults and related these to mortality.

Mostkovi/

Mostkovyi(1951)*[1] also wrote on the determination of burnt areas.

My work, (Wallace 1951) suggested that the head and neck, and each upper extremity had a surface area of 9 per cent, the anterior trunk, posterior trunk and each lower extremity an area of 2 x 9 per cent. This Rule of Nine is not applicable with accuracy to children*[2]

In America the Rule of Nine is associated with the names of Tennison & Pulaski. (Knaysi, Crikelair and Cosman, 1968).

Knaysi, Crikelair and Cosman (1968) described attempts at direct measurement of burnt areas and evolved a simple method of using steam autoclaved Saran Wrap and masking tape.

Sakson (1959) published a simplified chart for estimating burn areas.

Blocker (1963) re-evaluated Browder's figures and preferred and adopted Rules of 5's and 10's.

Kirschbaum (1968) modified the 'rule of nine' and suggested a subdivision, a 'rule of three'.

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*1. I have been unable to procure copies of the originals of the two Russian papers quoted.

*2. I recall in 1949 a discussion with my friend, the late Dr E.J. Pulaski of San Antonio, U.S.A. when I told him I was working on a Rule of Ten. By coicidence he had been thinking along similar lines but preferred a Rule of Nine. We agreed to combine, and there was never at any time thought of priority of claim but I take this opportunity of acknowledging the fundamental studies of Pulaski and his great sincerity and humility.

Moyer and Butcher (1967) proposed the following table for use in surface estimations.

Surface area of parts of body (cms^2 and percentage).*

Part of body	Child 1 yr. upwards.		Adult 18-66 yrs.	
	Body Surface (per cent)	Cm^2	Body Surface (per cent)	Cm^2
One wrist and hand.	2.9	14.9	2.6	563
One arm.	3.2	171	3.8	732
One forearm.	3.3	171	3.0	582
Back of neck.	1.4	73	1.7	298
Front of neck.	3.2	170	2.6	496
Scalp.	8.5	475	4.0	789
Face.	7.1	377	2.9	548
Upper Trunk.	13.5	719	16	3060
Lower Trunk.	10.3	450	6.1	1197
One ileo pectineal fossa.	0.8	42	1.0	236
Both buttocks.	5	267	6.0	1183
Perineum.	0.3	15	0.2	47
Scrotum.	0.7	38	0.8	174
Penis.	0.2	11	0.3	66
One thigh.	7	369	9.3	1770
One leg.	5.1	274	6.5	1246
One ankle and foot.	2.7	178	3.6	690

* Modified from von Meeh: Z. Biol. 15, 1879 cited by Moyer C.A. et al Archives of Surgery 90 812, 1965.

Development of fluid replacement formulae (in part related to extent).* A simple method devised by Harkins (1941), was to give 100cc of plasma for every point the haematocnt was above the normal of 45. For children the amount of plasma was calculated proportionately to body weight with the average adult weight set at 70 kilos. About the same time Black (1940) used the following formula.

X (amount of plasma to be given in cc) = $5 - \frac{500}{Hb_2}$ 1000. Where Hb_2 is the haemoglobin observed after the burn.

Another method was that of Elkinton, Wolff and Lee (1940) which used a more complicated formula which took into account both the haemoconcentration and the possible low plasma protein. A more simplified form was found to be equally efficient and this will be described

X = amount of plasma to be given in cc.

W = body weight in Kgm. Ho = observed haematocnt.

PO = observed plasma protein in gm/100cc.

$$X = 49W - \frac{5.5\ (100 - Ho)\ POW}{Ho.}$$

As Harkins (1941) stated the three methods corresponded remarkably well.

The National Research Council of America Armed Services Manual (1943) recommended 50cc of plasma for each 1 per cent of body surface involved. Cope and Moore (1947) considered that plasma and saline should be administered in equal porpotions so that the total protein and electrolyte content approximated to that of the fluid lost into the injured area.

They/

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* Emphasis must be made on the fact that all formulae are guides and were never intended to be rules. The term used by Moore of 'budget' is excellent.

They suggested a formula based on the concept that the demands were proportionate to the extent and that they were maximal around eight hours from burning and that the rate of oedema formation then decreased. In addition they stressed that the requirements of normal metabolism, including those of kidney function, must be met. In the average size adult, they said that for each 1 per cent of the body surface burned, 75ml of plasma and 75ml of non-colloid-containing isotonic electrolyte fluid were required in the first 24 hours, the latter because the blister fluid had a protein concentration one-half to two-thirds that of plasma. In addition 2,000ml of fluid were recommended in each 24-hour period to maintain urine flow.

They anticipated that other formulae based on surface area might well be evolved and suggested that in their opinion for normal sized adult patients burned up to 50 to 60 per cent of the body surface the figures recommended were safe, but for more extensive burns on patients of small or large stature, formula methods could be misleading as there was a limit to which the extra cellular space could be expanded.

Purnell and Evans (1951) modified the National Research Council's formula and suggested a colloid-saline ratio of 1:1 and so the fluids in the first 24 hours were : colloid, ml per kg body weight times the percentage of body surface involved, and non-electrolytes, 2,000ml of 5 per cent dextrose in water.

Kyle and Wallace (1950) of Edinburgh, working chiefly with burned children devised a table of fluid requirements for each 1 per cent involvement, with a separate table for patients with burns exceeding 30 per cent body area. Pulaski (1951) and Artz and Reiss (1957), advised the American Army practice popularly termed the Brooke formula - as originally modified by Evans: the intravenous colloid was/

was decreased from 1ml to 0.5ml times the weight in kilogram times the percentage of burn surface, while the intravenous electrolyte content was increased from 1ml to 1.5ml times the weight in kilograms times the percentage of burn surface, to provide a 3:1 ratio, but with the same total fluid volume.

Following the lead of Evans (1950) most formulae thereafter took into account both the surface area involved and the weight of the patient. A few only will be mentioned but before doing so mention should be made of a paper by Skerlj and Kulcar (1956). They challenged the seeming dependence of formulae on surface area. Their studies however did not evoke the interest that might have been expected. From anthropological measurements Skerlj estimated volumes of individual parts of the human body. All parts were considered as cylinders except the thighs which were treated as truncated cones. Skerlj considered that the various tables for surface area were not sufficiently accurate and pled for more precise anthropological methods of direct measurement to be adopted. Such figures, he believed, would give more accurate assessments of the volume of both intra- and extracellular spaces.

Batchelor, Kirk and Sutherland (1961) advised plasma transfusion in babies with involvement of more than 8 per cent body surface and in older children with more than 15 per cent. The amount of colloid given was 3ml per kg of body weight for each 1 per cent of body burned.

Phillips (1965) introduced a formula for disaster situations in which the total fluid requirement for the first 48 hours was obtained by multiplying by 100 the percentage body surface burned. Such a formula applied only to adults.

The Parkland formula (Moyer, et al 1965) advised lactated Ringer's solution, and in the first 24 hours prescribed 4ml per kg body/

body weight per 1 per cent burn surface.

Muir (1966) writing in general terms on the subject from personal experiences stressed : 1) Adults with burns of less than 15 per cent involvement did not tend to become severely shocked but children were less able to compensate, with a critical area around 10 per cent; 2) The rate and total quantity of fluid loss from the circulation could be anticipated to some extent and that through the means of formulae, requirements could be calculated and administered in controlled rates and volumes. A detailed account of many formulae can be found in the recent publication by Artz and Moncrief (1969).

For Moore's (1970) formula, appropriately termed "The Brigham Body Weight Burn Budget", an estimate of both the size of the burn and the patients' weight is required. Moore considered that in a patient with a deep burn of over 25 per cent body surface area, the size of a patient determined the amount of burn oedema. The author of the "Brigham Burn Budget" advised that the total colloid volume given in 48 hours be 10 per cent of body weight, with half administered in the first 12 hours, one-quarter in the second 12 hours and one-quarter in the second 24 hours. Additional fluids were required for renal needs, lung and skin losses.

As has been described by Monafo (1971) some workers relate the weighting of the size of subdermal burn to the total extent of the injury. As an example he stated: "A patient with a 40 per cent deep burn, one half of it subdermal, would have a burn index of 10 (the intradermal component being given half weight), plus 20 (full weight for subdermal burns) = a burn index of 30. Monafo, however, remarked that the procedure had not gained general acceptance owing to the difficulty of accurate early clinical assessment of depth - a problem still to be discussed.

EVOLUTION of CLASSIFICATION by DEPTH

To around 1700 A.D.

In early times, descriptions of burning injuries were commonly related to causal agents and were associated also with the form of local medicaments favoured.

The earliest known medical writing, the Edwin Smith Surgical Papyrus, described soft tissue injuries and though no direct reference was made of the appearance of a thermal wound, details of local applications were given. Hippocrates (5th Century B.C.) likewise did not leave any description though he wrote: "People who walk through snow or severe cold and become over-chilled in feet, hands and head, suffer severely at night from a burning and tingling sensation when they get into a warm atmosphere and wrap themselves up; in some instances blisters develop like those caused by burning". Again dealing with erysipelas, he stated: "next blisters swell up like those caused by burning and seem to spread inflammation under the skin". Early references to burn wounds were therefore indirect.

One somewhat amusing historical reference was by Aristophanes in relation to a friction burn in his comedy the "Wasps" (422 B.C.), where an Athenian citizen deplored the number of "immigrants" who obtained State benefit without having to discharge the usual service obligations of a citizen thus - "who never had a spear or an oar or a blister on his hand". Similarly in the "Frogs" (405 B.C.) an oarsman complained of his "blisters". In the 1st Century Celsus described burns by their response to local medicaments rather than by their local appearances, though he did refer to the prevention of blisters and also to the inflammatory response and ulceration.

Plinius/

Plinius the elder (23-79 A.D.) the famous encyclopaedist, wrote a Natural History of many volumes on many subjects. The medical section gave a picture of the medical practice of the times. Burns, he stated, would heal without scars if treated with plantain. An indirect reference to depth of injury.

In the 2nd Century Galen made frequent mention of the several manifestations of burns but not specifically to their depth. Reference to depth was inferred.

Marcellus Empericus around 400 A.D. varied his treatment of burns according to the absence or prescence of blisters or whether they formed ulcers, while Paul of Aegina 625-690 A.D. attempted by local applications to prevent blister formation. Their treatments were related to their appreciation of what might be termed local severity.

Paul of Aegina (625-690 A.D.) published his Epitome of medicine in seven volumes, which formed a guide even to the time of Fabricius and later. In Section XL of Book I he described the treatment of persons scorched by the sun while Section XI of Book IV, was "On Burns". He detailed the advancing processes of erythema, blistering and later ulceration, without any mention of actual depth. He also commented freely on measures recommended by Hippocrates, Celsus, Galen, Aetius, Actuarius, Nonnus, Rhazes, Avicenna, Haly-Abbas and Albucasis. Galen's differentiation in care between blistered and ulcerated surfaces was quoted. Paulus Aeginata also noted the effects of burns on hair follicles - a clear observation on damage in depth.

Rhazes (860-932 A.D.), the first and foremost of the Arabians, had a great influence on mediaeval medicine. He referred to "less extensive" and "more extensive" burns and he described the "blistered" and "ulcerated" forms.

Avicenna/

Avicenna (980-1037) the Persian, termed "Prince of Physicians", was the author of the Cannon, which has been described as an "unwieldy storehouse of learning" but which nevertheless became the medical source of authority till the Middle Ages. Avicenna assimilated the views of Galen and Aristotle. He laid down very particular rules for preventing blisters and for treating severe burns and appeared to appreciate injury in depth, but there is no definite statement to this effect. However, Albucasis (1013-1106) author of the Altasrif (or Collection) did refer to "not severe" and "more severe" forms.

Physicians of the middle ages, with few textbooks for guides, were greatly influenced by Arab medicine. Gugliemo de Salicet (1210-1270), professor at Bologna and later physician to Verona, was the ablest Italian surgeon of the 13th Century and it was he who restored the true purpose of the knife. Lanfranchi his most famous pupil became the founder of French surgery. From 1269 to 1275 he prepared his Cyrurgie (1898) which described burning by fire or by boiling water, and the applications favoured before and following blistering, but there was no direct mention of depth of injury. Teodorico Borgognoni (1205-1296) or Theodoric, Bishop of Cervia, completed a treatise in 1266 which was published as a Cyrurgia in 1498-1499. In volume 1 of this book he described along with many other subjects, two types of wound, one superficial and one with loss of flesh, certainly a picture of injury in depth. In volume II, Book III, chapter 46, he described "burns caused by fire, water, oil and other things". He referred to Avicenna's teaching of the two aims of primary importance in burn care: 1) to prevent the area blistering; and 2) to reconstitute what had been burnt. There was certainly an appreciation of trauma in depth but probably not of its full significance.

Henry/

Henry of Mondeville (1260-1320) a pupil of Theodoric gained much from the example of his master and his Cyrurgie and no doubt applied the principles of simple cleanliness he preached in all his clinical work. In addition in burns he stressed the prevention of blisters.

Guy de Chauliac (1300-1368) was the most eminent surgeon of the 14th and 15th Centuries. He studied in Toulouse, Montpelier and Paris and became physician to the Popes at Avignon. His most important work, the Chirurgia Magna, written in 1363 and published in French in 1478, became in abridged form the vade mecum of surgical practice even beyond the 16th Century. In the sixth chapter he described "burns with water and any other hot thing". He laid down three ideals: prevent blistering, soothe existing blistering, cure and relieve scorching. Again there would appear to be some appreciation of the significance of depth but no real classification though he recognised an ulcerated type.

In 1401 Valesco of Taranta when professor at Montpelier wrote a Philonum Pharmaceuticum et Chirurgicum and in it described three categories of burns, dolor, vesica et ulcera (Thomsen 1972).

John Mirfield, both monk and physician, worked in St Bartholomew's Hospital in the second half of the 14th Century. He wrote a Brevarium Bartholomei, part IX of which is surgical. In division 6, chapter 4, the heading is "Burns from fire or hot water and the like". The text resembles closely a translation of Guy de Chauliac, indicating a common Arabian influence and source if not a direct copy. His words were: "in treatment two things are required: 1) prevent blistering, and 2) rectify that which is burned".

Giovanni de Vigo (1460-1520), physician to Pope Julius III, in the Ninth Book of his Works of Surgery, in a chapter headed "Of burning by fire, boiling water or oyle", wrote: "Sometimes the burning/

burning of fire is light and in the overmost part of the skinne, and produceth onlie little blisters. Sometime it is the deepe and hurteth the muscles". Here would appear to be an early classification of superficial and deep. De Vigo lived in Rapallo and his Practica in Arte Chirurgica was first published in Rome in 1514 and in English some twelve years later. The above quotation is taken from a volume in the British Museum.

With the influence of the Renaissance period freshening changes in attitude or approach became more and more apparent.

