Some pathological bearings of Darwinism / by D. Astley Gresswell.

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D. ASTLEY GRESSWELL.

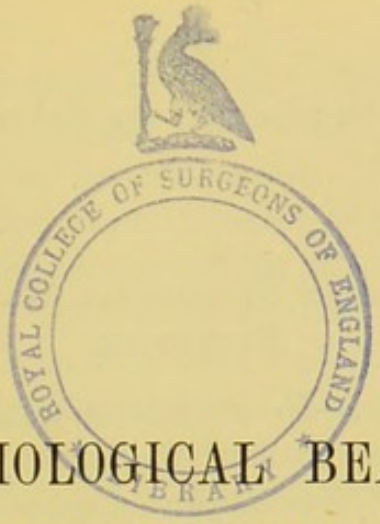
Price One Shilling.

The following pages were written more than a year and a half ago. They have indeed been in proof for some months past; but being desirous of obtaining further information concerning several matters, I have delayed their publication. As, however, attention is now being directed to Evolution in pathology, some statements and suggestions contained in these pages may, perhaps, be of interest, even in their present form.

I have to thank my brother, the Rev. H. W. Gresswell, M.A. Oxon., for kindly looking over the proof sheets.

D. Astley Gresswell.

February 27th, 1886.



SOME PATHOLOGICAL BEARINGS OF DARWINISM.

BY

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The sciences relating to plants and animals are slowly but surely confederating to form a biology in its true, its widest sense, a science of life's processes in general, regular and irregular. Are then the physiological and pathological processes of organisms in degree akin? *A priori*, yes! If the principles of Darwin and Herbert Spencer be beyond the sphere of conjecture, we may look to the structure and function of organisms, high and low, for help in comparison and thereby in elucidation of life's processes in general.

We must associate the off-shoulder lameness of the horse with the right scapular pain of man in some cases of hepatic irritation; the tiptoe walk of the horse with the paralysis of the extensors of the arm of man in plumbism; or, again, the fact that pneumonia attacks the right lung more frequently than the left in domestic animals with the like fact in the case of man.

Biology will progress as all science progresses—by comparison. The processes of life in plants and animals, processes both regular and irregular, must be brought into comparison with those of man if we would establish a science of biology in its widest sense.

An attempt will be made in the following pages to bring together some vital processes in illustration of the aid which Darwinism may afford us in explaining phenomena called abnormal. They

may be divided according as they are either mainly structural or mainly functional.

I.—Some Abnormal Structural Manifestations of Evolution.

Phases of Nutrition.—In organisms generally (vegetable and animal) it is found that most of the carbohydrates are convertible the one into the other, that fats and some of the carbohydrates are mutually convertible, and that albuminates are split up into fat and other bodies. A condition called albuminous infiltration is common in low (cell) life, and it occurs normally in high life. Albuminous infiltration, fatty infiltration, fatty and pigmentary degeneration—these are phases of nutrition manifested in the history of the individual, and in that of the race (even among its lowest members) as physiological events. No wonder then that they occur also in time and place such that they are to be considered pathological.

Again, if we stimulate or give an extra supply of food to low forms of life they grow and multiply more rapidly. Similar changes are seen in endothelium when stimulated into germination, as also in the cells within the capsules of cartilage when subjected to cauterization (Kremansky). Stricker indeed asserts that every living cell in the higher animals may divide, and Dr. L. Beale says that pus-cells may develop from bioplasm of any part of the body when too freely supplied with pabulum. These processes in high life are called inflammatory. Do they essentially differ from those witnessed under like circumstances in low life? Inflammation of avascular structures in high life is akin to rapid growth in low life; it is largely an increased nutritive activity. This is evidenced in the karyokinetic phenomena presented by an inflamed cornea; multiplication being nutrition carried beyond the limits of the individual. May we speak of it as in any degree reversionary? Certainly the cells that result from inflammation are fitted for but little more than the carrying out of their own ends, just as the rapidly multiplying cells of low forms go adrift each about its own business. There are, it is true, yet other factors in inflammation, which lend great complexity to the process. There is an increased activity of migrating cells, and in vascular tissues there are stasis of circulation and accumulation of leucocytes and ozone-bearing corpuscles.

New Formation.—Almost all of the new formations are charac-

terised by the preponderance of cellular elements—elements which may fibrillate and may calcify, but which rarely, if ever (Buhl), develop into muscular or nervous tissue. It may be that some of these should be regarded as reversionary to a remote ancestral condition, when cells alone constituted the structure of organisms. It matters not perhaps in this relation whether these lowly growths be excited into being by Schizomycetes (or other parasites) or whether their inability to differentiate as had been their wont result from other causes ; the end is a cytodic or a cellular growth, which there is plausibility in regarding as reversionary.

Of the new formations the Enchondromata seem most pointedly to illustrate reversion. Enchondroma myxomatodes presents characters such as are seen in the notochord. The cells of some Enchondromata are stellate (their processes uniting into a network), and in order to see a like condition we must descend to near the root-forms of the vertebrate-tree, the Selachii. Again, Enchondromata are most common in the limbs and especially in their distal parts ; and since the original condition of the vertebrate limb is represented in the Selachii as a multitude of cartilaginous rods arranged in a definite manner (the rods increasing in number towards the distal extremity of pro-meso- and meta-pterygium), I am inclined to regard these several facts as owning homologous relationship.

Corroboration is seen in the frequency with which cartilaginous bodies develop in connection with certain joints of the limbs in man and animals. These bodies are either single or multiple, and they are of all sizes up to that of a small apple. Cruveilhier figures a number of rounded cartilaginous bodies in the elbow-joint. Mr. T. Smith removed *over* 200 *loose rounded cartilages* from the knee-joint of a man on December 13th, 1882, at St. Bartholomew's Hospital. He also operated on a woman whose case has been recorded in the 'Transactions of the Pathological Society of London,' vol. xxxi, by Mr. Harrison Cripps, Assistant Surgeon, St. Bartholomew's Hospital. This woman, aged twenty-eight years, had for six years presented a tumour in the upper third of the right arm, immediately beneath the skin. The tumour was pyriform, tapering towards the axilla. It was three inches and a half long, and two inches in diameter at its thickest part. It was encapsuled, and within the capsule there were found one large mass of cartilage and *twelve or more detached lobulated bits* of cartilage. There were also similar detached nodules of cartilage in the axilla.

The limbs in fact of the higher animals have dormant germs of the ancestral rods of cartilage. Indeed, cartilage-cells have been found in the synovial tufts of some joints; and it is from such centres that some of the above-mentioned cartilages apparently developed.

