ON THE

MECHANISM AND MOTIONS

OF THE

HUMAN FOOT AND LEG.

BY

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1819.

TO THE RIGHT REV.

GEORGE GLEIG, L. L. D.

PREMIER BISHOP OF THE SCOTCH EPISCOPAL CHURCH,

AND TO

DR. JOHN BARCLAY,

LECTURER ON ANATOMY IN EDINBURGH,

THIS ATTEMPT

TO GIVE A PHYSICO-THEOLOGICAL VIEW

OF THE

BEAUTEOUS, AND INCOMPARABLE MECHANISM

OF

THE HUMAN FOOT, AND LEG,

IS MOST RESPECTFULLY DEDICATED.

CONTENTS.

ANIMAL MOTION.

In a former treatise on the human body, we took a cursory view of the vital organs, in their maintenance of life, and in their influence upon the character; and having traced them up to their orifices, mouth, and nose, were naturally led to the consideration of the rest of the face. There to stop short were to leave, in a most unfinished condition, our representation of humanity—endowed with an appetite which has no power of gratification—with an energy which has no opportunity of exertion—with a mouth which has no capability of reaching food—with a nose which has no means of following out the scent—with ears for hearing alarm which they cannot shun—and with eyes for discerning objects which they can never attain. These four isolated senses of the face would have been vain intelligencers without touch for giving interpretations—and useless without limbs for acquiring the objects descried—and could have given no certain intimation of personal identity, without the brain, that common sensory, where they all meet, whence all volitions are issued, whither all sensations are communicated, wherein all thoughts are revolved—the residence of the soul. We now therefore proceed to complete our view of man, by prosecuting our inquiry into those motive organs by which he performs, and afterwards into that presiding organ by which he plans.

Although unable to give a philosophical account of the slightest movement, or to trace it beyond a few relations, usually styled second causes, or to form concerning it a single abstract idea; yet, as the skin becomes hardened, and the feeling blunted by repeated pressure, the human mind, familiarized from earliest infancy with motion, and intimately acquainted with its laws, can now contemplate with a stoical insensibility, the unremitting, the stupendous, the mysterious motions of nature; and, mistaking effects for causes, and laws for agency, can delude itself into the idle notion of accounting for what the most scrutinizing of human faculties are inadequate barely to witness. To be conscious of ignorance is the first sure step towards the acquisition of knowledge; and to define mental faculties is as necessary at the outset of scientific pursuit, as a definition of terms at the outset of controversy. Had man never before perceived motion, the slightest movement would have been to him a phenomenon more astonishing than the seeming trunk of a tree to the more experienced observer, when it turns suddenly round upon him in all the characters and reality of a crocodile. All motion animate and inanimate, searched after with the keen inquisitiveness of philosophy, from natural law to natural law—from what we denominate proximate cause to remote—must be ultimately traced to the Great Original source of all motion; for law implies an agent, and human reason cannot rest satisfied with any cause short of the ultimate, in our retrograde research from consequent to precedent—or, which is the same thing, of the primary in the direct succession of cause and effect.

Unlike the chemical motions amongst the particles of matter—unlike the rushing of the loose element of water to its level, or of the looser element of air to its equilibrium—unlike the sublime gliding of worlds, these projectiles of

Deity, through empty unresisting space—animal motion is performed by a complicate machinery, which has to work, by its own exertions, its laborious and definite way, step by step, through a resisting medium. This animal machinery is composed of a solid frame-work of various bones, curiously jointed together into one firm moveable instrument, upon which is fixed a complexure of muscular and tendinous ropes, so constituted as to be capable of drawing in indefinitely various degrees of force, velocity and extent, and so arranged as to be capable of pulling in every moveable direction.

Attraction is the great reigning principle by which the attitudes and movements in the physical world are regulated. The movements, cohesions and configurations of chemistry are traceable to affinity, which is just an attraction on the small scale between atoms. The great orbital movements in the planetary system, the harmony of the spheres, are regulated by gravitation which is just an attraction on the great scale between worlds. Animal movements are performed by muscular contraction, which is just an attraction of two given points towards each other. But if the physical world had been consigned to this one principle, motion must have soon ceased, for gravitation would have soon brought the heavenly bodies together, had it not been counteracted by the tendency to move onwards in a straight line;—the atoms of matter would have soon settled into a fixed arrangement, but for the expanding and decomposing effects of heat and electricity and galvanism;—muscular contraction would have soon drawn the whole body together, had it not been held in longitudinal extension by the compages of bones. Even the movements in the moral world seem to depend upon two such counterbalancing principles—upon the predatory excursive tendencies of individuals, countervailed by the social and attractive tendencies of mankind.

The bones held together by moveable joints are the inert instruments of motion; while muscles, extending from bone to bone, and traversing joints, are the immediate agents. Muscle, although palpable in its substance, and computable in its effects, is no less mysterious in its nature than either gravitation or chemical affinity.

Endowed with the simple property of shortening itself when properly stimulated, the muscular fibre performs those innumerable motions of the tubular system within the body, which are at once the effects and the re-acting cause of life itself—and, at the same time, accomplishes all the greater evolutions of human beings amongst one another. On opening a dead body, so lately the instrument of vigour and activity, all is found quiescent, save the collapse of the lungs, when exposed to the pressure of the atmosphere, or the sliding of one organ upon another, so soon as that envelopment, which braced them all together into one firm package, is cut asunder. Here the mechanician, so far from discovering such springs of animal motion as were necessary to his automaton, finds the muscles, when freed from blood-vessels, nerves and cellular membrane, to be so tender that they cannot support their own weight; and the brain, whence the mind had issued its commands along the nerves to the muscles, to be a mass of pulp. When the automaton runs down, the unconscious machinery can be rolled up, and again made to strut its little round of mockery and caricature. And what does all this boasted clock-work accomplish? Can it do more than retard, at an equable rate, a weight from falling directly to the ground, or an elastic body put upon the bend from recovering itself with a jerk? Can it do more than distribute amongst wheels and axles, a certain force which had been produced by muscles, and which a child, in virtue of these, can call into existence? Clock-work does indeed spin out motion, but cannot produce as much of that momentum, by which motion may be set a-going, as would bend the minutest fibre of the most delicate down. All artificial motion then is dependent upon the muscular motion of man, whose moving principle is distinct from all the laws and qualities of matter, so far as our knowledge of that mysterious substance extends. On cutting into a living body, a most active scene presents itself; yet all the palpable, and all the infinitesimal movements in the vital organs cannot, upon any mechanical principle hitherto discovered, account for the bending of a single limb,—and, if they could, would themselves require to be accounted for, ere the mystery could be cleared up—nor does it avail our vain research to cut down upon the limb itself, and to expose the quivering and contracting of muscles. But although the cause of animal motion lies wrapped along with life itself in the deepest mystery; yet the instruments and the effects are within the reach of investigation, and constitute an object of mechanism and of mechanics, worthy to engage human study, and to command human admiration.