The development of the study of anatomy through the work of Leonardo and Vesalius became the starting point of modern scientific medicine and surgery. Osler believed that the De Fabrica Humani Corporis (1543) of Vesalius was the greatest book ever written. The effect of this book on renaissance surgery can be seen in the work of Ambroise Paré (1510-1590), who was first a dresser in the Hotel Dieu, Paris, then in 1537 an army surgeon, and soon, from vast experience in a succession of ware, to become the greatest exponent of his craft. He decried the prevailing doctrine that "diseases not curable by iron are curable by fire".

Many of his expressions have become classic: "A wound is a solution of continuity", "Surgery is an art which teacheth the way by reason", "The quick motion of an intrepid hand joined with experience". In Paré's book (1634) the chapter headed: "Of Combustions and Their Differences", began: "they first cause pain in the part and imprint in it an unnatural heat. If the combustion be superficial, the skin rises into pustules and blisters, unless it be speedily prevented. If it be low or deepe in, it is covered with an eschar or crust". Later he recorded: "You must note that a deep combustion with eschar is less painful than superficial. A great combustion deprives the sensitive parts of their sense"; and the/

"the falling away of eschars may be procured by deep scarification to allow deep humours to escape" and "One must remember that the Barbarians burn their slaves and the scars cannot be taken away or destroyed by an Art". Paré clearly recognised injury in depth.

The greatest of the English surgeons in the reign of Queen Elizabeth I was William Clowes (1540-1604). He gained considerable war service experience in both navy and army and later was appointed surgeon to St Bartholomew's Hospital, London. In 1637, Clowes published his"Profitable and necessarie Booke of Observations, for all those that are burned with the flame of Gun-powder:"

"It happened in anno 1577, two gentlement were drying gun-powder in a brasse pan, who (as it did appeare) had no consideration unto the overheating of the pan, but without knowledge of the danger, and care of themselves did continually stirre the powder with their hands it chanced so, that the powder upon a sudden fired, wherewith they were most grievously burned, both hands and face, with their bodies and clothes, which caused them to make a most lamentable crying: and being heard of divers in the same house, who perceiving a great smoke and smell of gunpowder, presently entered in, and with all haste that possible might be, carried the persons burned into another room, where they forthwith did cut, rend and teare off all their clothes from their bodyes; otherwise without their help, no question, but they had been burned to death. There dwelled near unto them a gentlewoman, by whom they were greatly eased with a whey which they made of berinyce and whey, nevertheless she was fearfull to proceed any further, for that she never had seen the experience in curing of such great burnings with gunpowder, nor could her stomach well digest the sight and filthy savors thereof; where upon I was presently sent for, and after diligent view had, I did first anoint the/

the parts that were scorched and blistered often times, specially their hands and face. But where the skin was cleane burned off and the parts made thereby raw are painful, then I did apply onely another unguent, the which I have many times approved in divers cures, with good success unto those that have been so burned with gunpowder, which medicine was never altered nor changed till the parts were perfectly made whole without any further helpes".

Though in this narrative Clowes does not actually employ the terms of slight and severe or superficial and deep there is no doubt that he had some appreciation of injury in depth.

The Scottish surgeon, Maister Peter Lowe (1550-1612), published the first of his four editions of a Whole Course of Chirurgerie in 1597. He founded the Faculty of Physicians and Surgeons of Glasgow in 1599 and wrote the first English translation of Hippocrates in 1597. Chapter X of his Whole Course of Chirurgerie, headed "Of Burning by Fire, Hote Oyle, Water, and Other Liquors", described burns thus: "Such as are superficial are subject to inflammation, such as are profound, to excoriation and ulceration. The meaner sort have only little blisters on the skin, in all which there is dolour, redness, and such like, all evident and apparent to the sight". Lowe's distinguishing features of depth can therefore be termed superficial and profound. (Lowe, 1634).

In any description of the classification of burns Wilhelm Fabry of Hilden (1560-1624), called Fabricius Hildanus, stands out by virtue of his thoughts, deductions, writings and originality. He is regarded as the "Father of German Surgery". In a recent letter to me from Professor J.P. Webster, founder of the Jerome P. Webster Library, Presbyterian Hospital, Columbia University, New York, he declared: "I am more and more impressed by the common sense of the great Fabricius Hildanus. I think his statement that the degree of burn/

burn depended on the temperature of the burning agent and the length of time applied to the human body is the most concise and comprehensive definition one could make".

In his classic De Combustionibus Fabricius, published in 1607-1608 in Basel, the following is a direct translation from the Latin Chapter 2: "Although burning may result from different substances, minerals and fluids, as we have described, it is no help or too little help in treating it. Since indeed burning caused by red-hot iron is like burning caused by red-hot gold or silver. So also burns, whether caused by boiling oil, wax, pitch, etc., do not differ from one another nor do they require a specific method of treatment, as Laurentius Joubertus, an outstanding man with great services to surgery, bears witness. Therefore no guidance to treatment should be taken from the substance burning but rather from the result it produces. So that the treatment should be properly prescribed, we will divide all burns from whatever burning substance they have been caused, into three degrees or types, namely (1) slight, (2) moderate, (3) severe.

"For if the substance which is causing the burn has not been in contact with the body for too long as it is light, e.g. straw, linen, hemp or some thin wood or water which quickly runs off, then only small blisters are raised: this is the first degree or type.

"But if the substance has been in contact a little longer or is endowed with a stronger heat, then not only are blisters raised but also the skin proper is deprived of its inherent moisture and somehow dried up and wrinkled but not yet irredeemably affected.

"Thirdly if the ironing substance is in contact a very long time and contains in itself a very strong heat, then not only the skin but also the flesh, veins, arteries, nerves, etc., are burnt/

burnt, shrivelled and dried up beyond repair, since indeed the inherent moisture is dried up and parched by the force of the fire. Remedies must be changed and applied in accordance with these differences, as we will later show. Next, guidance is taken from the part affected: for they are not all the same: the same remedy is appropriate for the eye, membrum virile, nerve, joints, muscular flesh, etc. Likewise women, boys and those endowed with delicate feeling need weaker remedies; on the other hand those who have hard flesh and are stronger people need stronger remedies, as Galenus has rightly advised. From this classification of burns the method of treatment can easily be seen, which we will later show under three headings (God willing), just as we have divided burns into three types.

"Symptoms, by which those three degrees of burns are to be recognised and distinguished.

"Chapter 3: Since we have divided burns into three types or degrees and next intend to prescribe appropriate remedies for each type we must state how these types are to be distinguished by symptoms and marks. And so the symptoms of the first type, if of very slight burning are these: reddened skin, very sharp piercing pain just as if the skin had been rubbed by a nettle. Soon (unless suitable remedies are very quickly applied to the patient) the affected area becomes swollen and blisters are raised, in which is contained clear, white water, and eventually also the epidermis is broken. A slight burn can also be recognised from certain factors, e.g. that the burning object was light, such as straw, linen, hemp and the like: or that it immediately ran off such as boiling water or that it had touched the body with little force. While in the second type the burning object has affected the body for some time or has had a stronger heat in itself, such as iron when ignited, or some/

some metal when molten, or very hard wood, pitch, oil, wax or something similar. From this it comes about that the part affected is immediately swollen, becomes red, causes pain, scorches, and instantly blisters are raised, in which is contained a fine water turning yellow, and the patient complains of skin tension: for it is shrivelled by the force of the fire. While in the last type, at the very moment while the burning object is in contact with the body, blisters are raised but they immediately die down again, especially at the place where the burning is severe and strong: the skin affected looks black or at least a livid colour and feels useless if pierced by a scalpel; for there is a hard, dry crust and when it has peeled off there is left a deep, festering sore. A severe burn can be recognised also from the nature of the burning object and the time it is in contact with the body."

This classification combined both appearance and depth and in some ways was almost as advanced in outlook as some modern forms. The description included loss of sensation.

In deeper burns Fabricius advised incision to allow escape of moisture to prevent inflammation and gangrene as if he appreciated progressive troubles.

In 1642 there was published a translation into English by John Steer of Fabricius Hildanus' De Combustionibus. There are today only five known copies, two of which belong to the library of my friend Professor Jerome P. Webster, New York.

Richard Wiseman (1622-1678), the outstanding English Royalist surgeon, published his Several Chirurgicall Treatise in 1686. Chapter 1, headed "De Ambustes or Of Burns with Gunpowder, etc.", began in this manner: "Forasmuch as it often happens, that in close Fights at Sea, men are sometimes burnt by Gun-powder by their Enemies, and by various Accidents amongst themselves: ..... If the burn be superficial, it raiseth the cuticula up in Blisters: if it go deeper into the skin, it causes an Eschar: if it burn deeper than the Flesh, the force of the fire makes a hard Crust with a Contraction". One might therefore say that Wiseman's classification by depth was: (a) blistering, (b) eschar and (c) ulceration.

On December 17th 1658 the first thesis on burns was published by Amman in Leipzig and included virtually all known aspects of the subject, causes, depth, symptoms and signs. Amman accepted and followed the classification of Fabricius. In 1706 from Magdeburg Buno in a thesis classified burns into five degrees, erythema, vesiculations, ulceration, involvement of muscles and involvement of tendons, vessels and nerves.

EVOLUTION of CLASSIFICATION by DEPTH

From around 1700 to around 1800.

By the 17th Century the common practice was to describe thermal injuries by their response to local treatments. In essence the custom could be considered as one of classification in depth.

Le Clerc (1735), in his La Chirurgie Complete, spoke of recent non-ulcerated and ulcerated forms and also of superficial burns and deeper burns with pustules.

The outstanding physician of the early 18th Century was Hermann Boerhaave (1668-1738) of Leyden. He had many famous pupils: Haller, Monro, Cullen and Pringle and van Swieten of the "Old Vienna" school. His Aphorisms were published in 1709 and were translated even into Arabic. His Modern Practice of Physic was translated into English by R. James and published in 1746. The pertinent aphorisms read thus: "476. If actual fire, or fire-latent in any ignited substance, is applied to the human body, there are produced a destruction of the vessels, and air extravasation of the humours proportioned to the variety of the cause, the duration of its action, and the nature of the part affected". "477. The various degrees of burns (mentioned in 476) resemble the several phenomina, which happen from the first and slightest inflammation (from 370 to 464) to the most terrible sphacelus". The succession of events of injury in depth were therefore well appreciated.

Gerhard van Swieten (1700-1772), also of Leyden, later did much in Vienna to advance Austrian medicine. His Commentaries upon the Aphorisms of Boerhaave (1741-1775) took over thirty years to produce. They are quoted fully in appropriate sections because they give much useful information of knowledge of the times. One reads in volume IV, section CCCCLXXVI - "If actual fire or anything which conceals/

conceals fire is applied to our bodies, there follows a destruction of the small vessels in the part, and an extravasation of their humours, varying according to the difference and duration of the cause and the nature of the affected part". In essence, one of Boerhaave's aphorisms, but he continued - "In the healthy human body there is a certain degree of heat to be measured by the thermometers, which degree of heat offers no injury either to the solids or the fluids; but this heat seldom exceeds the ninety-sixth degree of Fahrenheit's thermometer, even in the strongest men: which degrees are so called from the first portable thermometer made in these countries. But when the heat of the body ascends above the hundredth degree in diseases, the blood and its serum then begin to be disposed to coagulation: but if the degree of heat in the body is equal to the hundred and twentieth degree of the thermometer, the serum of the blood coagulates. Heat therefore raised to so great a degree changes the disposition of our juices, though the solid parts do not as yet seem to be much injured from thence. But when the heat is raised equal to that of boiling water, which is usually about two hundred and twelve degrees, then the solid parts are injured, many of them being dissolved: for if water that is boiling or near upon boiling, be applied to any part of the body, it instantly ruptures many of the small vessels which connect the skin and cuticle together, from whence the humours are extravasated, and being collected together, raise the cuticle into a blister. But when the heat applied to the human body is greater than that of boiling water, it destroys a greater number of vessels and that almost instantly; as for instance a red hot iron in a moment consumes any part of the body which it touches.

"But the fire which is applied to the body, either burns and shines, as for instance in the flame of a candle or a burning coal/

coal, etc., or else it is concealed in bodies so as not to shine and yet to burn up everything it touches; as for instance, when an iron is heated so hot as to kindle brimstone, or destroy the soft parts of our bodies down to the bones, and yet there is neither any signs of light nor burning in the iron itself. In that case the fire is said to be concealed in these bodies, notwithstanding it produces such sensible effects.

"These effects may be reduced to a destruction of the small vessels, with an extravasation or coagulation of their juices. Thus for instance if boiling water touches any part of the body but for a few moments, the small vessels are ruptured under the cuticle, and their extravasated juices are collected into a blister; but the skin and often the panniculus adiposus, which are placed under the cuticle, are so much altered by the boiling water, that their juices being coagulated, all the vital influx and efflux of the humours to and from those parts is intercepted, whereupon a gangrene or suppuration succeeds, by which it is necessary to separate all the parts thus injured.

"When a hot iron is applied to any part of the body, it immediately forms a hard and dry eschar, and yet there will be no appearance of the extravasated juices immediately in the burnt part; even notwithstanding the vessels are destroyed; the reason is very evident, because the same action of the fire coagulates the juices; so that the humours which would have been extravasated by a slighter burh are by the more violent action of the fire converted into a dry crust, both fluids and solids.

"But the effects of fire applied to the body differ according to particular circumstances. ..... We discover that some fluids are capable of receiving and retaining a much greater degree of heat and fire, than others. Water applied to burning fire, hardly/

hardly heats beyond the two hundred and fourteenth degree of Fahrenheit's thermometer; and when once the water has acquired this degree of heat, it cannot be heated to any greater degree, however much the fire be increased beneath the water.

"But olive oil and linseed oil or the like oils expressed from seeds or fruits, cause the mercury to ascend in the thermometer to the six hundredth degree when they boil; whence we observe a great difference in the effects, produced when any part is burned by the application of boiling water or scalding oil.

"Duration, etc. For in proportion as the fire continues to act a longer or shorter time upon the part, it is evident that the effects will be increased or diminished. A hot iron applied to the skin but one moment and taken off, will indeed burn it, but very slightly; whereas if it is pressed a longer time upon the part, it will destroy all down to the bone. Hence burning with boiling pitch is much more dangerous than with oil, because by its tenacity it very firmly adheres to the skin, whereas oil much sooner runs off.