Supernumerary fingers have been referred to the multifid condition of the rays of the Selachian fin.

Again, new formations of capillary vessels are generally congenital, and they are much commoner in the skin of the head and neck than elsewhere. These facts might suggest the possibility of their bearing homologous relations to the vessels which develop about the epiblastic involutions lining the visceral arches low down in vertebrate life. I recently saw a nævus, the distribution of which seemed to afford some corroboration for such a speculation concerning the homology of nævi. It extended in a snake-like form down the right side of the neck; it was distinctly raised, and it passed with a tapering extremity into the external auditory meatus, down which it extended some considerable distance.

The lowest forms of life multiply by fission and gemmation; the higher by gemmation. While, however, gemmation in the higher animals for the purposes of reproduction is limited to certain parts of the organism, in the lower it seems that gemmation may occur at almost any part. Even many Arthropods will throw off a leg at the joint above a lacerated segment, and then bud out a new limb from the centre of the stump; the newt will, it is said, replace an eye. May we bring into relation herewith the granulations that tend to occur on cut surfaces, the papillomata and other growths that occur on irritated parts of skin and mucous membrane, the villi of the chorion and their abnormal developments?

The Embryonic Layers.—The primordial condition of living forms is said to be protoplasm, apparently alike in its several parts in structure and in functional capacity. A later stage in animal history is spoken to by the Diploblastica, in which two layers of protoplasmic units are differentiated, either of which is capable of taking on the function of the other. A third stage is represented by the Triploblastica, in which no such distinct reversal of function is possible, and in which each layer is largely independent in its structure and functions.

The independence of the epiblast and the general likeness of its parts in higher animals are manifested in many ways—normal and

reversional. There is correlation of thickness and colour of the skin and hair. Some mammals develop hairs within the mouth, and most develop hairs within the nose and external auditory meatus. Some develop hairs on the conjunctiva. Selachii present every step of transition from scales on the skin to teeth within the mouth, and these structures are limited to regions covered by epiblast. There are also reversionary manifestations. The development of hair all over the body, the palms and soles excepted, has been noted in both man and woman. It is an interesting fact that the size of the teeth in higher animals is much more constant than that of the jaw bones. Is it that teeth have a much longer ancestral history than jaw bones, Selachii having marvellous teeth while their jaws consist only of cartilage with a calcareous coating? Or is it that enamel is of epiblastic while jaws are of mesoblastic origin, and that there is an independence of these layers which may serve to explain the contrast? It is not apparently wholly attributable to varying degrees of use and disuse.

The rashes of the specific fevers are of interest in this connection; for, though some of them are primarily mesoblastic changes, and though we cannot assert that similar changes do not occur elsewhere in the body, they do illustrate in some of their manifestations the similarity of the parts which they affect. Take, for instance, the rash of scarlet fever. It may occur in any part of the skin. It occurs on the face, though we may not be able to distinguish it there so distinctly owing to the fact that the skin of the face is naturally more full of blood, and also to the fact that the scarlatinal rash is much more uniform than most rashes are. The desquamation of fevers may be partly due to the rise of cutaneous temperature, but not wholly; and the fact that desquamation occurs on the face as elsewhere corroborates the view that the skin of the face is altered in some degree as is that of the rest of the body. The rash occurs on the scalp and on the oral and faucial mucous membranes. It occurs probably on the nasal mucous membrane, as evidenced by the constant thick stream of discharge so frequently seen flowing from each nostril of infants and children. It occurs on the conjunctiva. It occurs not only in the external auditory meatus, but also, I am inclined to think, in the middle ear and Eustachian tube. These affections of the mucous membrane of the middle ear and of the Eustachian tube in cases of fever are, however, generally said to be due to an extension of inflammation from the fauces. It may be

readily allowed that a *simple* inflammation may extend from the throat into the tympanum, but in the case of a *specific* inflammation, affecting as it does the general surface, we may be tempted to reflect upon the fact that the mucous membranes of the fauces, Eustachian tube, middle ear, and external ear are differentiations of a once common structure which lined one common cleft (the tympano-Eustachian cleft, the permanently open *spiracle* of the Selachii), and to consider that inflammation in these several parts in the specific fevers may not be the result of extension, but a primary event; they, like the structures from which they are differentiated, reacting somewhat similarly to the same force.

The same may be said of measles and of small-pox.

In eczema epizootica vesicles, similar to those in the mouth and between the hoofs, develop even within the lacteal ducts.

As serving still more markedly to illustrate the independence of the epiblastic structures there is the fact that epidermal cells are necessary to the new growth of epidermis, and also, as said above, the great constancy of size of enamel organs. Further, though we do not yet know whether belladonna and jaborandi act upon the secreting cells in the abdomen, we do know that the former causes dryness of all parts of the skin, including the mammary involution, and also of all parts of the mouth and throat; and, further, that the reverse holds with jaborandi. Similarly the patient suffering from rheumatic fever presents a moist tongue and a skin that is moist to excess. A phthisical patient also generally presents a moist tongue and a moist skin.

It has been proposed that the comparative frequency of hair-bearing cysts in the brain is to be referred to the fact that a large part of the cerebro-spinal system is of epiblastic origin. Their presence in the ovaries is similarly regarded by some.

It is likely enough that homology for many skin eruptions such as psoriasis, ichthyosis, and eczema is to be looked for low down in the scale of vertebrate life.

Reversionary processes serve also to explain other irregularities of structure. To E. Haeckel's law, the "lex hereditatis interruptæ," are referred cases of atavism of which alternation of generations is regarded as a physiological, and gout a pathological example. The application of the law may be extended to include cases of reversion to a long lost ancestral trait. Among these I would include the above mentioned cases of Enchondroma. The cases of

suprascapular developments recently brought before the Royal Medical and Chirurgical Society of London, by Mr. Willett, Surgeon to St. Bartholomew's Hospital, and Mr. W. T. Walsham, Assistant-Surgeon to St. Bartholomew's Hospital, were similarly regarded. Mr. Chas. Gresswell, M.R.C.V.S., informs me that he recently saw a foal which presented a tridactyle foot; the lateral splint bones were almost as largely developed as the cannon bone, and each was provided with pastern bones and a hoof. Such a case is to be held as reversionary to the ancestral condition presented by the Eocene Eohippus, the Miocene Anchitherium, the Pleiocene Hipparion.