Between motion and locomotion there is no radical distinction. All motion, implying a less or greater shifting of place or of relative position, must be virtually and philosophically locomotion. Indeed, the downy seed of the thistle finds its way upon the wafting breeze from field to field, and the aquatic vegetable floats about on the liquid element, while beings recognised as animals are doomed for life to an immoveable fixture upon the rock. But the chemical motions of mineral life, the irritable motions of vegetable, and all the other motions in nature, are quite distinct from the voluntary motion or locomotion of an animal. Neither motion nor locomotion then is peculiar to an animal. His characteristic is volition. Nor in the extensive range of life, with which the world abounds, do we meet with a muscular apparatus subservient to the will, until we have arrived in the graduated scale, at beings possessing a receptacle for food. Then a necessity is immediately imposed upon the creatures destitute of roots, to move about, and to search for food. This necessity is the first impulse given to animal motion, although it receives in its way acceleration successively increased as the faculties become expanded by the impelling current of circumstances. As the inanimate materials of nature would remain for ever at rest, if not impelled, and would continue for ever in motion, if not arrested; so the animate would lie down in one universal motionless repose, if not roused by motives; nor would the stir and bustle of life intermit, had not balmy sleep been seasonably interposed, wherein exhausted nature may be wrapped up, to be cherished and recruited for a renewal of the sad struggle. But amid all this necessarianism, imposed alike upon animate and inanimate, man claims the high prerogative of being influenced by motives, not merely suggested by the appetites, nor merely cognizable by the senses—not quite beholden to matter, nor entirely limited to time. That the human will is determined by motives, of which the most powerful, in the wise arrangement of nature always prevails—in other words, that man chuses wisely—is no argument whatever for his having no choice at all. Man is at once the subject of necessity and the lord of free will. While he has the stamp of animality, in being the thing of circumstances —he has also the stamp of divinity, in being a voluntary agent. While, as a part of a great system, he is connected by means of senses, appetites and passions, with the things amidst which he is placed; yet, as if he had received a slight transfer from the Divine nature, he contains within himself a little system of active powers, both moral and physical, with which he can react upon the things without, and thus, in contradiction to "a new view of society," lately broached, is enabled, in spite of all external circumstances, to determine his own character. But the active physical powers of man, which are placed in immediate subordination to the active moral powers, being exclusively the object of present consideration, we must limit our contemplation to that master-piece of practical dynamics, which nature has constructed of bones, and of muscles disposed over them, and subordinated to the will. To investigate this piece of consummate mechanism, is a task worthy of man, and suitable to his faculties; but all his hypotheses and theories about muscular contraction, deserve to be ranked with the merest drivelling. However successful may be our computations of muscles and bones, the immediate instruments of animal motion—or, however sage our contemplation of the mysterious council of brain and nerves, by which animal motion is directed—or however penetrating our research into that hidden laboratory within, whence the whole derive their vital supply—our researches behoove to terminate in that Great Being, who at first created, arranged, and set in motion all these vital and animal organs, and by whose unceasing energy they are continually upheld.

The world in all its magnificence is interesting, only in virtue of affording habitation and nutriment to such a multitude of living creatures. The whole animate creation may be viewed as one system of beings, all necessary to each other's existence and comfort; so that the most insignificant animalcule is indispensable to the completion of the system. That vast assemblage, making their various voluntary way over the ample and diversified surface of the earth, is richly demonstrative of Divine power and benevolence; while their various motions, contemplated in real life, and traced through the long gradation from rudeness, through complexity, to simplicity, afford a lively display of that vast importance which limbs possess in the animal economy, of their accurate adaptation to the requisitions, and, consequently, to the characters of the various tribes respectively, and of the mighty superiority of human legs and arms, above all the limbs and fins and wings in the rest of the animated world. Equal to the diversified field of locomotion, is the diversity of locomotive organs. A detailed enumeration of the infinity of animal motions would be far too voluminous for our present purpose, and would, besides, be quite inadequate to convey the faintest outline of nature's living volume—whose words are steps—whose lines are courses—whose paragraphs are lives and histories of animals. Nor can a cursory sketch be drawn in compliance with the arbitrary arrangements of natural history, without incurring confusion, prolixity and frequent recurrences. For the sake of order, though at the disadvantage of much omission, our present inquiry must be regulated by the three great regions, water, air, and earth, as inhabited by animals. But in adopting this order, let us recollect that all aquatic animals do not abide by swimming, nor all aerial by flying, nor all terrestrial by stepping—nor are they restricted to their respective native regions, for we find the crawling fish and the pedestrian bird, the aquatic bird and the amphibious quadruped, the flying fish and the flying bat. But in the midst of all that variety and intermixture of locomotion, we find that all fins, whether belonging to fish, or to fowl, or to flesh, act upon one principle—that all wings, whether belonging to fowl, or to fish, or to flesh, act upon one principle—that all feet, whether crawling on the bed of the ocean, or hopping from twig to twig, or from crag to crag, or traversing the earth with bounds that seem to spurn the very surface upon which they are performed, act upon one principle. Wherefore, out of all the numberless animalculæ making their earnest and various way through the stagnant pool, and all that frisk about in the stream, and all that inhabit the dread recesses of the deep, or range throughout its mighty extent, we select for our purpose the finny race—and out of all that can glide through the thinner element, we select for our purpose the feathered tribes—and out of all that can proceed over a solid surface, whether by crawling, or leaping, or stepping, we select for our purpose the four-footed animals. These three simple marks designate the gross of the lower creation, inhabiting water, air and earth, and exclude merely that diversity of animals which occupy the corners and crevices in the habitable world—exclude the awkward squadron which are unfit for the line, and unequal to the march, with the regular troops of creation.

Wherever air and food can be obtained, there we find life. It is in virtue of the air and food contained in the waters flowing on the surface of the earth, that lakes and rivers and seas and oceans abound with living creatures;—and it is in consequence of the scarcity of air in water, that animals, which breathe by gills, have a life so low—a circulation so simple—blood so scanty and cold—muscles so pale, inefficient and necessarily abundant. From the heaviness of muscle and bone, those fishes which have free course throughout their liquid habitation are furnished with an air-bag for reducing their specific gravity to an equality with the medium in which they live. Flounders and other fish which dwell at the bottom require no air-bag, and are flattened horizontally, for the sake of ascent and descent, which are their principal motions. The shape best calculated for moving onward and about, is represented by the salmon—long from head to tail—deep from back to breast—narrow from side to side. But how is the animal with such a shape duly to maintain such a critical position, more especially as there is a continual tendency, from the preponderancy of the back, to turn upside down, as is seen in a dead fish floating in the water. The equality of the fish to the water, in point of specific gravity, adds to the difficulty of maintaining the evenly posture. The whole bodily arrangement of the fish, in short, seems to conspire against that posture which it must and does maintain during life. What plan does Nature adopt in this seeming emergency? She just avails herself of all these apparent disadvantages, and turns them to the very best account. She furnishes the animal with fins, which it behooves assiduously to ply in resistance to this tendency of the body to turn upside down. This is a device that so combines simplicity with utility as to transcend all ordinary mechanical contrivances. From the simple arrangement of making the back heavier than the belly, the fins must labour to sustain the body against a weight, whose tendency is merely to turn it upside down, with the same activity and perseverance that are necessary to counteract a weight, whose tendency is to drag the animal to the bottom. Thus the fish, by keeping the fins in constant and active play, possesses all the steadiness that weight can confer, without the continual disadvantage of sinking. This buoyancy of the lower part of the body virtually constitutes a standing, upon which the upper and heavier part must be constantly poised; so that the fish, though equal in specific gravity to the water, and equally pressed by it on all sides, has a centre of gravity to balance upon a base of support. To maintain the equilibrium, and to adjust the position of the body to the direction of the course, is almost the whole duty belonging to those fins that are arranged over the body; while the tail fin is the main instrument of motion—of turning round, and of darting forward. Nay, it is astonishing how long a fish, cropped of all the other fins, can balance itself, or can recover the balance when lost, with the tail fin alone, as if it were paramount; until by the extraordinary exertion, necessarily called forth, the animal at length becomes exhausted, by and bye begins to reel, then fairly turns up its belly, and ere long expires. The tail fin, towards which the anatomist finds so much muscle disposed on each side, acts at once as helm and paddle. Thus the fish by striking the tail to the right, wheels to the left, by striking it to the left, wheels to the right, and by striking it doubly to right and left, or to left and right, darts forward with a rapidity which often escapes the acutest eye. It is almost incredible how the salmon, in prosecuting its instinctive route up fresh water streams, by a few lashes with the tail in the pool below, surmounts cascades of remarkable height. It is scarcely requisite to mention that the rapidity of swimming is proportional, other circumstances being equal, to the size of the fish. But fishes are not the only inhabitants of the deep. There are cetaceous animals—whales, dolphins, sea unicorns, &c. which avail themselves both of the atmospheric air on the surface of the water, and of the food abounding below. These animals, instead of breathing water impregnated with air, by means of gills, ever and anon ascend to the surface, and by means of lungs and chest, respire air itself through nostrils opening at the top of the head, and are therefore styled by mariners blowing fishes. Enjoying warm blood, a more complete circulation, a more vigorous life, and a more efficient structure, these animals prey upon fishes, properly so called, and hold the government of the mighty deep by the right of strength, and upon the principle of rapacity. Their blubber, from being lighter than water, enables them to dispense with air-bags; and from being a slow conductor of heat, enables them to maintain a high temperature in the midst of so cold a medium. For enabling them to ascend to the surface for breath, and then to dive into the deep for food, the tail fins are flattened horizontally. Comparative anatomists have idly and falsely endeavoured to find an analogy between the pectoral and abdominal fins of cold blooded fishes, and the fore and hind extremities of quadrupeds. Warm blooded cetaceous animals, however, with their four fins, two on the chest and two on the tail, are virtually quadrupeds in the midst of the ocean. The pectoral fins resemble the anterior extremities of quadrupeds, in function, in situation, and even in structure: but, as the purpose of Nature is not to satisfy the comparative anatomist, by carrying out analogies, but to furnish the animal with organs most suitable for swimming, so the two tail fins resemble the posterior extremities of quadrupeds, not so much in structure, as in function. In the amphibious seal, and sea cow, the two hind extremities, stretching backwards, and approximating toward each other, resemble tail fins, and thus form a connecting link between the hind extremities of cetaceons animals, and of quadrupeds. The natural history of cetaceous animals has been but little studied. What hinders their variety and gradation to extend upwards to water monkeys, whose shyness arising from superior cunning, and whose nimbleness arising from superior structure, may have enabled them, amid the trackless unfathomable ocean, so to elude human ken, as to have hitherto held naturalists sceptical with regard to the existence and nature of mermaids. Indeed man has but a scanty knowledge of the inhabitants of the deep. Of the various aqueous strata, and their appropriate inhabitants, he knows but little; for the few which he entangles and drags up, can give him but little information of the swarming multitudes and varieties that are left behind. In the fathomless depths and recesses of the pervading ocean, miles below the surface, there may dwell numberless creatures which the light of day has never reached, and to whose retreats the grasping hand of man can never penetrate.