"Nature of the affected part. But the different nature and action or use of the affected part in the body, will again make another difference in the effects of fire. Those smiths who are daily employed in making anchors, have the palms of the hands extremely hard and insensible like horn, insomuch that they are capable of holding burning coals; but the same smiths when they lie sleeping by the fireside, after they have been tired by their day's labour, have the skin of their legs often burnt and raised into a blister, by a small particle of such fire. When a citizen of the Hague was blowing with his mouth into a musket, the piece being charged unfortunately took fire, the man not knowing it was loaded; and by this accident his palate, gula, gums and tongue were miserably burned/

burned, insomuch he was not able to swallow any things for the space of eighteen days, though bleeding and other select remedies were had; and the dead parts afterwards separated from the living, which being extremely painful and sore, created much misery to the patient, till at length some fragments of bone being also separated from the palate, he did well and gained the better of death after a hard struggle. But it is very evident that a burn would be much less dangerous and troublesome, provided the hand was to be burnt with gunpowder instead of the mouth and gula.

"Of Burns, Section CCCCLXXVII". The different degrees of these several effects from burning (476) resemble those observed from the first and slightest degree of an inflammation, till it degenerates into the worst or most severe sphacelus (370-464).

"Whatever was the cause which contained and applied the fire to the body, or however long or short might be the continuance of its application, or lastly to whatever part of the body the fire is applied, the effects thereof will indeed be various, but always like those which are observed in the different degrees of inflammations in the same parts; for the most intense fire, destroying any part of the body, does no more than a sphacelus which corrupts the whole. But a slight action of the fire, though uneasy or troublesome, does no more than excite a kind of redness and tumour almost like an erysipelas, and upon increasing the fire the tumour and redness will be increased, so as to produce a true phlegmon; and if the fire be still augmented, blisters will be raised, and all the signs of a gangrene from a violent inflammation will appear; and lastly by fire, all the parts may be destroyed down to the bones, as happens in a true sphacelus. But it was laid before in the commentary on No.370 that a phlegmon derived its name from fire, an account of the similitude between the effects of both. But there may be as many

different/

different degrees betwixt the smallest and the greatest burn, as they may be intermediate degrees betwixt the slightest erysipelas and the most perfect sphacelus. In short almost the only difference is in the celerity of the action of fire, since by the application of this last a perfect sphacelus may be produced in an instant of time, which yet always follows, but by slow advances, even after the most severe inflammation.

"Section CCCCLXXVIII. We ought to be acquainted with the signs which denote the different degrees of burning. But the knowledge of these signs apertains to the diagnosis of the disorder. A slight burning is known from being acquainted with its cause, which was neither violent nor applied for a long time together; as for instance, if water, which is not yet scalding, touches the body only for a moment, in that case there follows only a slight redness and painful tumour of the skin, with few or no blisters, or if any, they do not arise immediately after the burn, and are full of limpid water, which absolves the diagnosis of this degree of burning. But a worse degree of burning is known from an acquaintance with its more violent cause, or its longer continuance with the intensity of the pain, and the sudden appearance of blisters full of a yellow liquor immediately after the burning, followed by a tensity or rigidity of the skin round the burnt part. But in the worst kind of burning, where all the vessels are suddenly destroyed by the violence of the cause, there do not appear any blisters in the burnt part itself, but yet there are blisters very often arise in its circumference, the skin turning livid, or sometimes quite black, but gives no sign of any sense of pain, although cut or punctured by the scalpel being hard or quite dry.

"But the prognosis depends upon knowing the nature or degree of the burn by its diagnostic signs, considering also the nature of the/

the injured part, and the habit of the patient. And here physicians and surgeons ought to be more particularly cautious not to promise more than they are able to effect. For where the burn is only slight, the cure may be performed without leaving any scar; but if the vessels are ruptured and the humours extravasated, or else congealed by the force of fire, the circulation will be then entirely suppressed in the part, and a suppuration would follow all round the parts which ought to be separated, whence that surgeon will be foully mistaken who promised an early cure of such a burn without a scar; for a separation of the dead parts will leave a hollow ulcer, whose lost substance can seldom or never be so far repaired as to render the surface equable with the rest of the adjacent skin. Now according as the part burnt is of a more tender or firm structure, the prognosis will be again on that account various; as for example, there will be always great danger of injuring the sight, even by a slight burn inflicted near the eyes. In atrabiliary, cacochymical and scorbutic people a slight burn frequently degenerated into a most stubborn ulcer. Attendance must be therefore given to all these particulars in the prognosis less the bad consequences following should be ascribed to the physician or surgeon if he takes no notice that such accidents are to be feared".

Van Swieten contributed much to our knowledge of the period.

R. James (1743), in the first volume of his Medical Dictionary, recorded: "New Burns may, not improperly, be divided into four kinds; the first and least seems to be, when the parts affected feel a pain attended with heat and redness and succeeded in a short time by a pustule. The second degree is, when after Ambustion, there is an immediate eruption of pustules, with a grievious pain. The third degree is when the skin and subjacent fat are burnt in such a manner, that they presently turn to a crust. The fourth/

fourth is, when the Ambustion is so vehement, that it penetrates and destroys almost everything before it, to the very bone. The third degree resembles a gangrene, the fourth a sphacelus".

John Aitken*[1] (1774) in the section Chirurgical Nosology of his Systematic Elements of Theory and Practice of Surgery introduced several interesting Latin quotations related to burn wounds: 'combustura - vulnus igni factum, inducta eschara - Linnaeus'*[2]. Burns - wounds made by fire lead to eschars. 'Encausis - inflammatio cutis ambustion - Vogelius'*[3]. Burning - an inflammation of the skin from heat. 'Ambustio - plaga a flamma ignis corporibusque ex igna candentibus, liquidis serventibus, aut radiis solis in socum coactis, nostro corpori illata, succedentibus phaenignio, phylctaenis, vel eschara - Sagar'*[4]. Burning - a wound to the body caused by flame from fire, by bodies that glow with heat, by boiling liquids or by the rays of the sun concentrated on a spot resulting in inflammation.

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*[1] John Aitken became a Fellow of the Royal College of Surgeons of Edinburgh in 1770 and lectured on most subjects of the medical curriculum - anatomy, surgery, midwifery, chemistry and the practice of physic (Comrie 1932).

*2 Linnaeus (1707-1778), the great Swedish botanist, was also a physician.

*3 R.A. Vogel was professor at Gottingen from 1724 to 1774.

*4 J.B. Sagar lived from 1702 to 1778. His definition is of some interest as he appeared to appreciate increase in depth of burning.

A further quote by Aitken was: 'ambustio - continui solutio a materia externa aduente causate, cuticulum semper, cutem plevumque, nomeumquam etiam musculos, venas, arterias, nervos, atque tendines laedens - Blancardos'*. Burning - a lesion caused by some burning external material which always injures the outer skin and sometimes even muscles, veins, arteries, nerves and tendons.

John Aitken (1774) in Section LV of his 'Systematic Elements wrote: "Organised matter of every kind, especially the animal body, may be altered or totally destroyed by the action of fire, which is the most stimulant of all the occasional causes of phlegmonic affections. Those which it excites are however, not specifically different from inflammations induced by other means. Their violence and extent are in proportion to the quantity acting, the continuance of its application, and the nature of the parts it affects". "LVI: Fire may be accumulated in bodies nearby in the degree of their density or solidity; in oil therefore more than in water, and in earths and metals more than in either; consequently the qua ntity of fire which has acted as an occasional cause of phlegmon may, in some measure, be estimated from the density of the medium through which it was applied, and the degree of accumulation and continuance". "LVII: Burning, like all other marked affections, requires curative attention in proportion to its quantity. Sometimes it is superficial and circumscribed, covered with vesications, at other times profound, extended and encrusted. Coetlogan (1745), in a/

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* S. Blankaart or Blancard or Blancaard (1650-1702) was a practising physician in Amsterdam who made the first successful injections of capillaries to demonstrate the anastomosis between arteries and veins. The English version of Blankaart's Physical Dictionary, London, 1684, was the first medical dictionary to appear in Great Britain.

a fascinating account of chirurgery of the times, referred to several classes of severity of burns: superficial; very strong with pustules; still greater with a crust upon it; gangrene. This is obviously a classification in depth but maybe more from intensity of the agent than to pathology and was employed mainly as a guide to local therapy.

The leading German surgeon of this period was Lorenz Heister (1683-1758). He was first to introduce the term tracheotomy. In 1742 and 1757 he published chirurgies. Like Van Swieten he stressed the importance of morbid anatomy. "Burns is a species of inflammation. When heat is applied to the body, the fibres and small vessels of the parts touched will corrugate and burst, whilst the blood and other contained fluids will be extravasated, stagnate and corrupt". Heister continued: "We may divide burns into four degrees. The first and slightest is that which occasions heat, pain and a small vesication of the injured part in a short time. The second degree is when the part is instantly affected with great pain and vesication. The third is when the common integuments and subjacent flesh are so burnt that they form a crust. The fourth and last is where everything is destroyed quite down to bone". As an aside he remarked that: "The third species is nearly allied to gangrene and the fourth is a sphacelus". Many years later Sonnenburg and Tschmarke (1915) described Heister's four grades as (a) reddening; (b) blisters; (c) superficial suppuration; and (d) eschar.

To continue, however, direct from Heister's book, he recorded: "The dangers of the burn will likewise be increased in proportion to the depth to which it has penetrated.

"Burns of the face are not only to be dreaded for the deformity which they may occasion, but chiefly for the inconveniences that they may produce by causing the eyelids to grow together. Deep burns/

burns of the neck, if not timely remedied, occasion a wry neck of that part".

G. Sharp, in a Surgical Treatise of 1739, referred to burns as: "very superficial; burns which excoriate; and burns which form eschars". August G. Richter (1799) ... another leading German of the period, wrote a history of surgery in which he classified burns into four grades:

"In the first and mildest grade there is merely a little redness without any swelling. The victim feels a smarting in the affected area and is without fever. The injury consists merely of a slight inflammation, which disappears in a short time.

"In the second grade the redness is associated with swelling, the pain is violent and if the burn is of some extent a marked fever is present. The victim has a severe inflammation which leaves him weak.

"In the third grade blisters arise at once or gradually and contain a light or golden fluid. In some places the epidermis is broken. Fever is violent and pain unbearable. It is seldom possible to prevent abscess.

"In the fourth grade the burnt area is insensible and dead, i.e. afflicted with cold burning. This begins either immediately at the moment of burning or it is the result of a previous violent inflammation. It is dry after a burn but generally moist after a scald".

The Encyclopaedia Britannica (1771), in describing an approach to local treatment, inferred clearly three degrees of depth: "(1) Very superficial, not raising suddenly any vesication; (2) one that excoriates and is very tender with prompt vesication; and (3) one that forms an eschar".

Von Creutzenfeld (1781), in the chapter "Ambustio" (page 31a) of/

of his classic Bibliotheca Chirurgica, offered 126 references, all in Latin, but mostly on the local care of burns.

W. Nisbet, a Fellow of the Edinburgh Royal College of Surgeons, who practised in his home town for some years and later south in London, published in 1789, a Clinical Guide in the form of a series of commentaries. No. CLXI read: "In directing the treatment of burns, they become properly divided into two species, the superficial and the ulcerated.

"The former consists in simple effusion into the cuticle, the consequence of the inflammation, displayed in vesication without any abrasion. The latter depends on a real denudation of surface and loss of substance, attended with the formation of matter".

This description is a clear indication of appreciation not only of depth but also of the pathology.

In White's Practical Surgery (1796) the following description was given: burns "may be divided into four different degrees or stages, when the part is affected with heat and inflammation without vesication; when it is immediately afflicted with intense pain and vesication; when the integuments are so injured, as to produce a deep eschar; and when the whole is in a gangrenous state".

The surgeons of the 18th Century would appear to have had a greater general appreciation of progressive involvement in depth, maybe dreived from the concurrent development of morbid anatomy. More attention was undoubtedly paid to tissue structure and the morbidity resultant from injury.

One man who left his mark on every aspect of the surgery of the period and probably one of the greatest surgeons of all time was a Scot, John Hunter (1728-1793). He established a sound basis for the principles of surgery through the basic sciences, and was in/

in addition a great surgical pathologist. The dignity of a scientific profession for surgery was achieved through him and, as a colleague remarked, "he also made us gentlemen" (Garrison).

His clinical descriptions are classic and one most apt for the subject under discussion is fully quoted: "A scab may be defined first, dried blood on a wound, dried pus on a sore, a slough from whatever cause, allowed to dry, mucus from an inflamed surface as in the nose.

"This might be considered as the first mode of healing a wound or sore, for it appears to be the natural one requiring no art; many wounds might be allowed to scab in which this process is now prevented; and this arises, I believe, from the conceit of surgeons who think themselves possessed of powers superior to nature, and therefore have introduced the practice of making sores of all wounds. ..... The mode of assisting the cure of wounds by permitting a scab to form is likewise applicable in some cases to that species of accident where the parts ..... have been deprived of life.

"This practice is the very best for burns and scalds".

Hunter taught exposure for superficial burns to encourage healing under nature's dry crust.

He described the deeper injury thus: "among the divisions of accidents, one is where death is produced in the injured parts and where inflammation plus suppuration must take place in consequence of the dead parts which separate, not being within the power of the former treatment to produce a cure". (Hunter 1835).

I could find no actual classification of burns by Hunter but one has been described by Sonnenberg and Tschmarke (1915) as by that great surgeon: "(a) superficial inflammation; (b) deeper inflammation; (c) scab; (d) charring or slough". How well Hunter narrated/

narrated the complications of well intentioned but misdirected local treatment in superficial burns! "But such accidents as have a superficial part killed (when the slough would readily separate and the parts suppurate kindly) are often treated improperly at first, by the patients themselves applying Friar's Balsam or some such medicines; but these not being within the power of scabbing, inflammation comes on and alarms the patient. ..... the slough appears ..... the patient becomes fretted from a sore, apparently so trifling, being so difficult to heal; but it is impossible that such a sore can heal while there is still a slough to separate".

How fascinating also was Hunter's description of inflammation - the first degree or least grade of burns: "This operation of the body, termed inflammation, requires our greatest attention, for it is one of the most common and most extensive in its effects of any in the animal body; it is both very extensive in its causes and it becomes in itself the cause of many local effects both salutary and diseased. ..... By these extensive powers inflammation becomes the first principle of Surgery; Inflammation has several well-marked local pecularities by which it is distinguished - pain, swelling and redness. ..... This increase of red appears to arise from two causes, the first a dilation of vessels, the second is owing probably to new vessels being set up in the extravasated lymph. From the account I have given - the volume of the part inflamed must be increased.

"This increase of volume is owing to the extravasation of the coagulating lymph and serum". (Hunter 1835).

Hunter left us many legacies of astute observation and clear deduction.

The cyclopaedias of his time are also valuable sources of information. Chambers' Encyclopaedia (1728), volume 1, suggested three/

three degrees of burn: (1) redness, a few pustules and a separation of epidermis from genuine skin: (2) skin burnt dry and shrunken but without crust or scab: (3) flesh, veins, nerves, etc., shrunk to form a scab.

The French dictionary, Encyclopedie des Sciences des Artes et des Metiers (1741) offered the three Chambers' degrees almost word for word.