Another of Haeckel's formulæ, the lex hereditatis abbreviatæ, is of interest. It is illustrated in the fact that Podophthalmatous Crustacea in the course of their development omit the Nauplius-form and pass very quickly through the Zoea-form. It may lie at the root of the difficulties that beset the determination of the homologous relations of Müller's duct with the segmental organs of lower forms.

The lex hereditatis sexualis is also of interest. It is so rigid that male Arthropods have often been placed in a genus or even order other than that in which the female has been placed. There is probability that to it also should be referred the fact that horses and geldings are more liable to roaring than mares (mares being seldom roarers save when there has been close in-and-in breeding), the fact that ichthyosis descends in only the male line, and possibly yet other facts of distribution of morbid processes between the sexes.

The lex hereditatis adaptæ speaks of progressive heredity; to it is referred the case of a bull which, after receiving an injury to the tail, became sire to offspring in none of which a tail developed. The epileptic guinea-pigs of Brown-Séquard, afford another illustration. Mr. J. Brodie Gresswell, M.R.C.V.S., recently showed me the leg of a foal in which the only development of bone below one hock was a small nodule in the position of the proximal part of the metatarsal, while the dam had suffered for some years from stiffness of all the joints below the hock of the corresponding leg. There have been also cases of a similar nature in man.

The former laws illustrate the importance of reversionary processes, the latter law illustrates the importance of incident forces.

Age.—Regeneration in mammals is the more active the younger the individual; similarly regeneration is more active the lower in the

scale of life the animal chance to be. In the ova of higher animals changes may indeed occur which recall the methods of reproduction in lower forms. The early embryo may apparently divide and each half develop into a perfect adult, a case of fission such as may be seen in the lowest of living things. The embryo even of man may, some think, attempt to reproduce a limb, a process which is common enough in lower forms even in their more adult condition.

The babe crawls before it stands erect; and the relation of its head and legs to the trunk for some time after birth is just that which is presented by a lower animal.

It appears that the epiblastic involutions about the head and face acquire during extra-uterine life a certain degree of independence of the rest of the epiblast. This is exemplified in the fact that coryza and otorrhœa are much commoner in infants and children than in adults when suffering from scarlet fever. It is the same with measles. Moreover, even the parts of the skin apparently become differentiated with age, as is seen in the greater frequency with which a general hyperæmia occurs in cases of smallpox in children than in adults (it is not rare to see children suffering from smallpox certified to be suffering from "scarlet fever with possibly varicella").

Erect Posture.—Among vertebrates the erect posture is met with only in the more highly differentiated. The erect animals are supposed to have been evolved from animals that were prone. Comparison between the former and the latter may then afford aid in the interpretation of some vital phenomena. A few scattered points in reference hereto are subjoined.

The lower surface of the prone animal becomes the front surface of the erect; the ventral surface was in relation rather with the earth, now it is in relation with space. Herein there is involved a great alteration in heat exchange. To the prone the earth affords a protection from excessive radiation; this is evidenced in rabbits when placed supine, for in such a position they die of refrigeration. The abdominal flannel worn in climates where there are sudden and great changes of temperature may be mentioned in this connection.

The abdominal contents in the erect animal tend, should their supporting tissues yield, to press upon the pelvic and inguinal structures, while in prone animals the pressure is downwards and

forwards in accordance with the slope of the ventral wall of the abdomen. Hence the fact that femoral, scrotal, and obturator herniæ are rare in animals as compared with man, while diaphragmatic and umbilical herniæ are as common if not commoner. The reply that most horses are castrated is met by the further fact that scrotal hernia is rare in army horses and in thoroughbreds, animals which are not castrated.

The child must early begin to place all its weight upon the hind extremities; a fact which explains in some degree the frequency of knock-knee and bowed leg in man as compared with animals.

The rudimentary condition of the coccygeal vertebræ (vertebræ which lie behind the sacral, *i. e.* behind those which serve for a support of the pelvic girdle) in erect animals has apparently special reference to their erect posture. Should a quadruped become erect the tail would apparently but embarrass the action of the legs. Many arboreal animals are erect and yet have tails, but to them a tail is of use as a prehensile organ, and also as a protection to the pelvic outlet. And, again, though some ancient and transitional forms of birds had tails, we know of no long-tailed modern forms. The anthropoid apes, moreover, have the tail but poorly developed. There would also be a further advantage in losing the tail, viz. that to be derived from a more consolidated condition of the sacrum attending upon atrophy of the coccyx. This correlation is actually manifested in animals, and by virtue of it we may perhaps explain the fact that the operation of docking is not performed on race-horses; docking, indeed, has other effects than a mere æsthetic one, effects which probably tell upon the condition of the hind quarters.

The shape of the tail, however, changes as prone animals become erect, a change which serves in some degree to support the pelvic structures. Despite this fact, however, falling of the womb and other of its displacements are comparatively frequent in humankind; they may be owing in part to the possibility that the walls of the vagina and the perineal body were not framed to support the weight of the uterus, the bladder, and other structures at the pelvic outlet.

When grey horses pass into years melanotic tumours often develop, and very frequently on the under surface of the tail, as well as elsewhere; a fact of distribution of morbid processes which it may be well to bear in mind when comparing tailed quadrupeds with so-called tailless bipeds. Dr. A. Gresswell, B.M. Oxon.,

recently examined with me some of these tumours; the microscope revealed a closely packed mass of deeply staining nuclear bodies, each surrounded by a small amount of pigmented matter. The nuclear bodies infiltrated every tissue, even the intima of the arteries.

The hind limbs of quadrupeds have a circulation which is feebler than that in the fore limbs; the erect posture of man may further act to impede the circulation in the lower limbs. Hence the rarity of "lymphangitis" of the fore limb of the horse, and also the frequency with which gouty deposition in man begins there where the circulation is most sluggish. Though these two affections are here brought together it is probable that they are not so closely related as are laminitis of the horse and gout of man. Indication of the close relation which these latter bear to each other is seen in the fact that the horse, which has access to wheat, is almost certain to become affected with laminitis, wheat as compared with the natural food of the horse being more highly azotised.