Birds, having a two-fold locomotion, are furnished with two sorts of locomotive instruments. The legs, being articulated with the hind part of the trunk, whose posture approaches to the horizontal, can form a basis of support, only by stretching forward to receive the centre of gravity, which is thrown back as far as possible by the elevation of the neck and head. Such legs, although necessary for alighting, for hopping about, and for again springing into the air, are quite inadequate for flight or for pursuit, and in emergencies are soon abandoned, that the more effective instruments of locomotion may take the charge. The leg of a bird has at once a simple and a curious structure. What answers to the twelve bones composing the body of the human foot, consists, in the bird, of a single bone; and must therefore be quite disqualified for diffusing any shocks but those to which a light bird, having wings ready for flapping or flying, can be liable. As if aware of this deficiency, the feathered tribes gradually diminish their speed, and at last hover for a small space, just before alighting. The long muscles which bend the toes arise partly from the leg bones, and partly from the thigh bone, and are connected with an accessory muscle descending from the pubis, in such a manner that a bending of the leg and thigh produces a contraction of the toes. Thus the very weight of the body, by tending to bend the thighs and legs, forces the toes at every step to grasp the ground. It is in virtue of this contrivance that a bird can sleep so securely upon the highest twig;—nor can the perch be left without an extension of the limbs, which simultaneously loosens the toes from their hold, and projects the body into the ambient air. In flying, the legs are stretched backwards, and are sometimes seen extending beyond the tail. The tail acts the part of a rudder, while the neck and head counterbalance it as a director. It is interesting to remark the general aptitude of the body for flying—how the plumage is light, retentive of heat, and inclined backwards—how the air cells of the lungs communicate with the cavities of the body—how the bones, from having a firm texture, are thinned, and hollowed, and filled with air, in place of marrow—how their food, from being the most nutritious, is the least bulky—how from being oviparous they are exempted from much encumbrance—how, in short, there is every contrivance adopted, and even sacrifice made, in structure and in function, for gaining the utmost lightness that is compatible with sufficient strength. We can neither find in Nature, nor can produce by art, a substance possessing at once so much toughness, pliancy, elasticity, and lightness, as the feather of a wing. The barbs, consisting of thin pliant plates, clasped to one another by innumerable minute fibres, and set edgewise to the resistance of the air, lie short and stiff on the fore edge of the stem, proceed longer and more pliant from the hind edge, and form a slight concavity on the lower surface. Upon the plan of the feather is the whole wing constructed; thus, the bones and muscles by which the wing is moved, and in which its strength resides, are situated in the fore part, whence the long elastic quills radiate backwards and outwards, with a gentle curve downwards, in the order of a fan. From this arrangement the wings perform a double motion; —both wings perform a motion upon the body as one axis; while at the same time the hind part of each wing performs a motion upon the fore-part as another axis. The wings of the flying fish, and of the bat, and of insects, are all constructed on the same principle. Had the upper and the lower surfaces of the wings been equally plane, the falling stroke would have been counterbalanced by the rising; while the specific gravity of the body would have brought the bird at once to the ground: and had the wings been of equal strength and resistance in the hind part as in the fore, they would have effected perpendicular elevation, but no progression. By the concavity of the wings on the lower surface, and their convexity on the upper, and their waving motion upon the body, a bird is enabled to elevate and to sustain itself in the air; just as a fish, by the working of the pectoral and abdominal fins, can uphold itself in the water;—while by the motion of the hind part upon the fore part of each wing, the bird is propelled through the airy element; just as the fish, by striking the tail fin from side to side or up and down against the liquid element, can dart forward with such velocity. How far the feathered tribes surpass the human race in mere locomotion, marks out how little comparative value Nature has placed upon that mechanical faculty, for its own sake. So little are wings really available, that birds are for the most part the prey of terrestrial animals, and winged insects the prey of the wingless, and the flying fish seems to be indebted to its wings, merely for escape from its pursuer. Had wings been highly important in animality, or conducive to its improvement, birds would undoubtedly have occupied a higher rank in the scale, nor would wings have been withheld by Nature from the more favourite members of her family. Even without wings mankind are too volatile; and with the lightness of body necessary to flying, would have been quite unfit for the ordinary duties, much more for the hardier achievements, of human life. The aerial tribes, whose highway is the atmosphere, and whose perches are the islands and continents that rise at convenient distances out of the wide ocean, present a picture of mere locomotion, grown into such exuberance, as to have engrossed almost the whole energy of the animal, and to have held the higher organs diminutive and tributary. Gliding and hovering above, in counterfeit superintendance of the surface below,—seeming with gambols in the air to mock, and with the stately march of a biped on the earth, to mimick, pedestrian man,—as if designed for a moral to teach him a striking lesson of humility, and a still more striking demonstration, from how far the lowest animal faculty can be carried, of the vast room which must still lie before the human faculties for improvement—these feathered tribes are virtually but quadrupeds, with their four feet divided between the two elements upon which they travel; nay, in the scale of quadrupeds, rank immediately above the reptiles. The winged tribes may be viewed as outcasts and outlaws from terrestrial possessions and terrestrial society;—in the language of Swift, by the mouth of the spider, as "vagabonds without house or home, without stock or inheritance, born to no possession but a pair of wings,"—which have thus been bestowed, not for the sake of animal superiority, but of reaching food that had otherwise been inaccessible, and of occupying a region that had otherwise been vacant of life.