A supplement to Chambers Cyclopaedia, volume 1 (1753) illustrated a different concept. Burns were divided into dry and humid forms. "Others make five degrees of burns; the first when the skin only is hurt without any great redness; in the second the pain is considerable, and the redness deep, attended with pustules; the third instantly produces pustules, with a throbbing pain, inflammation, and ulceration of the part; in the fourth degree, a great havock is made in the fibres, by which the skin is much corrugated, separated from the flesh, and as it were roasted, occasioning an eschar; the fifth degree is, when the fire penetrates deeper, and burns to the membranes, vessels, and nerves underneath, attended with a great shrivelling of the part, a violent inflammatory pain and blackish eschar".

Callisen (1788) in his Principles of Systematic Surgery presented a four grade classification: (1) characterised locally by slight redness, pain, swelling and some fever: (2) redness, pain and swelling of greater degree with the formation of blisters: (3) signs of a very severe inflammation, a very acute fever and excruciating pain: the epidermis often separated while blisters were often present: (4) in this most severe grade the affected parts were deprived of all life or gangrene might result.

James Latta was the author of a Practical System of Surgery, published in 1794. In Chapter 11, "Of Burns" he stated: "The immediate/

immediate consequence of these is violent inflammation, greater or less, according to the violence of the injury; and, according to the different appearances they put on, they may be divided into four different classes: (1) when the burnt part is affected only with a sense of heat and inflammation; (2) when it is also accompanied with intense pain and vesication; (3) when the integuments are converted into an eschar, by which the skin and cellular substance are entirely destroyed; and (4) when all the parts are destroyed to the very bone".

He continued: "Boiling water will destroy the skin but cannot produce any eschar. Boiling oil, pitch, resin or wax may produce a slight eschar and always will blister the part. Burning linen, cotton or other coverings of the body, when set on fire, will soon destroy the unfortunate patient; but the most dreadful burns are produced by melted or ignited metals which, it is evident, may destroy not only the soft parts, but the bones also. A burn by any liquid substance is more severe when it happens through the medium of clothes, than when it falls directly upon the naked skin; because thus the heat is applied for a considerable time without any diminution, or at least with very little; and therefore affects the parts to such a degree, that the skin almost constantly peels off with the clothes.

"In the mildest kind of burns with melted metals, or hot iron, the cuticle is scorched, and becomes white, yellow or brown, according to the degree of injury. Sometimes the skin is entirely converted into a hard eschar, and then separates - leaving an ulcer more or less deep or wide ..... but it is observable, that the pain attending injuries of this kind is much less when the skin is totally destroyed than when it is not. The reason is, that thus the sentient extremities of the cutaneous nerves are scorched and tendered/

tendered insensible, and thus the pain of the burn must be very much diminished; while in those cases where vesications only are produced, the nerves remain most exquisitely sensible, and the most violent pain is felt.

"In some of those cases which have fallen under my observation, where the cuticle was almost destroyed, the patient expired in thirty-six or forty hours in a state of stupor. In very extensive burns, by hot metals, or by inflamed combustibles, a most alarming degree of mortification takes place, so that sometimes the patient is destroyed by it almost instantly; at others he is wasted by the excessive discharge from the ulcer and the effects of the air upon the surface of such a large sore".

A series of clear clinical expositions which in many ways could not be improved.

White (1796) in his Practical Surgery described burns and scalds in the following manner: 'these are subject to the same events as inflammation, and may be divided into four different degrees or stages: when the part is affected with heat and inflammation without vesication; when it is immediately afflicted with intense pain and vesication; when the integuments are so injured, as to produce a deep eschar; and when the whole is in a gangrenous or lifeless state'. Again a very clear picture is given.

EVOLUTION of CLASSIFICATION by DEPTH

From around 1800 - 1900

Benjamin Bell (1749-1806), the "father of the scientific Edinburgh Surgical School", and John Bell (1763-1820), founder of the Edinburgh School of Surgical Anatomy, both contributed much to our knowledge of wounds.

Benjamin Bell began his medical studies at Edinburgh University at the age of 17 years. Later he spent two years at the Surgical Schools of Paris and then of London under William Hunter. He was the author of a System of Surgery in six volumes which was an attempt in part to rival Heister's System of Surgery, the great text book of the period. Bell's writings were unfavourably reviewed by both John Bell and Sir Benjamin Brodie, nevertheless they went through seven editions and were translated into both French and German.

In his System of Surgery (1794) Bell wrote: "Burns assume different appearances, according to their degree of violence, and manner in which they are produced. Thus, burns which merely irritate surface of the skin, differ materially from those which corrode and destroy it; while those again have a different aspect from such as affect the muscles, tendons, ligaments, and other deep-seated parts; and we know that such as are produced by boiling water, and other liquids, differ materially from those produced by the direct contact of hot metallic bodies, or of burning combustible materials.

"Burns which do not destroy the cuticle, and which irritate the skin only, act nearly in the same manner with cantharides and other vesicantia. The irritation with which they are accompanied, excites an increased action in the exhaling vessels of the parts affected, by which vesications are formed in extent and number proportioned to the violence of the cause. But when the skin

or/

or subjacent parts are destroyed, no vesicles take place. A black mortified slough is first observed; and when this separates and is thrown off, an ulcer is left of a depth corresponding to the degree of heat by which it was produced.

"In every case of burn, the pain is severe, but in general it may be observed, that it is more considerable where the skin has been merely much fretted or irritated, than where such a degree of heat is applied as to destroy the skin entirely".

Bell's classification in simple terms would appear again to be "superficial" and "profound or deep".

John Bell became a Fellow of the Royal College of Surgeons, Edinburgh, in 1786 and soon after began to lecture in anatomy. He was however essentially a surgeon and after thirteen years of lecturing confined himself entirely to surgical practice and for twenty years was the leading operator and consultant in Scotland.

I could find no direct reference to thermal injury in John Bell's writings but in Discourse III of his Discourses on the Nature and Cure of Wounds (1795) entitled "On Gunshot Wounds", he refuted the existence of a poison, condemned the treatment by cautery or burning, narrated the episode which changed Pare's practice to bland applications and also described his method to soften and loosen eschars.

James Earle, in his Essay on a Means of Lessening the Effects of Fire on the Human Body (1799), described (a) superficial and (b) ulcerated or excoriated types of burn.

About the same period, Kentish (1797 and 1800) referred to Heister's four classes with appropriate local therapy. He quoted also in detail from Van Swieten's Commentaries on Boerhaave's Aphorisms.

The 17th and 18th Centuries had been characterised by steady/

steady advances in mathematics, physics and chemistry which, during the 19th Century were applied more and more to medicine and surgery. The advances took place over a wide period and there was no sudden change but nevertheless considerable progress was achieved.

Bichat (1771-1802), the creator of descriptive anatomy also favoured the adoption of four degrees: (1) characterised by redness with pain, like erysipelas; (2) redness with blistering; (3) shrivelling and drying of the structure of the skin; and (4) tissues reduced to carbon. (1801-3).

In 1807, Samuel Cooper published his First Lines of the Practice of Surgery and burns were described as of four degrees:

"(1) In the mildest, there is but slight redness without swelling, and only a gentle inflammation is excited that shortly subsides.

(2) In the second degree the redness is attended with swelling; the pain is severe; and if the burn be of much extent, there is fever. The inflammation is acute, but it commonly ends in resolution.

(3) In the third degree vesicles containing a clear or yellow fluid, arise either in a sudden or gradual manner. The sympathetic fever is severe; the pain is intolerable; and suppuration can seldom be prevented.

(4) In the fourth the burnt part is mortified. This happens either at the moment of the accident or in consequence of violent inflammation".

He continued: "the quantity of injury depends on the degree of heat in the burning substances; hence even cases of the fourth kind and of little extent, might be insignificant, while others of the first description and of great extent may be very perilous".

Cooper/

Cooper (1809)also wrote in similar fashion in his Dictionary of Practical Surgery.

Pearson (1808) in his Principles of Surgery, divided burns into three categories: (1) superficial; (2) ulcerated; (3) carbunculous.

Moulinie (1812) submitted a thesis "Brûlures" to the Faculté de Médecine de Paris and his findings were:

"First: In the first degree there is redness and a burning sensation; the epidermis is not too much altered, the mucous layer seems to be the site of the damage; there is a little flushing, the terminations of the capillaries are more injected, the white vessels receive red fluids.

"Second: The second degree is characterised by alterations in the epidermis; there may be only slight thickening, cornification, or it can be lifted to cause blisters by the accumulation of fluids; or, it can be destroyed and detached, to produce excoriations.

"Third: In the third degree there is alteration of the dermis; it is hard, cornified, and tense; of a yellow, brown or black colour, or looks charred. Often, the epidermis is neither lifted nor detached, the skin is swollen, very tense in places, as if the fluids dilated by the heat had produced emphysemas. Fabrice de Hilden describes very well this third degree: 'Verum etiam cutis vera suo humido radicali ex parte destituitur et aliquo modo exiccatur et contrahitur, nondum tamen facta est eschara'. In effect, the skin, seen from the inner surface on post-mortem examination looks white and doesn't appear altered at all.

"Fourth: In the fourth degree, the skin is completely disorganised, reduced to an eschar with a black rust colour due to the action of the fire, or yellow-greyish due to the action of some caustics.

"Fifth: The fifth degree is where the burning agents extend/

extend their destructive action to the subcutaneous organs, to vessels, to nerves, to muscles, to bone, to the whole thickness of a limb, to viscera, etc.".

Coubret (1813) in a thesis "Dissertation sur les Brûlures" stated that the degree of burn varied according to the nature of the burning agent, the quantity of heat it contained and the duration of exposure, and submitted the following degrees.

First: The skin is irritated and becomes red, warm and tender, then tense and swollen. The pain is pleasant to begin with then becomes burning.

Second: As in first plus the epidermis raised by serous fluid.

Third: The burn involves the dermis but the skin is still white which shows that there has been no alteration inits organisation.

Fourth: Life in the skin stops and it is disorganised.

Fifth: The burn involves skin, subcutaneous tissue, vessels, nerves, tendons, muscles, bone, viscera.

"If infection occurs in a second degree burn it can progress into a deeper one".

John Thomson (1813), in his often quoted Lectures on Inflammation in a chapter entitled "Burns", postulated: "it had been usual to divide burns into different kinds of species. These divisions have sometimes been taken from the agents by which the burns are produced, but more frequently from the depth and extent of the local affection. The depth and extent to which the effects of burns have penetrated, appearing to me to afford the best grounds for distinction. I shall, in the few observations which I have to make upon these injuries, divide them:

"First, into burns which produce an inflammation of the cutaneous texture/

texture, but an inflammation which, if it be not properly treated, almost always manifests a tendency to resolution.

"Secondly, into burns which injure the vital powers of the cutis, occasion the separation of the cuticle, and produce suppuration on the surface of the cutaneous texture.

"Thirdly, into burns in which the vitality and organisation if a greater or less portion of the cutis are either immediately or subsequently destroyed, and a soft slough or hard eschar produced. This is a division of burns which, so far as I know, was first made by Fabricius Hildanus, and which since his time has, with some slight modifications, very generally been adopted.

"It is to be remembered however, that this, as well as every other division of burns, must be in many respects arbitrary.

"The phenomena which occur in the first species present themselves in the second and third".

Dzondi (1816), in a publication entitled 'About burns and the safest method of quickly and painlessly healing in whatever grade', expressed the view that there was no sharp differentiation between the four degress employed from redness to charring; where one ceased and the next began. The intensity or violence of the agent gave a lead. Four classes were distinguished.

(1) the lowest, which resulted in a painful irritation with pain, heat, redness and swelling.

(2) Lymph collected between the superficial and deeper skin layers.

(3) not only blisters were produced but the fibrous tissue and arteries in the skin were involved with production of eschar.

(4) Death and destruction or charring of the part.

A. Boyer (1757-1833), a pupil of Desault, was best known for his Treatise on Surgical Diseases (1814-1826), extending to eleven volumes and termed by Malgaigne as "a summary of the works and/

and opinions of the French Academy of Surgery" (Garrison). In the preface of his Traité des Maladies Cirurgicales (1818) he expressed complete personal satisfaction with the world and everything surgical and that "surgery was not to be improved in the future". There were characters in abundance in those days.

Boyer's description of burn classification was as follows:

"One can distinguish three different degrees of burns, to which one must pay much attention because each requires a particular method of treatment.

"In the first degree, the effect of the burning agent is limited to an acute irritation which attracts the fluids to the part concerned; it results in a cutaneous inflammation which resembles the characteristics of erysipelas.

"If the burning agent is stronger, the irritation produced is so acute that a blister is produced which uncovers the endings of nerves of the skin, and a superficial ulceration follows; this is the second degree of a burn.

"If the burning agent acts with even more energy and the duration of its action is longer, it disorganises the part with which it is in contact. The burnt area is transformed into an eschar. If it doesn't dry up it appears grayish-yellow. In both instances the manifestations of life disappear and the gangrenous part soon becomes surrounded by an inflammatory circle which heralds the efforts of the nature to separate it from the living parts.

"We have considered each degree of burn separately in order to get a clearer idea of them; but they often exist simultaneously. It is only the first degree which can exist alone. Whenever the second degree is present, it is accompanied by the first one; and when the third degree is present, the second and first are present too".

Delpech/

Delpech (1816) became professor of surgery in Montpelier and was the French pioneer of orthopaedic surgery. He classified burns in two grades: (1) inflammation response; and (2) destructive response.

Macdougall (1818), in a probationary essay on burns, considered this grouping adequate and concluded "this latter division appears to me to be well calculated for practical purposes, as it is not founded on vague or assumed principles, but on the usual train of symptoms which such injuries exhibit. The division of burns into three degrees is commonly to be met with in both ancient and modern, dramatic and foreign writers; yet it is obviously to be regarded more as an artificial than as a natural division, for the first degree of burn only can exist separately".

Macdougall also quoted the two divisions of Kentish (1817): "(1) those in which the action of the part is only increased; and (2) those where action of some parts is increased, and the organisation of other parts destroyed".

Chelius (1847) in his Handbuch Der Chirurgie accepted Heister's four degree classification.

Sir Astley Cooper, in 1823-1824, in a course of lectures on the principles and practice of surgery at St Thomas's Hospital, London, said of burns that they produced three different effects: (1) vesication; (2) desquamation; and (3) gangrene, and that the third state was when the life of the skin was destroyed.

W. Drumbeck (1825), in an introduction to a probationary essay on Burns, gave an excellent summary of the views of the time, and wrote: "In the science of medicine and surgery, there is perhaps, no subject on which there has existed more contrariety of opinion, or which has met with a greater variety of treatment, than Burns. If we consult the different writers on this important subject/

subject, we shall find, that, notwithstanding the numerous improvements that have taken place in the different branches of medical science, the mind is left in a greater state of uncertainty, from their contradictory opinions, than previous to the perusal of their works".