There is also interest in the fact that the nasal or oronasal portion of the respiratory tract forms with the tracheal portion of this tract a smaller angle in man than it does in animals, and since the bending of a tube diminishes the more the velocity of currents passing through it, the more it is bent, it comes about that man, when in need of more air (as in ordinary dyspnœa, in fever, and other conditions) has occasion to throw back the head through a larger arc than has a lower animal. Dyspnœic man places the head in that relation with the spine which was natural to a remote ancestry, and so it is, but to a less extent, with some of the higher animals. This posture taken by man in dyspnœa is precisely that in which a newly-born babe sleeps. I have thought that if the fœtus maintains the same relative position of head and trunk as is seen in the newly-born babe, and if we couple herewith the anatomical relations of the bladder (but rarely empty) and the flaccidity of the other pelvic contents, we may in these facts see a reason for the very general "head presentation" in man, the head presenting because the pelvis and its contents accommodate the fœtus in this position better than in any other. The same, too, holds of many lower animals, both prone and erect.

Yet one more correlation of the erect posture. The latter affords a freer play to the movements of the fore extremities. Dr. G. Rolleston taught that such additional freedom had done away with the necessity for the continued development of the panniculus carnosus,

and so had become instrumental in effecting its atrophy. This muscle is engaged in ridding the skin of some parasites, also in defensive and offensive operations (as in the erection of the spines of the Diodon, the scales of serpents and of the Manis, the quills of the porcupine and bristles of the hedgehog). But man, erect, has so much more freedom of movement of the fore extremities than have prone animals that this muscle from disuse has atrophied. The fact that man has remnants of this muscle in the Platysma myoides, and, according to Henle, in several muscles of the head, should be considered in relation with the fact that hairs still flourish on the head, the face, and upper part of the neck, and that these parts are not clothed. Birds, however, are erect, and yet some have a remarkably developed panniculus carnosus; this muscle presented even large tendons inserted into the feathers and skin of an albatross that I recently dissected. In birds, however, it may be noted, the fore limbs are more particularly specialised for flight, while the freedom of movement of the fore limbs in other directions is correspondingly curtailed. Man, inheriting the traits of a once quadrupedal condition, presents, like quadrupeds, right-handedness, but in greater perfection than they, for the fore limbs being freer to act have acquired a still greater independence of each other. The fact that the right limbs have taken on the more complex tasks is attributed to the left side of the brain receiving a more direct supply of blood, and this view is corroborated in human pathology by the frequency with which embolism occurs on the left side of the brain as compared with the right, just as the greater frequency with which embolism occurs in the left as compared with the right kidney is attributed to the more direct course of blood to the former.

If, indeed, the development of the higher forms of life be a monstrous illustration of the lex hereditatis abbreviatæ; if ontogeny in the higher forms repeat phylogeny in an abbreviated form; we may hope to read in the former some references to ancestral conditions. And phylogeny does serve to explain many irregularities of structure which its abbreviated form, ontogeny, cannot so long as it is imperfectly known to us.

II.—Some Abnormal Functional Manifestations of Evolution.

The mutual interdependence of functions is universally admitted. The assertion that functions have been evolved in association has been supported both inductively and deductively. "Associated functions" and "correlated structures" are expressions that enter into the widest generalisations of evolution.

The canary building in captivity flies about its cage with the straw prior to putting it into position; fowls are more likely to transgress a netted boundary if the latter be topped by a rail; man on joining the navy is probably awaked by the morning report of the cannon, though afterwards it may be that he awakes at the usual time of the report only when it is not sounded. It is said that the canary does under altered circumstances, where apparently it is not a necessity, what canaries do in nature where it is a necessity, and that by continuance in new conditions man and animals acquire new habits.

Again, while animals roam at large their characters may remain much the same for long periods, and yet by careful selection we may greatly change the development of a feather, a limb, or the whole animal, though the animal thus changed, if again allowed its freedom, quickly reverts to its original characters. Haeckel embodies these facts under laws of conservative and progressive *heredity*.

If, however, reproduction be nutrition carried beyond the limits of the individual, we may bring the first-mentioned order of facts together with the latter, under laws of conservative and progressive *assimilation*. An old habit is an expression of conservative assimilation; a new habit is an expression of progessive assimilation.

A swinging pendulum presents a definite movement. If it be touched from another direction the movement will maintain largely its original character; but there will be a change which will continue for a certain period after the modifying force has ceased to act, and finally the original movement will appear. The first movement is, so to say, conservative; the next is progressive; the last reversionary.

Somewhat similar reactions are witnessed in physiological processes as instanced above. They are also seen in pathological pro-

cesses. Man and animals may acquire a certain degree of toleration for morphia, for alcohol, for infectious agents. Such acquirements illustrate progressive assimilation, while the fact that toleration wears off when the modifying agent ceases to act bespeaks reversionary processes. Memory illustrates the former, forgetfulness the latter.

Association of function being, then, admittedly of such importance to the developed organism, and the acquirement of associations being of such importance to the developing organism, as also to the developing race, it may not be out of place to bring forward any association which has not perhaps received special notice, and to trace it, if possible, from its physiological into its pathological expression.

The majority of animals present two sets of phenomena, related to each other in some sense, as are heat and cold; each set has had its various factors associated for untold ages. They are called work and rest; it will be convenient to speak of them as the associates of work and the associates of rest. We may then expect that when some of the associates of work are manifested there will be a tendency for the others to appear, and similarly with the associates of rest.

The phenomena which constitute day and those which constitute night have likewise been severally coexistent for untold ages. Moreover, the associates of work have alternated with those of rest as day has alternated with night, and on a larger scale in the cold and temperate latitudes as summer has alternated with winter. We may then expect to find that the inorganic rhythm has left its impress on the organic, that conservative assimilation will be manifested though the conditions of life be changed, and progressive assimilation in accordance with that change.

Work.—An animal at work presents many associated phenomena, of which we will mention acceleration of the pulse and respirations, excitement, increase of perspiration and of fæcal discharge, and increase of metabolism and body temperature.

There is evidence to show that if some of these be aroused there is a tendency for others or all to be aroused. If the temperature of an animal be artificially raised the pulse and the respirations are accelerated and the cutaneous glands are more active, and conversely if the temperature be reduced.

Increased defæcation we have mentioned as a work associate.

Cattle when suddenly disturbed defæcate and set off apace; the horse passes fæces, which become increasingly fluid while engaged in the chase; a cockatoo and a blue-mountain, lately taken from the bush in Australia, defæcated whenever a stranger approached their respective cages, and they continued to do so for some time from the commencement of their captivity; in man too relief from constipation is very generally afforded by physical work or excitement.

These and other facts speak for an association between work, excitement, and increased defæcation, which results in reduction of weight; the cockatoo defæcating at the approach of strangers simultaneously raised its head plume—a preparation for defence.

With action, moreover, there is increased temperature; a contracting muscle rises in temperature, and there seems to be a very considerable total increase of heat in the body during action.