The principal inhabitants of the water and of the air, we have found to be furnished with four limbs. On making a survey of the land, we find that all its sizeable inhabitants, with the single exception of the serpent, the most formidable of them all, are furnished with four legs. In the whole range of nature, we do not meet with another instance of an animal endowed with the five senses, and, at the same time, destitute of feet—in the whole range of nature, we do not find another instance of an animal furnished with a back-bone, and, at the same time, destitute of feet, or of organs analogous to them. The crocodile, which so resembles serpents as to be ranked with them in the same class, has four feet—fishes have fins—certain of the molluscous animals have tentacula—crabs have articulated limbs—most of the insects have feet, or wings, or both—some of the very zoophites have moveable spines—while the serpent is an anomaly in the midst of animals, and forms an interruption in their gradation—a break in the continuousness of their system. That an animal of such passions and powers should be necessitated to trail its length in close pronation over the earth's roughness, is quite unaccountable upon natural principles; but tallies well with the doom recorded in Sacred Writ—"Thou art cursed above all cattle, and above every beast of the field; upon thy belly shalt thou go." The sentence pronounced seems to imply that the animal had originally possessed feet, which either were, as a penal forfeiture, stricken off, or allowed to decay through disuse, consequent on the assumption of the lying posture. Whether this animal was chosen, on account of its cruelty, as the most suitable instrument for effecting the diabolical purpose against mankind, or whether the cold cruelty of that animal, now become proverbial, may have partly resulted from the Divine curse—certainly the Arch fiend could not possibly have received a truer representative, in the shape of flesh and blood. The lachrymal gland for supplying tears is altogether awanting; and generally the salivary glands, instead of saliva, furnish venom, of which the fangs are the conduits and inoculators. Of benignity there is none —of sympathy there is none—of remorse there is none. Well was that glistening and variegated surface calculated to delude artless, credulous woman, from suspecting those eyes without a tear —and those ears deaf to the shrieks of fear and to the groans of agony—and that heart, through which the blood that circulates is cold—and that mouth, whose sole duty is to grasp, and while grasping to poison—and that throat which opens wide for devouring—and that maw, so insatiable as to glut itself, at every meal, into a long continued lethargy. For winding through shrubbery, and coming unperceived upon its victim, no other structure can be more suitable; and in so far as the attack of the quadruped is insidious, we find its posture approach to that of the serpent.

As more than two points of support are necessary for standing, as nothing short of a tripod can stand itself, and as a four-cornered piece of unbending furniture derives as steady support from four feet, provided they be sufficiently strong, as from four hundred—so there is little wonder that nature should have constructed so many quadrupeds. Additional feet, by diminishing the supply, the duty, and the freedom of the other four, would, without the substitution of a single advantage, have diminished at once the speed, the stability, and the durability of the animal. In emergency, the quadruped can even so far dispense with one of its limbs; for the centre of gravity may either fall or can be easily thrown within the remaining base of support. This is of incalculable advantage in those stages of animality, where limbs are in such risk, and where life itself so much depends on speed. As each leg of the quadruped constitutes one of the four necessary points of support, while the other active duty devolves upon the mouth; so the lower animals are almost devoted to feed themselves for a higher order of beings. This quadrupedal arrangement, while it thus dooms to a grovelling life, is calculated for the fleetest locomotion. Where the number of legs either exceeds or falls short of four, they must move in succession, at the rate of a walk, or of a trot. A quadruped alone can gallop—An antelope proceeds at a rate that is beyond reckoning—A Bengallee tiger has, according to computation, cleared a hundred feet in a single bound. Had locomotion been the sole design of limbs, they would not have been susceptible of farther improvement beyond the quadrupedal arrangement. But they have been also designed for ministering, by manual duty, to the exalted purposes of humanity. Although some of the more favoured of the lower tribes are enabled to lift their paws from the ground, in assistance to the mouth; yet all the four limbs are so indispensable to locomotion, that they must ever come to the alternative of striking or tearing or grasping on the one hand, or of pursuing their course on the other. In so far as the limbs attack, they forfeit their speed, and in so far as they pursue their course, they forego the attack. The limbs of the ape, although terminated with the similitude of hands, are all necessary to the peculiar locomotion of this curious animal. The ape being an inhabitant of the wood, and having its path through the midst of trees, far above the reach of the more formidable inhabitants of the forest, must sustain itself by means of its three limbs, whilst pulling the nut and conveying it into the mouth with its fourth, and must ply all the four in swinging along from branch to branch, so nimbly that multitudes have disappeared more rapidly than the eye could follow. The ape then with all its hand-like feet is quite a local being, altogether unfit, even had it the spirit, for traversing the earth's extensive surface. The king itself of the apes, stout, fierce, and armed with the club, dares not venture far from its wood; so unsteady is its footing on the two hind feet, and so defenceless does the animal become when the other two also take the ground.