He submitted a classification which had been suggested by Sabatier in his De la Médecine Operatoire (1822-1824), and also by Thomson (1813). The three divisions were:

"Firstly, into such as produce an inflammation of the cutaneous texture, but an inflammation which, if it be not improperly treated, almost always manifests a tendency to resolution.

"Secondly, into burns which injure the vital powers of the cutis and occasion the separation of the cuticle, and produce suppuration on the surface of the cutaneous texture.

"Thirdly, into burns in which the vitality and organisation of a greater or less portion of the Cutis are either immediately or subsequently destroyed and a soft slough or eschar formed".

Abernethy, in 1825, in his lectures on burns and scalds at St Bartholemew's Hospital began: "Now I say that the vitality of a part, may be destroyed, or even the animal structure decomposed, by fire; but these parts which are so acted on cannot be the subjects of surgical treatment. What is to be said of parts violently irritated?. As boiling water cannot decompound a part of the body, but is capable of irritating to a great degree various parts of the body, and as parts actually decompounded cannot be the subject of surgical treatment.

"Boiling water does not decompound animal matter; but the heat of boiling water will effect the coagulation of the animal juices which are capable of coagulation; of crisping up and coagulating the fibres of the cellular substance, because they are principally/

principally made up of gelatin. It will crisp up the rete mucosum, so as to cause a separation of the cuticle, but it does not decompound or kill the animal matter by its chemical properties. It is, however, violently irritating, but short of that power which produces the decomposition of the part. Now sloughing, or death of the part, does sometimes take place from scalds, but not always".

In volume 9 of Medico-Chirurgical Review (1828) there appeared a report of the Westminster Medical Society on a discussion in which Dr. Bingham made a statement that burns and scalds were conveniently divided into those which excite the skin or produce vesications and those which inflame or disorganise deeper seated structures, down to the bone itself.

Lawrence (1829-30), writing on burns, stated: "The important points for consideration, therefore, are the degree and extent of injury in those cases - the degree of injury, that is the degree of heat that is the quantity of surface which is involved in the mortification. The portion of the body deprived of life is generally called an eschar from the Greek eschara. 'Eschara' in Greek means that part of an altar on which the sacrifice has been offered and which, in consequence, has become charred and discoloured".

Callisen (1830-45) in his Medicinsches Schrifteller Lexicon accepted the four degree classification advocated by Heister. (Callisen 1788).

J. Burns (1831) divided burns into six degrees:

"(1) Mere erythema without vesication or with vesicles so small, that the fluid is readily absorbed, or if it ooze out a superficial dry scab is formed.

"(2) Vesications to a considerable extent may form, and these breaking, the cutis below, secretes purulent matter - we have no ulceration, which implies granulation.

"(3) Ulceration is produced, and this is in general tedious and much/

much disposed to form fungus granulations. ..... There is always a scar left and often the cicatrix is elevated, smooth and redder than the rest of the skin.

"(4) The subjacent parts are inflamed, or otherwise injured, and not only during ulceration, but also after cicatrization, there is great pain, and thereby inability to use the member. There is in this case, in addition to the tendency of the cicatrix to contract, a risk of the parts below contracting also. This specially so about the joints.

"(5) The part, from the first may be destroyed and eschars formed, which leave after their removal, deep ulcers.

"(6) Mortification may succeed the inflammation produced by the burns".

R. Perry (1831), in contemplative fashion, recorded of burning: "notwithstanding the frequency and fatality of such cases, professional men are not yet agreed about the nature of the injury sustained, ... much light however, has been thrown upon this subject by the researches of Mr. John Hunter, Bichat, and Drs. Burns, Thomson, Philip, Wilson, Paris, James and other surgeons. Perry was forthright and declared with emphasis: "to practice surgery without general principles, is nothing less than empiricism ..... and to be guided in practice by theory alone, is to follow an ignis fatuus, which will lead to the most dangerous and fatal results".

Of the actual injury he wrote: "when heat is suddenly applied in an over degree, it easily penetrates the cuticle, preternaturally excites the nerves, and increases the action of the exhalent vessels, which throws out the serous fluid, which they circulate so rapidly, that the cuticle which defends the extremities of the nerves, is quickly raised and forms a blister, and if removed, the nervous papillae are exposed and sensation increased. .....

still/

still the part is not deprived of life.

"Or the degree of heat may be so great that the cutis vera shall be partially or even wholly destroyed, or so far disorganised that it soon dies, and must be separated from the living parts; a process nature sets immediately about, leaving an ulcerated surface.

"Or, thirdly, the skin and adjacent parts may be so completely disorganised by the first injury, that it becomes black and incinerated, and must be thrown off like any other eschar".

Liston (1831 and 1840), the well known Edinburgh surgeon who later moved south of the Tweed to London, gave a clear picture of the surgical problem: "Different degrees of injury are inflicted on the surface from the application of heated solids or fluids. A slight degree of heat is productive only of redness of the surface with a sharp hot pain and then symptoms may subside with or without vesication.

"However, effusion of serum under the cuticle often takes place almost immediately after the contact of the heated body ..... the cuticle may be destroyed by the intensity of the injury ..... or the true skin may die, either partially or throughout its whole thickness and the subjacent parts be at the same time injured to a greater or less depth, but parts not severly injured at first, may afterwards perish, violent inflammatory action being excited, which terminates in sloughing.

"Burns of the trunk, particularly of the genital organs are attended by much danger".

Brodie (1832-33), recorded the following clinical remarks in relation to burns: "if the cuticle only be destroyed, it will very soon heal; but if the cutis below is burnt, you have a nasty troublesome slough, and it is a long time before it heals. Sometimes the cutis is only half burnt through, and then you have a smaller slough/

slough and you find the surface covered with minute, red, pinlike points. They are the remains of the papillae". A clear picture of superficial, deep dermal and deep burns.

Earle (1832), in a lecture on burns, stated that: "in very severe burns vitality of skin and flesh often are destroyed by action of the fire and render tissues caput mortium.

"Various degrees of injury can be arranged under three heads. In the first or mildest form of scald or burn, a degree only of inflammation is produced. In some cases vesication may follow after some interval. In the second degree of injury vesications speedily follow which increase in volume and number according to the nature of substance and extent to which applied. Some parts may be denuded of cuticle. ..... Later vesication may take place. The third and most important kind of burn is that in which the integument and the more deeply seated parts are deprived of their vitality either by the immediate violence and intensity of heat and duration of application or in consequence of high degree of inflammation excited. Such cases are always combined with the two former degrees.

"It is often difficult at first sight to form a correct opinion of the extent and depth to which the destructive processes have gone".

The most able French surgeon of the period was The Baron Dupuytren (1777-1835) who was at once a shrewd diagnostician, an operator of unrivalled aplomb, a wonderful clinical teacher, and a good experimental physiologist and pathologist (Garrison, 1968). He became surgeon-in-chief at the Hotel Dieu. His clinics drew students from all countries and he trained many brilliant men.

Dupuytren (1836), in his clinical lectures, described the classifications of Fabricius and Boyer and of Heister and Callisen and/

and then continued: "in all these divisions, regard has been paid only to the intensity of the symptoms of the burn itself, considered generally, leaving out of view the nature of the organs affected, of the tissues attacked or destroyed. Nevertheless, it is evident that the heat always affects the skin first, and that its effects then extend to variable and successively greater depths; that the three orders of phenomena, which we have mentioned above, are in direct ration with this depth, and consequently that if we wish to establish a classification of burns upon exact principles, we must take for a base the different kinds of organs which have been exposed to the action of heat.

"For these reasons we adopted long since another classification, and divided burns into six degrees, which are thus characterised. First erythema or superficial phlogosis of the skin without the formation of phlyctenae. Second, cutaneous inflammation, with the loss of epidermis and the development of vesicles filled with serum. Third the destruction of a portion of the papillary body. Fourth, the disorganisation of the whole dermis to the subcutaneous cellular tissue. Fifth, the formation of eschars, of all the superficial parts, and of muscles, to a greater or less distance from the bone.

"The character of these degrees of organic lesions produced by burns, although well marked, are nevertheless, in most cases, difficult to distinguish soon after the accident".

A.A.L.M. Velpeau (1795-1867), at one time apprenticed to his blacksmith father, became an able, hard-working surgeon and was referred to by Oliver Wendell Holmes as "a good sound head over a pair of wooden shoes is a good deal better than a wooden head belonging to an owner who eases his feet in calf skin"(Garrison). He wrote (1832), New Elements of Surgery with an Atlas in three volumes and recognised four degrees of burns: (1) simple rubefaction; (2)/

(2) vesication; (3) destruction of rete mucosum and first layer of the true skin; and (4) where the whole thickness of the skin is converted into an eschar".

In 1833, Sir George Ballingall published his popular book on Military Surgery in which he favoured the adoption of three classes or degrees in burns: "(1) those which merely produce a superficial redness and inflammation on the surface; (2) those which affect the vitality of the cutis, accompanied with the elevation of the cuticle into vesicles or blisters and producing suppuration on the surface of the true skin; (3) those where the whole thickness of the skin, and even the subjacent parts, are affected by the injury, leading to the formation of a slough or eschar, which must, necessarily be detached before a cure can be accomplished".

Lizars (1838) of Edinburgh, in his System of Practical Surgery related in his classicication appearance to depth of destruction. "A burnt part", he stated, "exhibited merely an efflorescence or a vesicated appearance, or a dark red tint or deep black colour. In the efflorescence or blush, the surface of the chorion is but slightly affected; in the second, or vesication, all the textures of the skin are inflamed; in the third, the skin, subcutaneous cellular tissue and part of the contiguous macular stratum, are inflamed and chemosed; in the fourth, all these together with the deep muscular substance, nerves and blood vessels, are charred".

On page 311 of volume XI of British and Foreign Medical Review, (1841), is an interesting report on Burns and Scalds with accompanying reviews of two books: Treatise on External Pathology and Operative Medicine by A. Vidal, Paris (1839-1840), and Elements of Surgery by R. Liston, London (1840).

The/

The reviewer stated that: "for most practical purposes, a classification of burns under two heads would be found sufficient, namely that in which the connection between the cuticle and true skin was at once destroyed, and that in which the vitality of organised tissues, is at once annihilated". "Both Chelius and Liston", he continued, "accepted this simple division but Vidal preferred the more detailed Dupuytren method". "In addition", he stated, "the first degree was the erythematous form of Rayer, the second degree the vesicular or bullous form of Rayer while the third and following degrees were comprehended by Rayer as gangrenous".

Lisfranc (1842), an ingenious and bold operator but unpopular for his openly critical attitude to his colleagues, favoured the classification of Dupuytren.

James Miller (1844), in his Principles of Surgery, classified burns and scalds by the Dupuytren method and gave a very clear clinical picture of the individual types; while Fergusson (1846), in a System of Practical Surgery stated: "they may be of many different sorts; the surface may be merely a little over-heated, the injury may be such as to induce vesication, and possibly subsequent inflammation, of which the effects may vary from the simplest to the most severe, or the part implicated may at once be deprived of vitality".

Druitt (1847), in Surgeon's Vade Mecum, quoted from the experiments of Blagden and Fordyce who found the contact of heated spirits could be borne when cooled down to 130°F; of oil at 129°F, water at 123°F and quicksilver at 117°F. They ascertained also that the body may be exposed to air of a temperature above 212°F without injury whereas the contact of a solid of the same heat would burn. (Blagden and Fordyce, 1775).

Druitt believed the most useful division of burns was the/

the three-fold one which he stated "has existed from time immemorial : as first burns producing mere redness; secondly, those causing vesiculation; thirdly, those causing death of the part burnt".

B.B. Cooper (1847), in a Course on Surgery at Guy's Hospital remarked: "Burns and scalds are not to be classified according to the intensity of the heat, the consistence and capacity for heat possessed by the fluid, or even to the length of time that the heat has been applied, but rather according to the effects that have been produced by its application, which often penetrate beyond the surface, excite violent action and become dangerous to life". "The most simple result from a burn or scald is a mere superficial inflammation ..... From the peculiarity of constitution, the same degree of heat may in another patient produce a greater degree of injury and its influence may penetrate into deeper structures and interfere with the vital powers of the true skin, occasionally at once, or subsequently, a separation of the cuticle from the surface of the cutis and an effusion of serum between them; or a higher degree of temperature may produce this aggravated result".

In 1852 Hervez de Chegoin raised the issue of whether a superficial burn could deepen in the first few days after injury by the continuing effect of the heat upon the skin or as a consequence of the reactionary inflammation.

In 1851 there appeared a thought-provoking article on burns and scalds including astonishing statistics in the Transactions of the Provinvial Medical and Surgical Association (volume XVIII) by S. Crompton. One read with not a little interest the following: "the evidence which I have received is of a conflicting character ..... Perhaps on no other surgical subject would it be possible to collect such conflicting opinions. There are almost insuperable difficulties/

difficulties. The first is the difficulty of registering cases of burns in such a manner as to admit of rigid analysis, and the greatest obstacle to this is the want of a good classification".

Here then, in 1851, is a criticism often expressed today. Crompton continued: "All the classifications of burn which are founded on the pathological effects produced in the injured parts, seem to me to be incomplete and of little practical utility. As a burn may produce simple erythema, or vesication, or mortification extending to various depths and as these conditions may be combined in various ways - it follows that any classifacation of burns founded like Dupuytren's, on the tissues affected, is for practical purposes nearly useless. His degrees serve as no tests of the severity of the case - though they define the local severity. I think it may be safely inferred that M. Dupuytren did not mean by his 'degrees' to express the severity of the burn <u>in relation to the safety of the patient</u> but simply the degree of injury done to the tissues in each spot. ..... Without professing to give a perfect classification I may denote those points which are essential to a sound classification which are, firstly, the effects produced on the constitution of the patient; and secondly, the extent of the burn".

William Pirrie (1852) was Professor of Surgery in Aberdeen University. He had graduated in Edinburgh in 1829 and had studied in Paris under Baron Dupuytren. This is of some interest, not only from his surgical leanings but also because his students from his generous stature termed him "The Baron"!

In burns he naturally taught that the Dupuytren classification was the most scientific and convenient and obviously, from his writings, he had studied burn treatment and pathology in great detail.

Erichsen (1853) referred to burns in his <u>Science and Art of Surgery</u> and spoke of a "superficial local effect, to excite inflammation/

inflammation and of a more intensive to destroy vitality of more or less of the soft structures and even bone".

James Bird, in his lectures (1855) on Military Medicine and Surgery at St. Mary's Hospital, London, declared: "if all such accidents be indiscriminately named burns, as if the general custom, they are usually divided, first into those of a superficial kind, attended by a mere redness, or vesication; and second, those deeper ones, where an eshcar, or slough, has been produced by the greater conducting however of the heated body applied. In the first kind the epidermic covering and true skin only are the seat of the injury, in the second kind the vitality and organisation of the derma are either partially or wholly destroyed, often aggravated by the death of the subcutaneous and deeper-seated textures".