With action, with excitement, with alarm (if not too great), there is also associated an accelerated pulse. The pulse of an excitable thoroughbred or even of a cart-horse is much higher if roughly approached than it otherwise is, and the same holds with other animals and with man.

The association, moreover, of some of these phenomena serves apparently to explain some pathological phenomena.

In exophthalmic goitre the heart beats more frequently, the action of the cutaneous glands is increased, there is restlessness, the bowels are generally freely open though the patient be confined to bed, the peripheral temperature is elevated, and at times also the oral temperature. These are the associated factors of work.

I took daily observations for thirty-three days upon a woman, aged thirty-two years, suffering from this condition, under the care of Dr. Southey, at St. Bartholomew's Hospital. Her pulse was always above 110, even when asleep; her respirations were always above 22; the bowels were very freely open every day on an average 2·4 times; the daily urine averaged fifty-two ounces, varying, however, from forty to eighty ounces; the nights were fairly good under the administration of sedatives, otherwise they were restless; the skin was at all times warm and moist; the tongue also was always moist; the appetite was always excellent; the oral temperature was generally normal, but it rose at times to about 100° F., and the palmar temperature was generally nearly as high as the oral.

The records of other uncomplicated cases to which I have referred at St. Bartholomew's Hospital agree in the main with this.

Some other diseases also, in which the heart's action is accelerated, illustrate the same thing. Looseness of the bowels is often seen in children at the outset of scarlet fever, smallpox, and measles, and in those instances where I have seen typhus fever from the very outset the bowels have been loose for a day or two; no doubt in such cases other causes also are in operation.

In the 'British Medical Journal' of July 26th, 1884, I recorded facts to show that the total heat in the body is greatly increased on entering the tropics, and that the increase is greater in children than in adults. I also adduced facts to show that increase of intensity of light causes acceleration of the pulse. This acceleration I found most marked in the young. Now, diarrhœa also increases on entering the tropics, and especially in children. Summer diarrhœa may doubtless be due to various causes. Of these I am inclined to think that the direct action of an increase of external heat and light upon the body may be of the greatest importance. Most of the children (about 50) among 400 emigrants recently taken to Adelaide in the "Aldergrove," suffered from diarrhœa on entering the tropics. They were fed, however, in the tropics much as they were in the temperate regions; the milk supplied to the younger ones was made up from condensed milk twice daily, and *every precaution was taken against uncleanliness.* Adults also very frequently have looseness of the bowels on entering the tropics; this I have observed, moreover, among the adult occupants of different parts of the ship during several passages through the tropics. Two of the climatic factors common to these cases are rise of external temperature and increase of intensity of light. The organic factors are rise of body temperature, acceleration of pulse and respirations, increased action of skin, diarrhœa—work-associates.

The fact that a child's temperature will rise in *constipation* and fall when the bowels are relieved does not militate against the view above drawn concerning the association of rise of body temperature and defæcation. It is paralleled by the fact that the temperature of a typhoid patient may rise during the convalescent stage owing to constipation, and fall after an action of the bowels, induced, it may be, by castor-oil. Indeed, though paradoxical on the face of it, these cases do but corroborate what has been said; the fæcal accumulation excites the intestinal mucous membrane and the intestinal muscle, with additional activity of which, according to the

view expressed above, there are naturally associated rise of temperature and other work-associates.

The ready response of a child's temperature to irritation and excitement is well known; this greater readiness in children as compared with adults is put down to a condition of less stable equilibrium. Patients also, especially those convalescent from febrile conditions, show a like contrast when compared with healthy persons.

It seems, in fact, that the processes of work have been evolved in such intimate association that when one of them is excited the others also are. Hence diarrhœa concurs with the rise of temperature and the acceleration of the pulse in the tropics. Acceleration of the pulse in the tropics has been denied. My own observations upon a large number of persons under different conditions while passing from temperate through tropical latitudes on four different occasions show that there is an acceleration of the pulse in the tropics under all ordinary circumstances.*

It may be said that the evacuation of the bowels during work is due to an increased action of the diaphragm, abdominal muscles, and levator ani; it certainly cannot, however, be said that this has much to do with the purgation of excitement while at rest.

Moreover, the action of some chemical compounds serves to illustrate the association of vital processes mentioned above. For instance, the administration of nicotine results in acceleration of the heart's action, perspiration, and diarrhœa—work-associates; while morphia in a certain dose on the other hand causes a slowing of the pulse, a dry skin and constipation.

Rest.—The associates of rest are the counterpart of those of work; they are more pronounced in sleep and hibernation. The animal that declines work, like the man that declines exercise, suffers from constipation. If one or more of the work-associates be kept in action sleep is almost impossible, so that, too hot or excited, we cannot sleep.

There appears then to be an association of vital processes concerned in action, some of which cannot be readily and separately aroused; there is also an association of vital processes called rest, induc-

* The pulse may be slower in a tropical latitude when compared with that in a colder latitude if the body be recumbent and at rest; but this is possibly, or indeed probably, attributable to a weak condition of the heart brought about by previous excessive action.

tion of some of which tends to be accompanied by induction of the others.

In this connection it may be of interest to compare the cart-horse with the thoroughbred. The former puts out force more slowly; it is less sensitive to pain; its vital processes are slower; it is therefore less liable to acute inflammations, and should it become subjected thereto it does not make so rapid a recovery. The thoroughbred will, as it is said, jump out of its skin owing to a degree of irritation, which a cart-horse will scarcely be aware of; it apparently is more sensitive to pain; it certainly withstands the effects of a much larger dose of chloroform. The thoroughbred is more likely to develop hypertrophy of the heart; the cart-horse a fatty liver and anæmic dropsy. In the thoroughbred there is in fact a more pronounced development of the work-associates. Men also of different temperament and constitution present like contrasts.

Work and Rest.—Muscles freely exercised hypertrophy, but if rest be not allowed they atrophy; the same applies to other tissues and organs. This is well known in man; it is true also of animals, and is markedly shown in the heart of the race-horse. All racers acquire hypertrophy of the heart. The hypertrophied tissue, however, by excessive action degenerates, and Mr. Chas. Gresswell, M.R.C.V.S., informs me that the race-horse at five or six years of age loses form to such extent that in handicapping for racing weight is taken off rather than added to after the age of six years, and that when racers go to stud (as most of the best racers do about the age of six years) the heart, no longer called upon to undergo the exertions of former times, fast degenerates; one such heart recently examined after death by us was three times its normal size, fatty and dilated. Herbert Spencer shows that alternate squeezing and relaxation causes currents to pass to and fro in plants, in trees, in animals, and he thus explains many normal growths as also the formation of bone that fills up the arc of the curve in rickets. The same explanation has been applied to the development of ring bones and bone spavins in the horse, and it may be applied also, I think, to some cases of splints and to sidebones.