But in the human limbs there is a complete distinction into feet and hands—a fair division of labour into going and doing. In virtue of this complete distinction, man has his standing upon the smallest possible area of ground, so that mighty conventions can consult or co-operate—has his ponderous brain, instead of bearing down with the purchase of a long lever, fairly poised upon the centre of gravity—has his senses at their highest elevation—and has two limbs exempted from locomotion, and devoted to that diversified action, of which all that we see around us, different from a wilderness, are but the vestiges. It is this very division of labour, into pedestrian and manual—enabling man to move so promptly, so steadily, and so extensively, over the earth's surface, and to do so much wherever he moves, and while he is yet moving—that renders him, even in his lowest capacity of a rude Indian hunter, capable, even without the aid of shelters, or of confederacies, to face and to subdue the wildest and the most formidable of animals—and that, along with the wisdom inherited from nature, and improved by education, gives him the undoubted supremacy over the whole animated world. Mind is indeed man's high prerogative, and metaphysics are his peculiar science. But in this world, wisdom would, without limbs, be unavailing as a mere breath. The limbs, although dependent upon the vital organs for vitality, and upon the nervous for motion and feeling, and although removeable with immediate impunity to life and to health—yet hold all the vital organs, and, through them, the nervous system, dependent for the two grand essentials, food and safety. A man may survive his own limbs, by deriving service from others; but were the whole human race dismembered, what a scene of lankness and death must inevitably ensue! In fitting out every animal with mechanical instruments for supplying its own wants, nature has erred on the safe side, by bestowing an amplitude, sufficient to meet all contingencies. What could the mind have done, with all its powers of devising, or the senses, with all their faculties of discerning, unless there had been feet to convey, and hands to execute. Without the limbs, man, with all that wisdom, to the attainment of which they have been in no mean degree instrumental, could not have escaped the ravages of rapacious animals; for habitations were not ready as places of retreat on the approach of danger. Without the limbs, man could not have subsisted; for food is not lying at the mouth, ready to be devoured. Without the limbs to execute mechanism, and to aid in performing experiments, the arts and sciences must have continued in embryo. To the limbs, therefore, he is indebted for safety, for subsistence, and even, in a great degree, for having scrambled up to his present pinnacle of civilization. Living securely in the most cultivated and civilized spot in the world, we can form but an inadequate idea of the struggles which mankind in rude stages of society have to make, first with ferocious animals, and then with one another; nor how much our distant progenitors must have been kept on the alert, ere the ferocious animals of this very island were hunted down, and extirpated; nor what an "admirable stand" was made "against the power of the Roman empire, till that memorable period in which they quitted their woods to subvert it;" nor what deadly feuds, afterwards, amongst themselves, and resistance and defiance of the whole world, have all had their share in bringing Britons to their present pitch of power and civilization, and the face of their country, naturally bleak, to its present state of a comparative paradise. It is in virtue of the limbs, which carry into execution the plans of wisdom, that it can be called power;—and it is in virtue of a complete distinction into feet and hands, that the human limbs are so powerful. Two handed is a true, but a most limited designation of man;—four handed is both a most false and a most limited designation of apes;—as if man's pre-eminence above the ape consisted in toes; or his title to humanity were held from the limited number of his thumbs and fingers. Less hurtful to the cause of humanity, because quite revolting to the human mind, is the crude barefaced doctrine of Lord Monboddo—that man has derived his original from the apes. Without the evidence of a single memorial of quadrupedal humanity, a judge, appointed to determine the rights and the birthrights of individuals, has traced the lineage of mankind to a race whence neither honour nor heritage could be derived! He seems to have mistaken the felons who came under his cognizance for a specimen of his kind, and the delegated bench for the oracular tripod. Instead of drawing animal distinctions from the instruments of motion, why not in a truer spirit of philosophy from the principles themselves—why not from the thing rather than from the mode;—and then we shall find that the lowest crawling, and the most stately walking, alike consist in an alternate stretching forward of a part of the body, and a drawing forward of the rest—that a grub proceeds on its way upon the same principle as a man—nay, that man, deprived of his limbs and of assistance, shall resemble the grub, not only in the principle, but also in the plan of locomotion. If man then can be derived from the ape, he can also, by a parity of argument, be derived from the maggot. It is by thus limiting our views to the animal nature of man, which the lower animals possess in common with him, in order that they might constitute his food—to mere life, which all enjoy in common as a better preservative of animal food than all the pickles of cookery—that naturalists and anatomists have such a tendency to entertain degrading views of human nature, and to run so readily into materialism. The science of physiognomy, on the contrary, in deducing qualities of mind, from qualities of body, so far from acquiescing in the illegitimate inference that mind is nothing but body, affords a powerful argument against materialism, by showing how the body may be dismembered, without affecting the character. Indeed, in some of the cold blooded animals, we see new limbs spring up in the place of those lopped off; and even in man we see a dislocated limb, although driven far out of its place, soon accommodate itself, as much as circumstances will permit, to the natural postures and movements. Here might be started a curious question of speculation, how much of body could be removed with impunity to mind. But although limbs may be lopped off, or thrown by external causes into deformity, without being admitted in evidence against the mind; yet a natural deformity of limb argues a natural deformity of character, and a natural deficiency of limb argues a natural deficiency of character—for here the deforming or the depriving cause is from within—there it was from without. These natural defects, however, may be made up, and more than made up, by moral discipline—nay, have a great chance of producing a sufficient moral or intellectual compensation, inasmuch as bodily defects have the tendency of bringing about humility, which is so conducive to mental improvement. On entering upon the subject of mind, encumbered and incorporated as it is with matter, so as even to be utterly incapable of an abstract idea, the mere naturalist immediately loses sight of man, and must abandon the presumptuous task of discriminating and defining and describing what he is. It is here that all comparison of man with other animals becomes nugatory. To place him at the head of the classification, and to give him an order by himself, is but a poor apology for bringing him into the company of brutes—for placing him in the same catalogue with his food. For the double purpose of deterring man from pluming himself upon organs common to irrational animals and rational, and of completing the gradation scale of animality, Nature has held out, as a beacon, the humiliating spectacle of a brute endowed with the semblance of humanity, actually reared on its hind legs, and, that the caricature might be complete, grasping a club in its fore-feet. What a humiliating lesson must a troop of Ourang-outangs, standing in martial array upon a neighbouring hill, have afforded to the elated conqueror of the world, in the midst of that rapid career, which was accomplished by legs, and of those mighty conquests, which were achieved by arms! Let not man then place his sole claim to distinction from inferior animals to the account of limbs. Never let biped become his definition, for there is a sturdy ape which marches on two feet. Nor ever let the human thumbs, as if humanity would pique itself upon such a badge, be snapped in contempt of the lower creation, for an animal, whose very name is a proverbial term of reproach, can almost retort the flout from every limb. But although the mere naturalist, from his arithmetic of members, is unable fairly to extricate himself from the inferior tribes; yet the physiologist, by his strict investigation into structure and function, can draw real distinctions out of nominal similitudes—can show that the lower limb of the best formed Ourang-outang is a very contrast to the shapely leg and foot of man;—and that the best endeavour of the ape to hobble forward from foot to foot is the merest mockery of the human walk;—and that although the fore-legs of many of the lower tribes are employed in more purposes than locomotion; yet it is not till we come up to apes that we see any thing like hands, nor till we arrive at the most refined of mankind that we see hands, in all their delicacy of touch, and alacrity of motion. But to render complete the comparison of human motive organs with bestial, the whole bony, muscular, and nervous structure must be taken on either side; when it will be found that the human body, although by no means the strongest, is by far the most effective organ of motion, and the most sensitive organ of touch, in the whole range of Nature;—that, in the mechanical apparatus which man in common with the lowest reptile is doomed so assiduously to ply for the maintenance of life, health, and happiness, humanity holds all the rest of animality at the immeasurable distance of a contrast, and contains a summary and improvement of them all. Although naturally terrestrial, man can travel throughout all the regions of his dominions, every where exercising domination;—can, without fins, traverse the great deep, and appropriate the finny race to his pleasures or necessities;—can, without wings, ascend into the higher regions of the thin element, whose feathered inhabitants are also doomed to be the sport and the victims of his recreations;—and can not only devote the animate creation to his service, but can also endow the inanimate materials of Nature with active motion and locomotion. The immense machinery which has brought the arts, especially in this country, to such a high state of improvement, and in a great measure superseded manual labour, so far from derogating from the human hands, constitutes so many proud monuments of what they have achieved;—resembles so many huge living beings, of which man, although he can scarcely be discerned amongst the shafts, the wheels, and the cylinders, is the animating principle. The human hands are now becòming master artists, whose whole duty shall by and bye consist in directing animals and elements to the performance of their task.