Syme (1856), probably the most famous of the Edinburgh Surgical School and father-in-law of Lister, wrote: "when a part is exposed to a higher temperature than usual, its actions are increased, and it becomes red, swollen and hot.

"If the heat applied is moderate or of short duration symptoms disappear when it is removed; but when it is intense or longer continued, redness is bright and permanent and there is a painful sense of burning. The part is then said to be burnt, while in the former case merely excited. The inflammation thus induced terminates in effusion of serum from the surface of the cutis which detaches the cuticle and elevates it into blisters.

"When the heat is still more intense or prolonged it destroys the life of the part. The cuticle is then detached and thrown into irregular folds exposing the subjacent cutis discoloured and dry".

Syme did not describe any classification as such but from discussion appeared to favour one of three divisions. Lister who helped to write his chief's lectures favoured the Dubuytren classification/

classification.

One textbook of the last century which impresses the reader even today is A System of Surgery, Theoretical and Practical, edited by T. Holmes (1860). Holmes himself wrote on Burns and Scalds and described the four divisions of Heister and the six of Dupuytren, and added, "various other divisions have been proposed; all of them indicating the depth of tissue implicated in the injury. Of these Dupuytreh's is the one which is most complete and the most practical ..... It does not and is not intended to embrace all the elements necessary for prognosis and treatment. It indicates the depth of the burn at its deepest part".

Of some interest, Beeton's book of Household Management (1861), described three classes of burns, the first : "which were altogether superficial merely redden the skin; the second, where the injury is greater and produces little bladders containing fluid called serum; the third where in burns charring occurs and in scalds a pulpiness with perhaps a complete and immediate separation of the part which occurs at once or in the course of a little time".

In 1862, in volume XXIX of British and Foreign Medico-Chirurgical Review a report on the treatment of burns by Professor Roser appeared in which the classification resembled the superficial, deep dermal and deep employed by some schools of today, Roser stated: "much depends upon the depth to which the injury has extended, for while a destroyed epidermis is rapidly reproduced, when the skin has suffered to a great depth or throughout its entire substance, the reparation, after the separation of the mortified parts, may be very tedious, in consequence of the great loss of substance, or of the unsuitable character of the parts affected".

In Edinburgh surgical lectures on burns and scalds of Professor James Spence (1868) one can note the undoubted scientific build/

build up of the presentation as his talk progressed. The introduction too was apposite: "it is perhaps more difficult to form a correct estimate in these injuries than in any other", while the whole text indicated considerable clinical experience, as illustrated in the following selection:

"In scalds we must take into account the nature of the boiling liquid - water or oil or a liquid-retaining temperature longer and which requires a higher heat than 212°F. for its boiling point. Also whether the liquid contains some peculiar substance in solution and so possesses some acrid qualities besides the mere heat". And further - "if boiling water be applied almost directly to the surface of the skin it will seldom completely destroy the vitality of the true skin or cutis. It may do so partially. .....

"In all cases, the local effects of the burn by fire are very severe, compared with those produced by scalds; ..... in the burn, there is not only destruction of the true skin and of the subjacent cellular tissue, but beyond that there are changes - though their vitality is not absolutely destroyed, they undergo a peculiar change".

His classification might be termed superficial, deep dermal and deep.

F. von Hebra (1816-1880) was a Moravian by birth and studied under Rokitansky, a fellow countryman and an eminent pathologist in Vienna. Von Hebra became the founder of a histological school of dermatology in Vienna. In 1864, C.H. Fagg published an English translation of his On Diseases of the Skin, in which one read under the term Dermatitis Ambustiones: "In general any temperature above the natural 100°F. causes the cutaneous vessels to be hyperaemic. In other words an erythema (erythema caloricium) is produced. If the temperature has gone beyond 145°F. the erythema disappears/

disappears only at the end of some days, after which the cuticle directly affected by heat undergoes desquamation. On the other hand when the temperature reaches 212°F. or still higher, the epidermis is destroyed by it and the cutis exposed; while at other points inflammatory exudation is rapidly thrown out beneath the cuticle and charring takes place and yellow, brown or black eschars form. Thus the appearances produced in the skin by burns may be considered under three heads or as presenting three degrees of intensity:

"1st degree: Dermatitis Ambustiones Erythematosa (Brûlure, Rayer, 1826-1827). Characterised by reddening of varying intensity, disappearing beneath pressure of finger, a considerable degree of swelling and persistent pain.

2nd degree: Dermatitis Ambustiones Bullosa. (Brûlure vésiculeuse et bulleuse, Rayer).

The characteristic appearance of burns of this degree is the formation of vesicles or bullae, the epidermis being raised by serous exudation accumulated beneath it. ..... but the epidermis may be torn from the subjacent cutis and is observed as a white pulpy layer, or as a soft white membrane, rolled up and lying on the surface of the true skin, which last is then intensely reddened and presents numerous bloody points produced by haemorrhage. The degree of swelling and pain depends partly on extent - partly on its anatomical position.

3rd degree: Dermatitis Ambustiones Escharotica. (Brûlure, gangreneuse, Rayer). The characteristic is the formation of eschars which are of an ashen grey, yellow, brown or black colour and more or less dry, hard, firmly adherent and devoid of sensation.

"It is not possible from form, colour and thickness of eschars/

eschars to determine directly after accident to what extent subjacent parts have been injured, as well as the tissues of skin itself. For the appearance presented by the eschars is nearly the same when the muscles and even the bones have been destroyed as when the skin alone has been attacked".

I now turn to consider the teachings of the greatest surgical benefactor to mankind of all time, Lord Lister. In his lecture on burns and scalds (1868-1869) to students the use of Dupuytren's classification was suggested. That Lister fully appreciated the protective barrier of normal skin was illustrated by notes taken in 1867-68 by Taylor: "If we knew of some germ poisoner that was unirritating, then if the wound was sprayed with it, then the wound could be treated as a subcutaneous one. There is no antiseptic yet discovered that will kill the germs without irritating the tissues". Other articles on the same topic were published. For instance, in 1870, he wrote in a pamphlet: "From the statement of others you would suppose me to have taught that, if you do but apply carbolic acid freely to a wound, you will prevent suppuration; whereas I have all along pointed out that carbolic acid being a stimulating substance will itself induce suppuration by long continued action on the tissues". In other words, Lister was aware of the dangers from further injury by local applications.

His thoughts were expressed in 1890 in another way. "It has long been evident that the living tissues exerted a potent influence in checking bacteric development. This used to be an enigma but now receives its natural explanation in the phagocytic action of the cells that collect the lymph soon after its effusion".

The benefits to burn treatment of the introduction of antiseptics is not easy to assess as the Listerian principles seem to/

to have been improperly applied. The story will be followed later in the works of his young colleague Watson Cheyne.

Some young burned patients under the care of M. Giraldes (1870), in l'Hôpital des Enfants Malades, were referred to in the Lancet. Giraldes considered that it was unimportant to give a full description of the lesions according to the different degrees pointed out by Dupuytren or Webster, and that clinical facts were more necessary. Thus, it was most important to observe carefully the general condition which attended burns of the second and third degree, but above all the danger depended on the extent of the lesion.

Billroth (1877), the eminent surgical pathologist who adopted Lister's theories and became a pioneer of visceral surgery, taught in his lectures a three-division classificationfor burns. He said: "These, it is true, run into each other but they may without difficulty be distinguished according to the accompanying symptoms; the object of this classification being to facilitate explanation".

His description of each degree was full and resembled closely that of Hebra. He undoubtedly appreciated the importance of skin loss in his statement: "strange to say, it was formerly asserted that cicatrices after burns contracted more strongly than other cicatrices. This difference, however, is only apparent, inasmuch as in other kinds of injuries there is scarcely ever so great loss of skin as takes place in burns". He continued: "Should the extent of the burn not itself cause death, in many cases the great loss of skin and the consequent suppuration may prove dangerous, especially to young children and old people".

Billroth certainly pinpointed the importance of both extent and depth and so indirectly the significance of classifications.

The general attitude around 1886 towards classification of burns/

burns in depth was well summed up by Gant in his Science and Practice of Surgery in the following terms: "Formerly burns were classified according to their different degrees of structural disorganisation as represented by inflammation, suppuration, sloughing and ulceration. Fabricius Hildanus, Boyer and Dr J. Thomson observed only three degrees of disorganisation; Heister and Callisen recognised a fourth; but Dupuytren was dissatisfied and distinguished burns by their various degrees from the surface inwards to deeper parts". Gant observed: "the distinctions laid down by Dupuytren, although still generally accepted, are, I conceive practically useless. Deep burns of fourth, fifth and sixth degrees are not attended with corresponding different degrees of shock".

Heath (1889), in his Clinical Lecture at University College Hospital, referred to the "Classical classification of Dupuytren" but continued: "in practice it is quite sufficient to have three divisions. The point for you to determine is this; is it simply a scorch as you may get from an explosion of gas; or is it something more severe, leading to vesication (common condition of scalds); or is it something more severe still - a charring which can only occur from the application of dry heat, actually scorching up and burning the part?. Those three degrees are practically all you require; - a superficial burning, a burning with vesication or a burning with an eschar".

This interpretation was supported by Unna in 1896 though probably for other reasons. In his Histo-pathology of Diseases of the Skin, he wrote: "Since Hebra adopted Boyer's division of burns of the skin into three grades we have been accustomed, surgically and dermatologically, to regard burns from their three most striking results; first, redness of the skin; second, formation of bullae; and third, the formation of scabs". He continued with the following interesting/

interesting addition: "It is thus usually tacitly assumed that only the third degree of eschar formation is accompanied by a true necrosis of the skin and the fact that every form of burning induces necrosis of a lesser degree is consequently overlooked".

However, Watson Cheyne and Burghard (1899) supported the use of Dupuytren's classification as did Joseph Bell (1899). Watson Cheyne was closely associated with Lister, and Bell with Syme.

Throughout the 19th Century there had been a more scientific approach to the burn problem but to my mind in the first part of the 20th Century there seemed a ready acceptance of fact and sometimes a forgetfulness or ignorance of what had previously been achieved. The New Royal Encyclopaedia Londinensis listed four degrees of burns: (1) the slightest leading to pain and small vesication in a short time; (2) the affected part suffers prodigious pain with vesication; (3) the common integument and subjacent flesh are so burnt they form a crust; and (4) everything is destroyed right down to bone.

The Reference Handbook of the Medical Sciences (1901) favoured classification by first, second and third grades as the Dupuytren classification was too complicated though it had been in vogue for a period but was now generally discarded. The classification of T.G. Morton was the one suggested for adoption: first degree - erythema, irritation and inflammation without vesication; second degree - inflammation of skin and formation of vesicles and bullae; third degree - eschars, gangrene, superficial or deep, involving skin or subcutaneous tissues, carbonisation of a part or the entire body.

For medico-legal purposes the Reference Handbook (1901) recommended the following grouping: (1) involvement of skin and subcutaneous/

subcutaneous cellular tissue; (2) extensive injurious effects to muscle, nerves and blood vessels; (3) involvement in their effects of the internal organs and bones; (4) previous classes combined.

EVOLUTION of CLASSIFICATION by DEPTH

From around 1900

Biddle (1902), in a reflective, partly historical paper declared: "After a careful study of many cases, and with a fair share of experience, I am convinced that the classification of burns in many different degrees is of little value in the treatment. It does assist us, however, in making a prognosis as to whether or not the patient will be disfigured". Biddle quoted the popular Dupuytren classification but stated a preference for division of three used by Morton of the Pennsylvania Hospital.

Thomson and Miles (1904), authors of a popular Edinburgh surgical textbook, adopted the Dupuytren classification but discreetly added that the severity usually proved greater than at first sight appeared.

Sneve (1905) published a very illuminating paper in many ways in advance of the period. He considered Dupuytren's classification to be cumbersome, referred to the popularity of Boyer's simple three degrees but favoured the adoption of one of four degrees: (1) hyperaemia of skin; (2) destruction of epidermis as shown by vesication; (3) destruction of dermis; and (4) of deeper tissues. Sneve made use of very clear outline diagrams for each patient to illustrate the extent and degree (by shading) of the lesions - clearer than many modern case records. What a tragedy that the early example set by him was not followed by others!

Woodward, in Choyce and Beattie (1912), referred to the several classifications in vogue for depth, that the German and American workers favoured three, the French and British six degrees. He warned that a burn which appeared to be of third degree often turned out to be partly of fourth degree.

MacLeod (1918) confirmed the popularity of Dupuytren's classification in France and Great Britain while in America the simpler three degree method held favour.

Staige Davis (1919) opted for three degrees which he described as: (1) skin reddened; (2) skin blistered; (3) entire thickness of skin and possibly deeper tissues destroyed.

Writings of the period however gave very little lead and there appeared to be confusion of surgical and dermatological approaches to the problem with a consensus of opinion that standard classification in depth or even in extent were relatively unimportant.

A revealing paper by Bancroft and Rogers (1926) threw some light on the apparent indifference of the times. "As one reviews the literature", they declared, "one sees that the pendulum of interest in these deplorable accidents of civilisation swings as it does elswhere in medicine. At times surgeons are stimulated to extreme interest, and this is reflected in the literature. Too often there is a lack of interest and these unfortunate patients are delegated to the most inexperienced house officer". Bancroft and Rogers proposed that the three degree classification employed should have a fourth degree added: third degree burns should be those that destroy the epithelium but not the hair follicles and the fourth degree burns would be those with necrosis of all the epithelium and subcutaneous fat.

Tauber (1926), a dermatologist, in a dissertation to the Academy of Medicine of Cincinnati, gave a lengthy philosophic description of classifications. He proclaimed pontifically: "In life, burns come to all of us. ..... When life was simple, burns were either due to the sun, fire or boiling fluids, but in the 20th Century, progress has reached us and our penalties have become much/

much more complex and we have burns from chemicals, electrical, occupational industries, dyes, synthetic products, etc., which makes a newer classification of burns necessary - a classification according to (1) cause; (2) degree; and (3) extent.

(1) "Cause:

(a) Rays:- (i) sun: (ii) radium: (iii) X-rays and electricity.

(b) Direct action fire.

(c) Liquid:- (i) boiling water: (ii) moulten metals: (iii) greases.

(d) Chemicals.

(2) "Degree:

(a) Congestion - purely an erythema (120° to 160°) merely the epidermis and its four layers.

(b) Vesication (160° to 220°) epidermis and derma.

(c) Destruction or disorganisation (over 220°). This is of two degrees either (i) partial or (ii) complete.

(3) "Extent:

Proportion of body burnt is estimated as extent more important than depth. Twenty per cent must be added to the total area burnt as that area of subjacent unburnt tissue cannot function properly. Adults cannot survive if one-half of their integument is burnt and children under ten with one-third and children and infants under two with one-quarter burnt cannot survive".