Rest and work must alternate. We see the injurious effects of disturbance of this alternation in tissues and organs. We see them, moreover, in the system. Lymphangitis, or "weed" of the horse, for instance, is so common on Mondays that it has been called Monday morning disease, a fact which indicates its relation to

Sunday's over-rest and over-feeding. Man, too, pays a like penalty for like indulgence.

The alternation of work and rest in animals has been observed for ages past, and it is important to attend to preservation of this rhythm, for the muscle, the limb, the organism, the species suffers when the old alternation is too abruptly or too largely interfered with.

It is said that some plants grow more quickly and apparently more perfectly when subjected to the action of a light of constant intensity than when left to sunlight; but in comparing the higher plants with the higher animals it is well to remember that plants are (as Herbert Spencer has said) accumulators while animals are rather expenders.

Elasticity we may suppose would develop *pari passu* with contractility. It is an essential property of muscle. It is also apparently essential to those structures which are displaced by muscular action from their position of rest. For instance, in expiration, not only do the inspiratory muscles recoil by virtue of their elasticity, but the ribs, costal cartilages, the lung itself, and the laryngeal and facial respiratory mechanisms, one and all recoil by virtue of their elasticity. The claw of the carnivore, disturbed by muscular action, recoils by virtue of elasticity. Many organs after suffering engorgement as a result of some degree of paralysis of pale muscle recoil to their original size by virtue largely of their elasticity (Hilton); this is illustrated in erectile organs, spleen, liver, and other organs. The elasticity of skin, again, is a most important property. The arm of man enlarges with each systole of the heart and it diminishes with each diastole, so that the elasticity of the arteries in assisting the circulation of the blood has a *collaborateur* in the skin.

Indeed, in the history of the individual as in that of the race elasticity runs *pari passu* with irritability. The recent investigations on Eristalis are of singular interest in reference to the relation of muscular and elastic tissues. In later years elasticity diminishes and the left ventricle hypertrophies owing to loss of elasticity, not only in the arteries, but also in the skin and other tissues.

Day and Night.—Day is characterized by sunlight and sunheat; and with day there have been manifested in animals for untold ages the associates of work. The pulse and respirations are more frequent by day; metabolism, as evidenced by the separation of

carbonic acid and urea, is greater; the body temperature is higher. In the 'British Medical Journal' of July 26th, 1884, I recorded evidence to show that light stimulates the heart, and that tropical heat is accompanied by rise of body heat. Moreover, physical work is one expression of increased metabolism, and the absorption of food is accompanied by rise of temperature.

The factors, then, which constitute day, external or inorganic and internal or organic, are each and all concerned in adding to the activity of vital processes. The external factors (light and heat) in reference to the internal stand to some extent directly in the relation of cause and effect. They stand also indirectly in this relation, as they afford opportunities for working which are not present by night.

A rhythm has thus been established in organisms in relation to day and night; it is moreover evidenced for a while though some of the factors concerned in the causation of the rhythm be altered, just as the variations in the frequency of the pulse which have reference to meal-times persist though we pass the whole day without food. For instance, when we commence to work by night and rest by day it is some time before we obtain a reversal of the temperature curve, and the reversal is probably never complete. If, however, we proceed gradually from one meridian to the antipodal meridian we gradually change all the associated factors of what was our day for those of night, and under these circumstances the daily curve of body temperature persists; but there are facts which tend to show that, even under these circumstances, the old rhythm does not yield with the best grace.

Moreover, in pyrexia the body temperature tends to rise and to fall at the same times as it does in health. The fact that pain is so generally more intense by night than by day, and the greater likelihood of a febrile patient being restless and afterwards delirious by night than by day, though the temperature be no higher, may be paralleled by the fact that in health, when hot by night, we cannot sleep, while we may, though hotter, be able to sleep by day. Day is the time for action, and the febrile temperature is therefore better borne then than it is by night.

Months.—The monthly divisions of time have reference to the phases of the moon. Menstruation was referred by Darwin to an ancestral time when spring tides brought an extra supply of food. The fact that delivery occurs at the usual time of a menstrual

epoch is read in the same light, and similarly with ante-partum hæmorrhages.

The Seasons.—Summer and winter differ much as do day and night, and they intergradate much as do the latter. In summer there is an addition of light, of heat, and of food; there is also an addition to the activity of life's processes. In spring and summer, as compared with winter, the pulse is quicker, the temperature is higher, metabolism is more active. With each recurrence of spring, life, comparatively dormant during the winter, bursts into renewed activity; the hibernating animal takes new life; spawning and pairing, multiplication of cold- and of warm-blooded now takes place; there is also a great increase of peripheral growth, as evidenced in quicker growth of hair, nail, and hoof, and in the shedding of hair and cuticle in moulting.

We concluded above that vital activity had been so long associated with day as to explain the fact that organisms exhibit a rhythm corresponding to the alternation of day and night. There is some evidence that organisms exhibit another rhythm corresponding with summer and winter. The Rev. J. G. Wood records a case in point. Some Australian plants set in the suburbs of London made an attempt to blossom just as our winter had set in, but in the course of a few years they grew gradually later in blossoming until they had found the proper season, and then they were content to put forth their leaves and flowers at the same time as the indigenous plants. Hilton, in his 'Rest and Pain,' mentions facts which he interpreted in the same way. Lastly, Dr. J. Crichton Browne says that many children at spring show a restlessness and excitability, a perversity and irascibility of temper, or a listlessness and indisposition for exertion that are not seen at other times, and he suggests that these so-called irregularities are to be classed with the vernal activity of organisms generally.

The Fight, Excitement.—Animals quickly enter into competition with one another when introduced into a maiden environment; and the majority of animals may perhaps be called upon at any time to fight or to make good their escape. In either case the associates of work are summoned into action, and in the fight there may be pain, with anger and rage, and therewith redoubled energy.