All this bony and muscular apparatus, which we have been contemplating, and all the minute granules and fibrils, entering into its composition, have their interstices, large and small, filled up, and are thus united into one mass, by cellular membrane, which is the pervading substance, the universal stuffing of animal bodies. Having filled all the interstitial spaces, and constituted comfortable cushions whereon all the stationary organs may recline, and formed smooth lubricated sheaths wherein all the moving organs may glide, this cellular substance becomes condensed towards the surface into the chorion, so called from consisting of gelatine and thus being convertible by means of astringents into leather. This chorion or leathery portion of the skin is white, elastic, perforated by innumerable pores, covered by a reticular membrane, and beset all over with numberless nervous papillae; and thus serves at once for covering and bracing the parts subjacent, for giving transmission to the perspiration, and for constituting a most befitting seat to these nervous papillae, which are the true organ of touch. Each papilla is a small tuft or pencil of nervous fibres, longer in the middle than towards the edges, and thus terminating in a conical top; upon the principle of the patent brush, whose bristles, being unequal, present points to the surface, whatever be the pressure applied. With these papillae the whole skin is thickly invested, especially in the lips, in the fore part of the hands and fingers, and in the lower surface of the feet and toes. On exposing the papillae with which the tip of a finger is covered, and applying the microscope, they present the appearance of white silk velvet, arranged into concentric ridges. In intricacy and extensiveness, all the other senses come short of this organ of touch, as shall be more fully demonstrated when the hands, which are the more appropriate instruments of this sense, come under discussion. These delicate nervous papillae are defended against cold by hairs; against dryness by the rete mucosum; and against injuries by the cuticle. Hairs, which seem to be of a vegetable nature, grow from bulbous roots planted in the cellular membrane underneath the skin, and are thus exempted from those slighter accidents to which the surface is so often exposed. Fat and hair, which have both their seat in the cellular membrane, are almost peculiar to warm blooded animals, whose superior temperature they conduce to maintain. A hair consists of a central medullary portion in which the colour resides, and of an external white cuticular portion on which the microscope discovers minute scales lying over each other and proceeding outwards. All the mammalia are less or more covered with hairs; even cetaceous animals have a few scattered over their mucous surfaces. Feathers are just a modification of hairs. Indeed the chick is first covered with hairs which grow in small bundles from the bulbous rudiments of the future feather; and even the advanced bird has hairs interspersed amongst the feathers. The mucous net work lying immediately over the true skin is a delicate coloured layer keeping the nervous papillae moist and soft, and reflecting outwards the colour of the animal. The cuticle, which is the outmost covering of all organized bodies, is a white, transparent, insensible substance, perforated with hairs and with pores, and indented all over with lines correspondent with that surface to which it serves as a covering. In some parts of the body the cuticle is naturally thicker than in others, and always becomes thickened by pressure. Nails are the only horny appendages of the human cuticle; and, being situated behind the exquisitely sensitive tips of the toes and fingers, like the teeth behind the lips, are most admirably fitted for seizing what is felt. Warm blooded animals are furnished with claws, hoofs, and horns: cold blooded reptiles and fishes are generally covered with scales: invertebral animals are for the most part surrounded with crusts or shells. In proportion to the strength and extent of these cuticular appendages, the sense of touch is shut in; and in proportion to their scarcity and thinness, they are disqualified for resisting injuries. Now it is the compromise which Nature, proceeding upon the benevolent principle of affording protection against injury, where she withholds perception of danger, has established between the defensive on the one hand, and the sensitive on the other, according to the various circumstances and necessities of her creatures, that has occasioned such an endless diversity of animal covering. It is truly interesting to contemplate with what tender care Nature defends her diminutive offspring, like so many fondlings—placing some in holes and sheltered situations, where they may safely move about with naked sensitive surfaces—providing others with shelly coverings, whence they may grope about, or even sally forth, in search of food—furnishing many with crustaceous armour, in which they may move about, under the guidance of feelers and imperfect eyes. So liberal is Nature in her protection of testaceous animals, that she seems to be manufacturing shells for the admiration of conchologists. Corals themselves constitute rocks, which actually encroach upon the boundary of the ocean. The complexity, the variety and the frequent renewal of crustaceous coverings show how exhaustless are the stores of Nature, and how boundless and unwearied her benevolence. In the external horny apparatus, serving at once the purposes of skin and bone, in ten thousand species of insects, swarming over the earth's surface, we become lost in amazment. Although all animals are not in the highest degree efficient and sensitive, yet they are all and each constructed upon the best possible plan for occupying, without transgressing, their respective stations in this deversified scene. Nor can we fail to remark, how the hard covering, while sufficing for defence and motion, restricts to the requisite diminutiveness. The calcareous crusts of animals, though serving the purposes of an external skeleton, are still merely cuticular; for they are deciduous, and instead of phosphate of lime, the chemical basis of bones, are composed of carbonate of lime, and are thus assimilated to those durable calcareous rocks which abound in the mineral kingdom. Calcareous crusts then, and, from analogy, horny crusts also, must be deemed cuticular; while their internal muscular apparatus may be held analogous with the fleshy pannicle by which the more advanced animals are enabled to bristle their prickles and other excrescences, and sometimes to coil their whole body into a globular form. Indeed, in the testudinous genus of reptiles, we see the crustaceous covering reduced to dorsal and abdominal crusts; while an internal skeleton and muscular system, without which the turtle could not have attained such magnitude, have been erected within—as if a gradual metamorphosis were taking place—another emergence into a higher state of animal existence. In this new animal structure the order of hard and soft parts is reversed. The bones, being now situated within the muscles, have indefinite scope outwards into levers; and the muscles, being now situated without the bones, have indefinite room for accumulation; while the skin, being situated over a mechanical instrument so improvable, becomes more and more saved from every duty that is inconsistent with the appropriate office of feeling. Still, throughout the animal kingdom, bones, muscles and skin form the crust which encloses the vital organs. After all, it is just one crust throwing off another—throwing off a worse, for the sake of a better. The vertebral skeleton is not central; but forms the framework of that case in which the vital organs are enclosed, and by which they are carried about; but instead of surrounding, like the crustaceous covering, vital and nervous organs in one compartment, receives the nervous organ, into an appropriate and safe compartment within its own central pillar. With a back bone, for affording to the brain a safe conveyance along the body, that all its parts may have a ready supply of nervous endowment, and for constituting the buttress of the moving machinery, an animal may extend to indefinite dimensions, and may attain to indefinite power. As animals, however, acquire hugeness, they require the more food, and become the more unwieldy for acquiring it. This is the true check against overgrowth. That animals of great bulk would break down by their own weight, is a position altogether untenable; for the supporting powers would increase with the weight. Indeed, antiquarians can shew remains of skeletons, which prove the world to have been inhabited by animals of stupendous bulk; and, in the ocean where food abounds in shoals, we find animals of vast, of incredible magnitude. That the middling size, however, by being more in the centre of objects, is the most advantageous, is sufficiently evidenced in man. Of all animals he is the least furnished with natural shield or weapon, but, in compensation, is endowed with the most sensitive surface, and underneath, as if lying in ambush, with the most efficient instrument of muscle and bone; so that, naked, delicate and vulnerable as he naturally is, he can control the hugest and the shaggiest of Nature's inferior productions; nor requires to put on a coat of mail, or a cuirass, unless when he has to encounter man, for then only his tactics are unavailing. The soft sensitive surface of man is therefore doubly subservient to intellectual improvement—indirectly from being so vulnerable as to render artificial measures of offence and defence so necessary—directly from that sensitive duty, to which we are mainly indebted for our acquaintance with the external world.

Touch, being mediately or immediately essential to animal motion, is less or more bestowed upon all animals, and most liberally upon man. Many of the lower animals have no other sense to direct their motions; and even man, when deaf and blind, must grope his way by means of touch; nor without it are the other senses in the slightest degree available; for neither the tongue, nor the nose, nor the ears, nor the eyes could, of themselves, have performed their respective duties in the animal economy, or even afforded intimation of materiality. A sapid body introduced into the mouth communicates a particular sensation to the nerves of taste; but without those of touch, with which the mouth is also furnished, there could not have been the slightest intimation that a substance was present; nor without the aid of this sense could it have been at all introduced. A fragrance may be enjoyed by the nerves of smell; but the organs of touch, whether lips or limbs, must search out the source of these grateful effluvia. Sound, having no natural similitude to impulse, could never have suggested it to the mind, or of itself communicated alarm; yet being always traceable to impulse, which is cognizable only by touch, must be indebted to this sense for all intepretations. Even vision, which penetrates far into space, and holds communication with other worlds, requires to have been under the tuition of touch, and is beholden to it for ascertaining the constituents of all the representative colours, that are ever crowding into the pupil. And where the eyes are wanting, there the hands with their increased sensibility become, for the ordinary purposes of life, almost a substitute for vision. Independent of touch, vision could never have guided a single movement. If we stood still, rays from surrounding objects would have continued to form their unmeaning, and almost unvarying picture upon the retina: if we ventured to move, the colours would have shifted, and the picture would have varied without the slightest reference to external existence. Mere sensations of colours, in all their variety within the eye, could never have suggested to the mind, that it was looking through a little optical instrument upon surrounding scenery, much less that the little coloured spots in the picture were the representatives of objects possessing length and breadth and thickness, some near, at the distance of inches, others remote, at the distance of millions of miles from the place of sensation. Human memory cannot revive upon its tablet the slightest vestige of the sensations of earliest infancy, or retrace the steps by which the eye became acquainted with the material world. But that information, which the imbecility of infant faculties seemed forever to preclude, has been afforded by disease. The crystalline lens, through which all the rays of vision must pass, and by which they are refracted, has before birth become opaque; so that up to adult age the light of day has been completely precluded. Long ere this the blind man was familiarly acquainted by means of touch with all the objects within his reach, but had not yet formed the conception of colour. By a nice surgical operation the opaque lens was removed—immediately all the pictures of surrounding objects were admitted into the eye. How the astonished man believed that every thing pressed upon his eye—how the eye could neither ascertain nor distinguish objects, even those with which, by means of touch, he had been familiar, but behooved to receive repeated lessons from the hands—have all been recorded; and the metaphysics of vision thus brought to the test of experiment; so that we have only now to wonder how the hands, from which we directly receive so many sensations, and by which vision has been so industriously trained for visual discernment, have received so little of our attention, and compelled so little of our admiration. We may remark with what assiduity the infant puts forth his hands to feel and to seize every thing within their reach; how, when the eyes are first directed to objects, he reaches as readily at those that are distant as at those that are near; how by and bye the eyes begin to discriminate near objects from distant; but long ere the mind can be capable of metaphysical enquiry, or can communicate the simplest idea, he has become familiarized with examining and discriminating objects without assistance from the hands—has insensibly arrived at optical principles without mathematical preliminaries. The education has been acquired; but the rudiments and lessons have passed into oblivion. So far indeed from tracing vision back to its elementary principles, the human mind, during that sprightly season of mere sensations, has seldom the leisure or the disposition to stir the more obvious question for what end itself and all the surrounding objects are designed. Were man, endowed with all the faculties of mature life, to start at once into existence, how astonished would he be at all this mysterious scenery, and how perplexed about himself, a conscious being, in the midst of it! But without reverting to our earliest sensations, or availing ourselves of the sudden restoration to sight of the man born blind, we can subject vision, as we now enjoy it, to a kind of metaphysical analysis. On deducting from the perception of an edifice, that arrangement of colours contributed by the eye, there remains a great supplement to be ascribed to the hands. On deducting from the more complex perception of an extensive landscape skirted by the distant horizon, all the seeming confusion of colours and shades lying on the same plane, as they are exhibited to the eye, there still remains an ample balance which must be placed to the credit of the hands. On looking upwards the eye can merely discern a multitude of coloured dots slowly and irregularly shifting about amongst each other—these confined within the compass of an eye are expanded by virtue of the hands into a vaulted canopy of stars. Although the hands have never reached these mighty orbs, nor ascertained their shapes, nor spanned their relative distances—although the hands have never traversed the extensive landscape, nor may ever touch the lofty summit that commands with majestic grandeur the whole surrounding scenery—although the hands may never even have slidden along the walls of the edifice, nor the fingers have poked into all the frieze and cornice with which it is ornamented;—yet by the hands have the eyes been tutored to compute from the apparent what must be the real. Of this the art of painting is a proof and illustration. Thus the eye acts in a double capacity—in its own, and in that of the hands; and whereas they of themselves must have calculated and measured by the tedious and laborious process of digits and cubits, the eye, thus instructed, can calculate with more than the rapidity of algebra, without the vexation of signs, and can measure with more than the accuracy of geometry, without the formidable array of implements, or the plaguy construction of diagrams. The eye, by the co-operation of touch, is endowed with instinctive mathematics, upon whose principles all our artificial mathematics have been reared. What indeed are all our boasted mathematics but imperfect notations of vision as instructed by touch, or rather of touch transferred to vision; since experience has taught that eyesight is by no means indispensable to the mathematician?