Tauber considered that extensive burns were serious because the function of skin was upset.

Goldblatt (1927) adopted a fresh approach to classification: "As a result of study I desire to call attention to a practical classification. ..... Burns have been classified, as to the agent causing them; as to the extent of penetration into the tissues, into first/

first degree or erythema forming; second degree or blister forming; and third degree or eschar forming. ..... As the practical trend in surgery is to think of every condition in terms of end-results, the classification of burns rearranged in accordance with this advance is a desideratum". Goldblatt therefore proposed two main types, those that healed with scar formation to be termed Type I, and those that healed without scar formation termed Type II. Under Type I would be third degree American classification and under Type II the first and second degree American classifications.

Pack and Davis (1930), in their textbook, listed the following: the Dupuytren classification; what they termed the American ; that of Morton of three degrees; and also the four degrees of Heister and Callisen.

Barnes (1933), in a review, referred to a preference of English, German and American workers for a classification of only three classes. In addition he made use of Stewart and Lees' table to illustrate the similar characteristics of burns and those of inflammation:

	Burns	Inflammation
(1)	Erythema or first degree	equivalent to Hyperaemia
(2)	Blistering or second degree	equivalent to Exudation
(3)	Charring, phlegmon or third degree	equivalent to Necrosis
(4)	Suppuration	Suppuration
(5)	Cicatrization	Repair

Barnes offered as a useful definition of a burn wound: a solution of the vital continuity of skin but not of its physical or mechanical continuity. It may be that a hidden solution to several problems lies in an appreciation of the full significance of this proposal.

In 1942, the Department of Health, Scotland, set up a committee/

committee to advise and report on the treatment of burns: the classifications in depth contained and compared were those of Dupuytren (six degrees), the German-American (three degrees), what was termed the Scottish of superficial and deep and the method of degree of skin destruction, partial and complete. The Scottish classification was naturally the one adopted by the Committee. Though not actually mentioned in the report the superficial included the epidermal, dermo-epidermal and deep dermal types and since 1944 the classification of the Edinburgh surgical school in clinical teaching has been superficial, deep dermal and deep.

Lehman (1942) raised objections to the three degree .. American classification and proposed a delayed classification made after all dead tissue had separated.

In 1944 the National Research Council of Canada published a Treatment of Thermal Burns in which the following grouping was submitted:

First degree: Destruction of epidermis.

Second degree: Destruction of the epidermis and partial destruction of true skin to varying depths.

Third degree: Complete destruction of the skin with or without destruction of underlying tissue.

A proposal was advanced to divide the second degree into two: superficial second degree burns in which regeneration of epidermis can be expected and deep second degree burns which can also heal by epithelialisation and formation of "scar skin" but which are best treated by skin-grafting.

A concluding paragraph stated: "although the term 'degree' applied to a burn is used to designate the extent of the pathological changes in the skin when treatment is being considered all burns can be placed in one of two great groups: first - those that can be/

be expected to go on to satisfactory healing without skin grafting and, second, those that should be grafted".

Converse and Robb Smith (1944) compared the healing of surface cutaneous wounds with that of superficial burns, and in a discussion, stated that within the group of burns classified as second degree, variations in the rate of the healing depended upon the depth of dermal destruction.

In summary they declared: "In defining the depth of the burn, it would seem more logical to use anatomic terms", and they suggested the following table:

Epidermal Burns	Erythema: Epithelial desquamation.	Heal Well.
Superficial Burns Dermal Burns (partial skin loss)	Blistering: Destruction of superficial layers of dermis: Mixed burns, small areas of deep dermal burns alternate with small areas of total loss. Deep dermal burns, destruction of dermis down to the deep layers.	Heal slowly with constriction; may require skin graft.
Deep Burns (total skin loss).	Destruction of the whole thickness of the skin into or beyond the fat.	Heal with difficulty, producing constrictions and deformities. Skin grafting the rule.

Clarkson and Lawrie (1946)recognised three depths of burns: "each distinct in prognosis and treatment": (1) epidermal (E.B.); (2) full thickness loss (F.T.L.); and (3) dermal (D.B.). They stressed the importance of the third group.

Seeger (1947) in Lewis's Practice of Surgery favoured the American classification of three degrees with the possible sub-division of Bancroft and Rogers. Consideration was given also to Goldblatt's viewpoint. Seeger warned of a tendency to underestimate depth/

depth and to overlook first degree burning around the margins.

Hartwell (1955), in the light of wound healing studies, proposed that burns be classified as first, second and third degrees with two simple sub-divisions for second degree burns. First degree burns were characterised by epithelial cell trauma and dermal irritation, while in second degree burns epidermal cells were killed and dermal cells injured with the tips of the dermal papillae devitalised. Dermis was therefore involved in the healing process with production of fibrous elements. A combined epithelial and fibrous healing resulted - the deeper the injury to skin the more the fibrous healing; eventually a time arose when the number of available cells for epithelialisation was inadequate. Hartwell considered that subdivisions in classification were essential and pursued his argument: "In superficial second degree burns the major damage is still epithelial but there is also injury to collagen fibres. These, though not cellular, may undergo changes which lead to a local organic foreign body response. With a larger number of dermal papillae damaged there are innumerable dermic wounds to be re-epithelialised once the papillary tips slough off or are digested. Scarring however will be minimal provided infection be prevented and dressings if employed do not damage.

"In deep second degree burns the same factors exist but the balance is different: epidermal cell destruction is complete and dermal cell destruction penetrates deeper. In healing, more dermis has to slough before the remaining viable epithelial cells can extend. More time is required and the resultant scar is greater in the region of each dermal papilla. Infection or superimposed trauma will lead to more fibrosis and disturbed healing and may even convert a burn to third degree type.

"In third degree burns there is devitalisation of all skin layers/

layers and appendages and thus no epithelial cells are available for surface cover. Any epithelialisation must come from the marginal cells. The third degree burn is in reality a sub-epithelial wound with fibrous tissue healing dominant and prolonged.

Hartwell postulated that a "pinch-graft" applied to a large granulating surface would expand to a certain point in all directions and then stop as more total cells were required for additional extension. Dermis injured but possessing viable epithelial cells of adequate number would heal. "Anything which kills living cells or which takes away living or keratinised cells will delay epithelialization of a wound. Likewise, noxious factors which involve the fibrous tissue base over which the epithelium must find its way or which made that base untenable for the epithelial cells, will delay epitheliation". I believe this last sentence from Hartwell to be very important. The presence of even microscopic groups of dead cells delays epithelial extension. Burns characterised by varying intensities of dermal involvement are notoriously slow to heal and are difficult to classify with accuracy.

Since the Second World War most surgeons who deal with burn injuries have adopted some form of a three division classification.

Though there are several modern methods of classification available confusion remains among surgeons in general. Even with surgeons who treat burns there is an absence of unanimity in approach.

Baxter (1959) for instance preferred the straightforward three degree method. Elliot (1960) advanced a thoughtful line and as an introduction submitted that the concept that a burn wound was one of loss of substance was fundamental and quite unlike other forms of trauma: that a burn diffusely effects the tissues around it/

it: that the full extent (surface area involved) and depth (penetration) was not usually as apparent as in other injuries. He advised a classification of three degrees or simply of partial thickness and full thickness.

Monsaingeon (1963) deprecated the all too common use of the term 'degree' and suggested the general adoption of the divisions 'partial skin loss' and 'total skin loss'.

Nardi (1965) preferred a three division classification, erythema, vesications, and full thickness destruction.

In an attempt to enlarge knowledge of the pathology of burn wounds Order and Moncrief (1965) contrasted experimental second and third degree (American classification) injuries.

Second degree experimental burn	Third degree experimental burn
1) No period of total avascularity.	1) Arterial vascular occlusion and devitalization.
2) Presence of cellular inflammation in the dermis.	2) Lack of cellular inflammation in the dermis.
3) Revascularization by the re-establishment of arterial potency one week post burn.	3) Revascularization by abundent neovasculature of granulation tissue three weeks post burn.
4) Granulation tissue present in the dermis.	4) Granulation tissue present at the fascia.
5) Re-epithelialization.	5) Period of eschar separation. No epithelialization. Requirement for auto graft.

Moyer et al (1965) described what he termed a <u>Functional classification</u> which is used in the Hartford Burn Unit. The details were:/

were:

1. Epidermal
2. Superficial dermal

) minor injury

3. Intradermal
4. Subdermal
   - A. Intra adipose
   - B. Fascial
   - C. Musculo skeletal

) major injury

Crews (1967) suggested a classification of six grades 1) First degree; 2) Superficial second degree; 3) Deep second degree; 4) Third degree (full thickness); 5) Fourth degree (skin and tissue deep to it destroyed, even down to bone); 6) Charring (with total destruction of an area of the body).

Ollstein, Symonds and Crikelair (1968) described present day attitudes clearly: 'superficial as contrasted to deep and partial thickness as contrasted to full thickness skin destruction comprise reasonable diagnostic terms' but 'traditional terminology demands reference to 'degree' classification of skin burns'.

Moncrief (1969) though he proposed acceptance of the terms 1st, 2nd and 3rd degrees reflected that partial thickness and full thickness described depth more accurately.

Moyer (1970) indicated that depth assessment was often impossible to determine for some weeks and that blistering occured in some burns of full thickness loss. He stated that burns at one time were classified into seven catagories or degrees but gave no additional information. He believed that some surgeons employed a four degree system: 1st of erythema; 2nd, death of epidermis with viable epidermal appendages remained within the dermis; 3rd, death of epidermis and all its appendages within the dermis; 4th, carbonification of a part.

Moyer/

Moyer however considered that most surgeons used the simpler classification of partial thickness, cutaneous injury, and full thickness cutaneous injury.

MacMillan (1972) considered that the classification most acceptable in American Burn Centres today was:

partial thickness

superficial

deep dermal

full thickness

Any classification with the terms degree should be avoided.

VIEWS on CLASSIFICATION of DEPTH.

General Surgical Views: To obtain a picture of present day surgical opinion a study was made of text books in a well known London medical library. Maingot (1936) retained the six degrees of Dupuytren. Romanis and Mitchiner (1952) did likewise but referred to the divisions of partial and complete skin loss. Aird (1957) also chose the six degree classification but also described the simpler Scottish two division method.

Handfeld Jones and Porrit (1957) also quoted the Dupuytren, American and Scottish classifications but made clear their unwillingness to employ the term 'degree', and their preference for the divisions of simple erythema, superficial skin burn and deep skin burn with subdivisions whole skin and whole skin plus subcutaneous tissue destruction. Welsh and Powers (1958) favoured Dupuytren as did Kiely (1958). Blackburn and Lawrie (1958) on the other hand advised a three degree classification while Swan in Oliver's Basic Surgery preferred the divisions of partial and complete skin loss. Horner & Lunn (1962) advised the American grouping but pointed out the value of two divisions. Cotton (1963) also advised the American classification but Macfarlane and Thomas (1964) on the other hand retained the six degree and Nardi and Zuidema (1965) the three degree method.

Som (1968) of India proposed what he termed a British classification of: 1) superficial or partial thickness; and 2) deep or full thickness; and also an international classification: a) partial epidermal; b) dermo-epidermal; c) full-thickness.

Du Plessis (1968) retained the use of a simple three-

grade/

grade classification while Condon and Nyhus (1969) preferred a two division class but each with grades: partial thickness, subdivided into superficial, intermediate and deep; and full thickness, subdivided into superficial and deep.

This survey of modern textbooks of general surgery indicates an overall lack of unanimity or even confusion of approach to the problem, even a lack of direction. This unsatisfactory state of affairs is basically due to failure of appreciation of the many possible gradings in depth each with its own characteristic behaviour pattern.

What has been the response of burn specialists to a solution of a vexing problem?.

Modern Views: Derganc (1962) has given a lead for some years. He appreciated the existing gap between the superficial and the deep types of burn and since 1953 has adopted a subdivision of the American second degree: (a) superficial (11A) and (b) deep (11B). Histologically in the 11A type the borderline between dead and viable tissue is represented by the papillary zone of the dermis. In the 11B degree only the deep epithelial elements of the dermis and subdermis have survived - on the average there are in every square centimetre 100 sweat glands and five sebaceous glands. In his conclusions Derganc affirmed that if the deep layer of the dermis with its epithelial elements was preserved viable, the course might move towards spontaneous epithelial regeneration. He affirmed that the concept of the 11B degree burn had been adopted in Yugoslavia and that the terminology had been added to their medical lexicon.

Mir y Mir (1969) employed two main classes. Superficial and deep with several subdivisions of the former, erythema, superficial dermal and deep dermal. Mir y Mir expressed favour of anatomical classifications such as Converse and Robb Smith.

In a recent publication, Monafo (1971) suggested a simple classification of burns, intradermal burns and subdermal burns with subdivisions and "that the actual word degree" should be dropped. Monafo's classification in tabular form read:

Designation	Synonym	Anatomical Depth of Necrosis
Epidermal	(First degree)	Stratum corneum of epidermis.
Intradermal (a) Superficial (b) Deep	(Second degree) Partial thickness	Dermis to variable extent.
Subdermal	(Third degree) Full thickness	Subcutaneous adipose tissue or deeper: all the dermis and its appendages are destroyed.

The Proceedings of the Third International Congress for Burn Injuries, published in 1971, contained much information.

In it Bales, Hinshaw and Pearse stated that the gravity of a burn injury related to the volume of tissue damaged or destroyed by heat, and believed that estimation of depth by appearance of the surface remained the most adequate single method.

Benaim (1971) pled that the word "degree" or its equivalent should have some form of international agreement. He submitted a classification in relation to the depth of burns and their resolution which he had employed with benefit since 1954:

Type A: Superficial skin destruction: epidermal and superficial dermal in nature.

Type AB: Intermediate skin destruction: deep dermal in nature.

Type B: Total skin destruction: Full thickness in nature.

The questionable AB type will progress in one of two directions: it may heal spontaneously and be called AB-A, or it may require skin grafting and be termed AB-B.

Derganc (1971) for reasons of inadequacy, deficiency and ambiguity again appealed for international agreement and submitted a plan:

Epidermal burns:	Erythema only. Erythema with wrinkling of the epidermis. Erythema with blistering at epidermo-dermal junction.
Dermal burns:	Superficial dermal burns - lesions of the upper half of dermis. Deep dermal burns - necrosis reaching into lower half of dermis.
Subdermal burns:	All the lesions deeper than dermis.

Jackson (1971) believed an acceptable classification should satisfy five standards:

(1) Should be based on depth of necrosis - not on intensity of surface burning.

(2) Should be anatomical.

(3) Should allow for early diagnosis to permit early surgery where indicated.

(4) Should facilitate prognosis assessment.

(5) Should include all previous types.