Pain.—Pain is a feeling in response to which an animal exerts its best endeavours to remove itself with all speed from a source of danger or to satisfy a want. It has been especially associated, more-

over, with the excitement, the anger, or rage it may be, of the fight. In an animal suffering pain there is increased action of the heart and of those muscles which are engaged in fighting (including the retractor muscles of the ears, eyes, and lips); there are also perspiration, excitement, perhaps screaming. But these associates concur in animals and in man not only when they are consciously directed to the removal of the pain-giving agent, but also when the pain is a result of morbid action. In the former case pain is conservative by directing the animal to defence; in the latter it is by no means always so. In an acute attack of gout the febrile disturbance is supposed to be secondary to the joint affection; there are acute pain, rapid pulse, some rise of temperature, perspiration, great restlessness with excitement, "expression of the emotions," possibly screaming.

Let us consider some of these phenomena in greater detail.

The pulse of pain is accelerated; the pulse of a horse suffering from pleurisy may fall by even 30 beats per minute on the application of a tight bandage to the chest, and the fall of pulse in a horse suffering from laminitis may be as great when the animal is obliged from exhaustion to lie down. These facts have frequently come under my notice.

The pulse of pain is strong; this is very noticeable in laminitis of the horse.

Restlessness and muscular action are manifested in pain; the horse stamps with energy when a corrosive is applied to a quittor, as the leg of a frog contracts when irritated by an acid; and the like is seen in man.

Groaning, screaming, and other noises are uttered by most of the higher animals suffering pain, even when they cannot be ascribed to any other cause than the fact that they have been associated with pain in the more direct struggle for existence.

The temperature frequently rises, measurably, in pain, and falls when the latter is subdued by morphia. In this relation it may be well to remember that peripheral increase of heat may occur, though the oral temperature be not altered.

Perspiration accompanies pain. The horse suffering from colic or enteritis or laminitis sweats profusely, and the same holds with man. There is additional sensibility to cold in pain as also in excitement.

There is evidence that pain may result in albuminous metamorphosis, especially of cardiac muscle.

Does pain result in increase of the fibrin factors? Those animals would apparently survive which could most readily occlude vessels opened by injury, and pain would accompany injury. And in ourselves the fibrin factors are said to be especially increased in cases of rheumatic fever, and in other cases of painful inflammations.

Dilatation of the pupils concurs with pain. I recently noticed the pupils of a lad suffering from Peliosis rheumatica to dilate whenever one elbow-joint, which was exquisitely tender, was pressed. I have noticed the same thing in strong children undergoing tracheotomy without an anæsthetic. The pupil also of locomotor ataxy very frequently dilates when an attack of pain comes on. Conversely, myosis is seen when the centres of sensation are dulled, though later, towards death, mydriasis sets in; for instance, there is contraction of the pupil in sleep, in opium stupor, the stupor of typhus and of enteric fever, and, it is said, in that of relapsing fever; and similarly in the anæsthesia of chloroform the pupils contract, and later, when the stage of profound narcosis supervenes, the pupils dilate. In the preparation for defence, for action, some animals show dilatation of the pupil. This is well seen in the cat. Moreover, in ourselves the pupil dilates if sensory nerves be strongly irritated, also as an effect of excitement and during severe muscular exertion.

Again, if a horse be suddenly put to work inflammation is likely to occur over the crest of the navicular bone, *i. e.* over a part where leverage is afforded to the corresponding flexor tendon; sudden extra action of the muscle is attended by an extra amount of friction there, and consequent inflammation. Similarly those joints are first affected in rheumatic fever which are most in use at the onset of the disease, and this holds in animals as well as in man. The endocarditis of chronic Bright's disease is attributed to the extra blood-pressure, which in truth is one of the earliest manifestations of inflammation of the kidney. The value, then, of the subjugation of pain in endocarditis and in pericarditis of rheumatic fever may be to some extent due to the coincident sedatising of the heart.

The infliction of pain then arouses the associates of work not only in health, but also in disease. While being thus related to the mechanism of work we shall not forget that this mechanism, by continued action, may become "run down," that the sufferer may become exhausted, and be then no longer able to manifest this relation. A

horse suffering from laminitis affords a good example of a case where, though the animal becomes greatly exhausted, pain still maintains in vigorous action the associates of work.

Irritation.—Irritation of the skin causes contraction of muscle with the object apparently of removing the irritant, and as the irritation is intensified more and more muscular tissue contracts to the same end. The laws formulated hereupon apply, however, not only in health but also in disease.

Many of the cutaneous diseases of animals cause them to bite and rub. Similarly in man; the erythemata itch, roseola itches, psoriasis also at first, eczema also and herpes and pemphigus, each of the so-called papular inflammations, each of the rashes also of the specific fevers (children sometimes begging to be scratched from head to foot in scarlet fever and in measles); similarly with teething in animals and man.

Irritation then excites scratching or rubbing; this is conservative when the irritant can be thus removed, but scarcely so at all other times.

Again, *irritation* of the conjunctiva causes contraction of the lids, that of the nasal mucous membrane causes sneezing, that of the throat causes attempts at swallowing, that of the rectum causes tenesmus both in animals and in man. These are conservative, but *inflammation* of these structures has the same effect yet more pronounced, and then the effect is by no means conservative.

Similarly an animal suffering pain from internal causes frequently bites or even kicks savagely the corresponding side, and in a part which has apparently a relation through nerves with the internal part which is affected. So also probably with the relief that follows the application of one or more leeches or of a small blister to a painful part at the surface in cases of inflammation within. These are instances, so to say, of reflected itch.

Irritation may be intensified into pain, and then all the associated mechanism of work, of the fight, is called into action; instance the thoroughbred when constantly worried by an insect, or the sheep, which after the failure of all efforts to dislodge the Œstrus ovis, runs madly until almost exhausted; or man himself irritated by the harvest bug until he is in a semipyrexial state.

Pain then and irritation exceeding a certain intensity call up the associates of work, but not solely in health, also when the result of diseased processes.

Physiological processes which work for good are carried into pathological processes where in some instances they work a vast amount of harm. The constitutional unrest set up by the pain consequent upon an injury works for harm, and the dog or deer that has met with a fracture of the leg and is suffering pain at each movement of the fragments, seeks quiet and darkness, not perhaps simply that it may rest its leg, give local rest, but also that the darkness and quiet and fasting may subdue the constitutional excitement which it is better in the direct part of the struggle for existence that the individual animal be subjected to, though in the indirect part of the struggle it would be better that it were exempted from.

Timidity, Fear, Fright.—The conservative effect of timidity and fear is exemplified in those animals which have no fear of man and retaliate only when injured. Fear calls up the associates of work.

All gradations may be witnessed in man and animals, between the ready action of timidity and fear, and the inco-ordination and paralysis of fright. The rough handling of a nervous horse may cause palpitation audible at a distance; it may cause an irregular and intermittent beat; it may cause the beat to cease. "Polands" have died, it is said, of fear when taken by surprise, as they easily are taken, owing to the large size of the crest which obscures their vision. In man, too, the paralysing effect of fright is so well known as to have received expression in slang language.