No wonder that the nervous papillae of a sense so radically important, so indispensable to animal and intellectual purposes, are so nicely constructed and so extensively, nay universally distributed over the body, and are crowded to such an exquisite degree on the most moveable organs, and, being from exposure liable to injuries, are gifted not only with self-reparation, but also, such is Nature's solicitude for the interests of mind, with self-reproduction, and, unlike the other senses, are seated in a part essential to life. Had perception depended upon the precarious tenure of ears, so liable from the intricacy of their mechanism to obstructions, and from the delicacy of their structure to inflammations, or of "sight, to such a tender ball as th' eye, confin'd, so obvious and so easy to be quench'd," both the animal and the intellectual economy, must have been in continual jeopardy. But the parent sense, which instructs all the others, and unites them into a harmonious co-operation for the benefit of the animal economy, and, in emergencies, can become a substitute for them all, by performing every necessary sensitive duty, is " through all parts diffused, that she" can " look at will through every pore."

Thus we find that touch is necessary to motion, and motion in its turn is necessary to touch, and both are necessary to intellectual purposes. An instrument of muscle and bone, well calculated for moving about and for performing evolutions, bespeaks a naturally enterprizing character, which however may fail to be successful, for cautious plodding too often gets the start of bold undertaking in this doubtful lottery of human affairs; nor does an aptitude of muscle and bone for achievement denote more than a natural tendency to enterprize, for the human character is most susceptible of transformation by moral discipline. From the limbs alone is deducible almost the whole zoography of any of the lower animals, whose bodily fitness and instinctive tendencies give a pertinacious uniformity to the movements. The ruling principle of the lower animals is self-preservation, whereby they prolong their own enjoyment of life, and keep themselves in existence for the use of man. He also has his bodily aptitudes and instinctive tendencies for the security of human life, but over and above all these is endowed and intrusted with mind, which is so alterable in its nature, so susceptible of improvement from proper moral cultivation, and of deterioration from indulgence in idleness or vice, and moreover so exposed from the structure of society to moral influence, as almost to supersede bodily tendencies—not however without acknowledging the body—not without leaving upon it an impress of the change—not without bringing about, as much as possible, an adaptation of the old natural body to the newly acquired moral character. To compute the force, the velocity, the extent, the variety of motion performable by this "high wrought matter," is little more than to compute the suitableness of the tools with which the man has to work. The contractile power of a muscle is partly seen in the force that is sometimes required to reduce a dislocated limb, is partly seen in the dreadful disease of tetanus, is partly seen in the bar of iron bending like a twig on an arm whose muscles have been braced into vigorous contraction; but the physical power of the human muscular system is best seen in the might to which it can be roused by moral incentives. The human mind under whose direction all this machinery acts, is that part of man, which renders the whole a feeble or a powerful, a mild or a terrific being. How fear paralyses the most athletic muscles—how hope and the love of glory inspire the feeble frame with mightiness! It is the spirit of man, like the general of the army, that leads the rank and file of muscles and bones to all that is wondrous and incredible in human exploit. To the exertion and perseverance of man, fired with zeal or intoxicated with enthusiasm, there is no barrier, and to his efficiency there is no limit but downright impossibility.

Man, however, though a powerful, is not naturally a destructive being. That instrument of muscle and bone, with which he can do so much, is covered over with a soft cushion, that his blows may not be deadly, and with a sensitive surface, that he may feel the smart of every blow which he inflicts. We now begin to see the muscles and bones to be no other than ministering agents to the sense of touch, and the whole human body to be a most sensitive instrument, whose chief duty is to furnish sensations to the mind. We now begin to perceive that this sensitive surface is the surest earnest of man's better feelings, and of his clearer intellect, and that the whole human body is truly an intellectual machine. Could such an experiment be made as to retain social intellectual man in all his natural asperity, and to prevent him from being smoothed by society, polished by civilization, and refined by education, we would perceive a being acting according to his bodily aptitudes, and moving about according to his instinctive propensities—we would see the animal part of man take the ascendency and lord it over the moral—we would find him, controlling the lower animals by superior address, become the grisly and the shaggy king of the forest, and would hear the hollow roaring of the lion give way to the more authoritative notes of a wild and half articulated vociferation. Natural man is indeed a rough slab, but of the finest texture, and of the most variegated hues, and susceptible of the highest polish. Left to Nature, the original roughness would increase until no eye could distinguish him from her coarse materials. But as marble by rubbing polishes marble, so man by social intercourse polishes man. Society, securely established upon a mutual dependence on one another for safety and subsistence, forms the basis of all those inestimable privileges which have raised human beings to such a high pitch of moral elevation, and which, by bringing the prospective faculty of the human mind into full play, have carried their speculations beyond the present transitory life into a boundless futurity.

THE HUMAN LEG AND FOOT.