His suggestions were:

Erythema	No loss of epidermis.
Partial skin loss Superficial Intermediate Deep	 No loss of dermis. Healing from hair follicles. Healing from sweat ducts.
Deep dermal burns	Scanty epithelial cells which may or may not epithelialise the surface.
Whole skin loss	Healing from edge only.

EVOLUTION of CLASSIFICATION by SEVERITY

The term severe has been employed for hundreds of years but has had a loose connotation and its usage most often employed to distinguish from injuries of minor or moderate types.

In recent years a series of factors have been acknowledged as to contributing to a clinical picture of severity. In 1831 Perry stated: 'among the older surgeons, burns were considered as simple inflammations - differing in degree, according to their extent and severity: the inflammation was usually found to spread - this spreading - was attempted to be explained by supposing that fire had united with or become fixed in the part.

Suzuki (1897) reported that of 57 Japanese soldiers burnt at the battle of Yalu with an area of more than one-third of the body involved only 2 survived.

Weidenfeld (1912) using a three degree classification for depth concluded: 1)'that burns of the second degree end fatally after a longer time than burns of the third degree of the same total surface area: 2) that burns of the second degree involving the whole body surface correspond with burns of the third degree, involving only one-third of the surface of the body: and 3) that burns of the second degree covering one-third of the body are equalled in severity of results by third degree burns involving only one-ninth or one-tenth of the body surface'.

Miller (1921) believed all vesicant burns were fatal if one-half of the body surface was involved and that all of one-tenth of the body surface must be considered serious.

Lee (1923) considered that the intensity of shock from burns was greater than that from any other form of trauma.

Pack/

Pack (1926) listed the prognostic factors as:

1) the nature of the burning agent.
2) the age, sex, occupation and individual tolerance of the patient.
3) the extent of the body surface affected.
4) the degree of depth of the burn involvement.
5) the particular regions of the body burned.
6) the incidence of unusual and significant symptoms which have a grave import.

Willems and Kuhn (1936) studied the records of 1206 cases of burns over a twenty-eight month period from the files of a leading insurance company and found, as one would expect, incomplete and inadequate information.

The following are some of the findings: 'compensation for permanent disability was paid and recorded in 22 cases. It is probable that minor disability existed in many more but no mention is made of it. Temporary disability was present in all cases ranging from 5 to 570 days. The mortality rate was 1 per cent'.

Hoffman (1942) declared that the prognostic factor had been comparatively neglected in the literature of burns and that it depended in part on the etiological faction involved.

Some studies in mortality, taking into account age and extent of burn were carried out by Lutken (1937) and Perdup (1950) both from Copenhagen. Clarkson & Lawrie (1946) postulated that the mortality from thermal injury in each age group bore a sigmoid relationship to the size of the burn. Bull and Squire (1949) supported this approach and held that to compare results in different centres or in different periods in one centre, the factors such as age of the patient and severity of the lesion required to be standardized. The measure of severity suggested was the proportion

of/

of the body surface affected. Bull and Squire taking account of both age of patient and area of burn demonstrated that the relationship could be made linear by Probit analysis (Finney 1947), and approach to the question of severity changed. The results by age groups of this Probit technique were correlated to show the expected mortality for any given age and area and a grid table was provided for making a simple comparative assessment of the results obtained in other series.

Moyer (1953) in a clinical study reported: 'a number of criteria might be used from the comparative evaluation of various variants of burn therapy: however the only one which readily lends itself to objective analysis is the death rate - such studies can be very misleading - a mortality rate of 5 to 8 per cent is considered good today - yet during 1845, 1850, 1864 and 1867 the mortality from burns and scalds admitted to the Glasgow Royal Infirmary was 7.9, 6.3, 5 and 6 per cent respectively (Dunbar 1934). During three other years 1847, 1854 and 1859 the death rate from thermal injuries were 22, 24 and 21 per cent at the hospital but the therapy used was the same'.

It is of interest that Bull and Fisher (1954) could not demonstrate a higher mortality in infants and young children compared with young adults.

Sevitt (1957) offered the following comment: there is a minority more susceptible to burning and its complications than others, and secondly that among patients with more extensive burns in whom the mortality approaches 100 per cent there are a few less susceptible than most. In other words the sigmoid relationship statistically exposes variations in susceptibility and resistance to death among a burned population of the same age. Attempts have been made to include a correction for depth of burn.

Lewis/

Lewis et al (1963) referred to the scant attention given to psychological studies in severely burned patients and submitted proposals for a concerted attack on this aspect of a major problem. They described several 'rating scales' which might well be employed more widely with advantage while modifications of this form of approach could be applied to other aspects of thermal injuries.

Korlof (1966) followed up and recorded questions from patients burnt at least four years before and his publication is the only one to focus attention on social and economic sequelae including changes in life patterns in 264 persons e.g. matrimonial harmony, choice of employment, working progress, financial consequences and disability estimations.

Rittenbury et al (1965, 1966) carried out a profit analysis of over 1800 burns and found the significant factors in determining the level of mortality rates were: 1) area of full thickness burn; 2) extent of burn and age of patient (only one fourth as important as extent); 3) pulmonary complications; 4) central nervous system complications; 5) development of shock; 6) pre-existing disease; 7) race.

Kulcar & Pirc (1966) from statistical studies both in Yugoslavia and with W.H.O., Geneva, considered little was known of the time incidence of burns while record keeping and means of classification were rough and ready. They attempted to classify burns with code numbers 18.01 up to 18.09 where four categories were used to classify burns below 5 per cent of the surface area, 5-10, 10-15 and 15+ (World Health Organization: Epidemiological and Vital Statistics report (1961) . . . Their conclusions were: all efforts aimed at the study of the incidence or mortality and other epidemiological questions of burns on an international or world-wide scale are or will be only partially successful as long as/

as the World Health Organization (W.H.O.) does not introduce a better statistical classification of burns. International epidemiological work on burns will always be but partial and inadequate if the problem of classification is not solved.

Bull (1966), writing on Probit analysis of burns mortality, described how, in cooperation with Squire, he had studied all the likely factors which might determine the death of patients and that two were outstanding, the size of the burn and the age of the patient. Taking the age groups separately each gave a sigmoid mortality curve in relation to area burned. A Probit analysis technique was applied. In 1971 Bull demonstrated that Probit analysis can be applied to study increased length of survival from extensive burns while results of modern methods of therapy could be compared.

Stone and Boswick (1968) proposed an arbitrary classification of minor, moderate and severe.

	Minor	Moderate	Severe
Per cent partial thickness.	Less than 15%	15% to 30%	More than 30%
Per cent full thickness.	Less than 2%	2% to 10%	More than 10%
Hand, face, feet & perineum.	Not involved	Not involved	Involved
Age	.....	.....	Less than 18 months, more than 65 years.
Etiology.	.....	Minor chemical & electrical burns.	Major chemical & electrical burns.
Complicating illnesses.	.....	.....	Cardiac, renal, and metabolic.

On depth of injury Stone & Boswick expressed the following opinions: 'burns of the skin are traditionally classified as first degree if there is erythema only, second degree if some dermal are spared which can reguvenate the epithelium, and third degree if all layers of the skin are burned and grafting is required for wound closure. Presently, many surgeons prefer the terms 'partial thickness' and 'full thickness' as more anatomically descriptive. Within either category, there are grades of injury and corresponding variations in the prognosis. A partial thickness burn can be superficial, intermediate or deep. A full thickness burn likewise can be superficial, intermediate or deep. Even the most experienced surgeon finds it difficult to diagnose accurately the depth of many burn wounds and to distinguish between deep partial thickness and superficial full thickness burns, particularly during the first two to three weeks post-injury. Therefore, the depth of many burns is classified "indeterminate" and the exact diagnosis of depth is made in retrospect after the wound heals spontaneously or the need for skin grafting is apparent.

Ramirez, Tamandong, Delcastillo and Dino (1970) reported on Probit analysis of burn deaths in a developing country. Their purpose was clearly stated: to complete figures from their own hospitals; to provide a basis for reference from other institutions in the Phillipines wishing to assess mortality rates; to facilitate comparison of data with that of the rest of the world; and to enable evaluation of the progress of their own patients over a period.

O'ya and Fukuda (1971) referred to the lack of nation-wide statistical surveys on burns in a study on Japanese patients. They considered their data related to occurrence, climate, age and sex, place and causes might give a lead not only to reduction in mortality but/

but also guides to prevention.

There can be no doubt of the ideal requirements but Lockwood (1971) issued a warning in his paper 'Accuracy of Scottish Hospital Morbidity Date'. His summary read: 'A study into the accuracy of transcription of hospital morbidity data was undertaken in 38 hospitals throughout Scotland. Information contained in 2515 morbidity returns was compared with the information recorded in the hospital medical case records. Errors and omissions in the transcription and coding of the hospital case reference number, and the patient's name and sex, were each less than 1%, but errors and omissions in the date of birth were 3.7% and in occupation 14.7%. Data relating to the principal diagnosis were correctly transcribed and coded in 942 of the forms examined. The greatest error and omission levels were found for information relating to subsidiary diagnoses, which were shown to be recorded accurately in only two thirds of relevant cases.

THE FUTURE

Classification of burns has remained a problem and defied solution over the centuries and to offer simple solutions would prove invidious.

The problem is not restricted to any one country and any remedy must prove acceptable and applicable internationally.

In 1965 the International Society for Burn Injuries was established with a secretariat at the Edinburgh Royal College of Surgeons by the generosity of the President. In 1968 the Society became one of the non-governmental organizations in official relation with the World Health Organisation in Geneva.

Since the foundation of the Society most countries have become collaborators and have formed National Burn Associations or Chapters of the International Society.

In 1971 the International Society for Burn Injuries sought closer collaboration with W.H.O. and proposed the establishment of a series of Action Committees including that of Teaching and Records. This particular committee will also advise on classification and epidemiology. The other committees were, prevention (and first aid): burn unit planning and organisation: staffing and recruitment: and the requirements of pathological laboratories.

I firmly believe the answers to most burn problems should and will come from an international body which first must gain the respect of the family of doctors through its integrity, practical ideals and sound intentions.

I was most impressed by the contribution of Dr G.E.W. Wolstenholme to the Ciba Foundation 100th symposium on Health of Mankind (1967).

He/

He stated: 'in our modern world good news is no news'. 'Journalists are expected to write only of friction and disaster'. Personally I am sustained in my work by the unremitting endeavours of colleagues all over the world to seek answers to the many burn problems. Wolstenholme praised the humane and creative work of W.H.O. but remarked: 'W.H.O. can only act on request from governments'. The same holds for the I.S.B.I.

Wolstenholme then made suggestions for the formation of a World Health Service (W.H.S.) 'First of all' he stated 'we need an assessment of what would be required in the way of medical teams, to provide the basic essentials of medical therapy, of disease prevention and of health education throughout the world'. Such a pronouncement follows closely the aims of the I.S.B.I. and conforms to the hopes of the W.H.O./I.S.B.I. Action Committees.

I will pick out a few other items in Wolstenholme's paper: 'A W.H.S. would be an expansion of W.H.O: the recruitment of all members would be expected to establish standards for the world as a whole. Members of a W.H.S. would be expected to take pride in their own country's contribution to its work whilst sharing in loyalty to the Service, and at the same time learning to understand and engage heart and soul in tackling the problems of the areas in which they are called to serve'.

I believe the W.H.O./I.S.B.I. Action Committees already described, conform to the vision so beautifully outlined by Dr Wolstenholme and that this form of W.H.S. will obtain some solutions to burn classification.

In my opinion there is little to add to classification by extent except an insistence on special charts for younger age groups and a possible check second estimation at the end of one week. Much however can be said in relation to classification by depth. Every classification/

classification which employs the term degree should be avoided and a classification which has adopted anatomical terms adopted. The International Society for Burn Injuries has suggested: 1) Epidermal; 2) Superficial dermal; 3) Deep dermal and 4) Subdermal.

In view of the difficulties in appreciation of depth, close and repeated observations and studies are a necessity in histology, in histochemistry of normal burned skin (Washburn and Blocker 1954) and of the histopathology of the healing processes in burned skin.

In this regard recent observations on the healing of burns and surgical wounds by Winter (1971) are fascinating. In his summary he stated: 'the scab and eschar are basically similar and in both surgical wounds and burns the migrating epidermis moves through the dermis beneath the scab or eschar so that it is surprising to find that epithelization is long delayed in burns compared with surgical wounds. Perhaps thermal injuries do not provide the appropriate signal to activate regeneration in adjacent epidermal tissue. Epidermal regeneration is believed to begin when the cells at the edge of a wound are freed from the inhibition of movement normally ensured by their contact with homologous cells. Unlike surgical wounds which have a definite edge, most burns grade imperceptibly into undamaged tissue'.

'Epidermis may be unable to migrate through the dermis because the heated collagen resists digestion by the epidermal collagenase'.

'Histological evidence reveals no fundamental difference in the mode of healing of surgical wounds and burns'.

Whatever the explanation for the poor healing of burns it

is/

evident that therapeutic measures taken during the first ten days after injury are largely doomed to failure in the face of a basic imperfection in the healing process. A method of activating epithelization of burns would bring about a worthwhile improvement in the rate of healing of these injuries, or the histochemistry and histopathology or of the healing processes following burning injuries. A so-called standard burn would be difficult to produce in the human dermis considering variations in age, sex, site, etc. The question might well be asked can a so-called deep dermal burn be classified with more accuracy?. Is a definition sought for a lesion that cannot be defined because of the undoubted pathological complexities?. There is no accurate test. Can one be evolved?. There is undoubtedly room for further research, in histochemistry, in histopathology, in tissue culture and in thermal-wound healing.

Do patients and surgeons suffer from a lack of a more accurate classification?. This is debatable but a more accurate division of depth would allow of better timing of surgical interference. The International Society for Burn Injuries, after consideration of the suggestions of Benaim, Derganc and Jackson and others might well elaborate or compound one method for general adoption for a pilot study. During this period research could be continued and the problem reassessed at intervals. Hope is reflected in a series of presently active occurrences:

(a) A return to the antiseptic system as seen in the employment of dilute silver nitrate.

(b) A more judicious and selective use of antibiotics.

(c) An increasingly intelligent application of biological cellular dressings.

(d) An increasing appreciation of the importance of the structure of dermis and of the importance of dead/

dead dermal tissue.

(e) An awareness of the importance of team spirit in burn units with the avoidance of too great an influence of any one discipline.

In classification by severity, the age, site, extent and depth should all be included. Figures should be available to allow for comparisons. This step might well be encouraged by the appropriate I.S.B.I./W.H.O. action committee.

As McNeill (1971) aptly remarked, there are many pleas for more to be done in the field of burn prevention but no one in authority will listen till convinced that both the incidence and morbidity of burns are high.

Finally the problem of recording of morbidity must be faced and some form of anatomical, pathological, psychological and social assessments elaborated maybe with the help not only of surgeons and nurses, parents and teachers, but of medico-legal, legal and business insurance experts and statisticians.

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