Fear calls up the associates of work, alertness for the exertion of escape or that of the fight; fright is fear carried to such excess that inco-ordination, resulting it may be in paralysis, ensues. It was reported of Lefroy Mapleton, the murderer, that, on his way by train to gaol, as the people crowded at the window hooting and yelling at him his face worked convulsively, his fingers clenched and then opened, and his arms twitched in the grasp of his captors; he had the weary fearsome look of a hunted creature, and as he passed the people cursing and groaning at him his brows more than once contracted, and his upper lip was raised, exposing the gums and showing the eye teeth pressed together. Fear called forth the associates of work.

Sympathy.—Sympathy occurs primarily, perhaps, in the family. The parent protects the offspring at the cost of its own life. The hen may be tempted by the sight of a chalk egg to lay when otherwise it would not do so. Secondarily sympathy prompts to asso-

ciated action in communities, and it may lead at times to actions which good sense would not endorse; the first of a flock of sheep in flight may jump a fence, the next may knock it down, but the rest may, nevertheless, jump as if the fence remained. Sympathy with action inspires action; sympathy with failure leads to depression.

These associations are, moreover, seen in pathology. When a lad screams with pain, and his mother, suffering from neuralgia, declares she feels an additional pang, we call it sympathy. One miscarriage in a cowshed is very often followed by others, and the infectiousness, so to say, of miscarriage in humankind is well known.

Pleasure.—Pleasure has extremes; one we call pleasurable excitement, joy; the other we call comfort. With the former there is associated the mechanism of action; with the latter rather that of rest.

Conclusion. — The organic processes concerned in excitement, irritation when considerable, pain, joy, timidity are those of work; when any of these becomes excessive the mechanism of work acts inco-ordinately, and it may be so that death results as in excessive pain and excessive fear.

The development of these associations and of their correlated mechanisms we may understand as necessitated by the survival of the fittest. I have endeavoured to bring into notice the fact that these same associations, though primarily physiological, seem to explain many pathological phenomena, and that while they may be of immediate benefit in the more direct part of the struggle for existence, they may work great harm (as far as the individual is concerned) in the more indirect part of that struggle. The constitutional excitement aroused by pain resulting from injury is of advantage in redoubling effort, and should the animal be victorious the pain will be of further value in dictating local rest, but it will in many cases be harmful by reason of the constitutional unrest that still continues to be kept up by the pain. And much more is the harm manifested when the pain is the result of morbid processes.

Or again, organisms have been evolved in which two wide sets of phenomena occur in association. One of these is concerned when the organism must obtain food, effect its escape, or fight; the other when these objects have been met or when the mechanism concerned

in the former needs rehabilitation. But these associations, developed, so to say, in physiology, are carried into pathology, where, though in some cases some of the processes then manifested may work for good, some may work harm, nay, may kill.

Inflammatory fever, again, may be attributed to the same processes which operate in the rise of temperature of pain. This we have traced to the struggle for existence, and inflammatory fever is possibly its pathological expression.

Another association may be mentioned, one which has developed we may say as a necessity of evolution and still persisting in pathology, where it frequently effects harm.

If a nauseous or an irritating substance be swallowed vomiting may ensue; if an irritant be applied to any part of the digestive tract vomiting or defæcation may ensue. A nauseating or an irritating body is in most cases best rejected; such reflex effect is of supreme importance. It persists, however, under conditions pathological where it does harm. So alive are the intestines to the reflex effect caused by irritation that vomiting may occur in enteritis or owing to compression of a portion of gut in a hernia, or, for instance, it is said, in the apparatus of Dupuytren. Nay, further, vomiting occurs if structures in close relation with the intestines are injured, *e. g.* in peritonitis, in compression of mesentery in a hernia, in biliary colic; similarly with the tenesmus excited by irritation and inflammation of the lower part of the intestines. In many of these cases the reflex effect is harmful.

This reflex effect is seen even in irritation of the fauces, and on the passage of a pencil a very short way within the anus of a child.

There is reason to think that the irritation of the throat is a part cause of the early vomiting in scarlet fever. Of 175 patients suffering from scarlet fever whom I closely questioned, 130 were unable to speak with certainty as to whether the soreness of the throat or the vomiting took precedence, so closely related were these symptoms; forty, however, distinctly asserted that the soreness preceded the vomiting.

Vomiting also frequently occurs at the onset of diphtheria and of smallpox, in which the fauces are attacked, and it is often closely sequent to the onset of inflammation of the fauces.

Violent coughing may cause retching, due apparently to the irritation of a pellet of mucus which has been coughed up into

the throat. Similarly even teething often apparently causes retching in the horse.

Evolution, then, has resulted in the formation of an alimentary tract, which is peculiarly sensitive to irritation. The mechanism continues, however, to act in association in disease where in some cases it may do good, while in other cases it does a vast amount of harm.

Therapeutics.—If the above be faithful to nature, then of our therapeutic measures those which excite to action and those which induce rest are most important. Among the former there are physical work, external light and heat, noise, food, out-of-door scenery, stimulants, tonics. Among the latter there are reduction of work, of external light and heat, of noise, and of food, sedatives, venesection, reduction of irritation, of pain and of excitement (whether that of pleasure or fear). Tales of success excite, tales of happiness cause comfort, tales of failure depress. In some cases of disease excitement is more easily induced than in health; a boy in the convalescent stage of pneumonia I recently saw, who was so excited by a noisy delirious patient in the next bed that his temperature rose straightway from a normal value to 104·4° F.; an hour and a half later his temperature had fallen by 1·8° F.; and next morning at 8 a.m. it was 98·2°; it then oscillated up and down for seven days, after which it remained at the normal. So also the patient convalescing from enteric fever, if excited to pleasure or to fear, almost always expresses the excitement in a rise of temperature.

Further, the organic world exhibits a periodicity of action and rest in obedience to an external rhythm, and there is evidence to prove that hygiene and therapeutics must be directed with attention to these rhythms.

There is, indeed, evidence to show that the principles of Darwin and Herbert Spencer explain in degree some, and possibly should explain most abnormal as well as normal, manifestations of life. If so, these principles should lie at the foundation of rational biology, morphological and physiological, whether regular or irregular (normal or abnormal).

PRINTED BY J. E. ADLARD, BARTHOLOMEW CLOSE.