The important distinction, already noticed, of the four extremities into locomotive and manual, is admissible only in virtue of a minor distinction of the two lower extremities into legs and feet—into legs for walking though not exclusively, and into feet for standing though not exclusively; for the legs co-operate in standing, and the feet in walking, and the whole body in both. The main principle of standing is to balance the centre of gravity within the base of support. Had the feet been exclusively devoted to standing, they would have been the better fitted for their duty the more they extended upon the ground: but as they are also intrusted with an active part of the step, whose due performance is incompatible with a lengthened base, so they are restricted to moderate dimensions; while a greater exertion to maintain the balance is devolved upon the body in general. The main principle of walking is to throw forward the centre of gravity, and then to stretch forth the two limbs successively to receive it. Standing and walking then are both performed upon the principle of balancing the centre of gravity within a base of support. The only difference is that in standing the centre of gravity must be accommodated to the stationary base; whereas in walking the base must be accommodated to the progressive centre of gravity. In order to underprop the progressive centre of gravity, the two limbs stretch alternately past each other, transferring the weight from limb to limb at every step—act the part, in short, of two moveable spokes. By the time the one spoke has made its turn upon the ground, the other is always in readiness to perform the part of a new spoke. Thus the two limbs possess all the virtue of a complete wheel. Some of the lowest animals have the body actually arranged in the form of a wheel revolving fairly upon its axis. In more advanced animality, where the mouth and senses are arranged into a front, and the whole body into a longitudinal form, revolution is quite inadmissible; and accordingly along the lower surface of the body moveable spokes are disposed, whose repetition of office gives them all the progressive virtue of the wheel, without the necessity of its revolution. The limbs of multipeds and of quadrupeds constitute a pair of wheels; whereas the two limbs of bipeds constitute but a single wheel, whose spokes, from their lateral arrangement, communicate a less or greater rocking from side to side, as they move successively along. In proportion as the step is sprightly, this lateral motion becomes evanescent. This successive bending and extending of the limb is performed from the hip joint, which must be viewed as the primary joint; while all the others, although highly important, are merely secondary—chiefly serve to accommodate the rest of the limb to the motions of the hip joint, but besides, are enabled from the arrangement of the foot, and from the rapid contraction of which the muscles are capable, to aid locomotion upon the principle of the spring. The sluggish walk is performed entirely upon the principle of the wheel:—the energetic walk and the run are performed upon the principle of both the wheel and the spring:—the leap is performed solely upon the principle of the spring. Some of the invertebral animals can move upon one principle, and others upon either; but quadrupeds and man can call the two principles, either separately or simultaneously, into action. There are two respects then in which the structure of the human lower limbs must be viewed—in respect of the body under which they are alternately bent and extended—and in respect of the ground upon which they have to rest, and from which to raise all the superincumbent weight. The limbs, in their capacity of stepping, have their centre of motion in the hip joint; and in their capacity of treading have their resting point in the heel, and their pivot in the tip of the great toe. As we proceed we shall find that the knee is supplementary to the hip joint, and that the ankle is subservient to the sole of the foot. Accordingly, although the principal muscles belonging to the foot are situated on the leg, in the same way as the principal muscles belonging to the leg are situated upon the trunk; yet, in general arrangement and in function there is a distinction into leg and foot, sufficient to warrant us in giving each a separate consideration. We must never, however, forget that leg and foot form one single instrument, whose parts are all accurately adapted to each other, and all co-operate in one duty. The whole limb indeed appears to proceed from the body in the manner of ramification. Accordingly, there is first a single thigh bone, then two leg bones, and beyond the cluster of bones called instep, five metatarsal bones and toes. In reptiles the ramification is more distinct; for the two leg bones both enter into the knee joint; and in the ankle joint the tibia joins with the astragal bone, and the fibula with the heel bone. Thus the human lower limb may, from analogy, be viewed as growing from the body in one stock, which first divides into two, and then subdivides into five. This ramification in the bones of the lower limb from its commencement to its termination, serves the double purpose of rendering the diffusion of impulse greatest, where the shock is strongest, and the whole instrument simple or complicated, just where simplicity or multiplicity of action is required. Besides this ramification in the bones of the human limb, there is also, from its commencement to its termination, a diminution in their length, in order to afford extent of motion, where extent is necessary, and alacrity, where alacrity is necessary. Ramification is not limited to limbs, but is the plan upon which blood-vessels and nerves are distributed throughout the body.

THE HUMAN FOOT.

The human foot itself can afford the only correct demonstration of its excellent mechanism. Drawings or paintings of the fresh bones held in conjunction by their natural ligaments, or of dried bones strung together by wires, conceal the best part of the mechanism. To represent the disjoined bones is to annul the mechanism —is indeed little better than to draw accurate and laborious sketches of the materials of a former fabric—reminds us of the novice represented in one of our Greek school books as carrying about with him some of the stones and mortar as a specimen of a house for sale. A drawing of the whole bones of the foot in their adaptation to each other must be a figure of unravellable complexity, a picture of confusion, requiring models for illustration of what was designed to be illustrative. To attempt a description of the foot without the bones would be a task more arduous than Euclid would have encountered had he proceeded in his demonstrations without diagrams. Of this, all anatomical writings bear ample testimony, for out of the whole of them, the best artist could not construct a figure that would approach to a caricature of the skeleton of the human foot. Mere description, so inadequate to convey an idea of a simple object, must come far short of conveying a correct idea of a structure so complicated as the human foot, and even though successful, would after all convey no clearer idea than could be at once gained, and more forcibly impressed on the mind, by an examination of the bones themselves. Such tedious, idle notations of the sizes, shapes, and connexions of the various bones as they obviously appear to the senses, have rendered osteology an uninviting, even a repulsive study. It is the mechanism that should be described, and the bones, separate or conjoined, just in so far as they form integral parts of that mechanism. All the various parts of a bone need not be minutely detailed for their own sake, but because they serve certain useful or indispensable purposes, and should be so described as that these purposes shall never for a moment be out of view. The uncouthness of the names, generally of Greek etymology, and taken from fanciful resemblances, although detrimental, is quite unavoidable, but present no insurmountable difficulty to an earnest, much less to an enthusiastic inquirer. The bones must have names, which, however simplified, shall continue technical so long as their prototypes are so little studied. The foot is a subject with which teacher and taught are alike unwilling to perplex themselves. Thus the demonstrator hurries over the bones of the foot, and at length the students congratulate one another that the dry subject of tarsus and metatarsus is now past for a season. So many bones, so small, and so irregular, are very tantalizing to the anatomist, for Nature has not confined herself to regular lines and surfaces, nor are her materials either rounded by compasses, or cornered by squares, or faced off by plummets. Nay, the direction commenced is continued or abandoned just as it suits her plan, and serves her purposes. How can an anatomist find bones so shapeless to be really shapely, how can he find a cluster so irregular to be most mathematically arranged; for that is the proposition, and this must be the demonstration!

We formerly found the cellular membrane condensed towards the surface into skin surrounding the whole body. Out of this pervading substance, all the inert materials within the body, membranes, ligaments, tendons, even cartilages and bones, seem also to be constituted. They are all, with the exception of the calcareous part of the bones, composed chiefly of gelatine or of albumen which are convertible substances. Indeed what is now bone was at an earlier period mere cartilage; nay, at a still earlier period the whole body was mere gelatine. Gelatine then is the original substance out of which the human body has been formed by that mysterious plastic power with which its vital organs, as second agents, have been endowed. On tracing this cellular membrane down to the bones, we find it condensed into periosteum covering them and closely adhering to their substance—we find this periosteum passing from one bone to another, and thus surrounding and enclosing the joining between the two bones—we find ligaments and tendons arising from the periosteum and the bones, and incorporated with both:—in short, we find the whole bones, ligaments and tendons to be curiously wrought into one inert instrument, of which the tendons are so many convenient handles by which the contractile muscles take their hold for the purposes of motion. That the pressure produced by the muscular action, may have caused the ossification of the original cartilages, is countenanced by tendons and ligaments becoming ossified from pressure, by the bones becoming hardened as life advances, by their continuing long soft in those children whose muscles are feeble and slack, by the largeness and hardness of the bones in those that are athletic, even in some women naturally slender, whose muscularity has been in a great measure superinduced by hard labour. Ossification, although it does not immediately depend upon pressure in individuals, may from that cause have been originally produced in the general—may have received that tendency which is transmitted along with propagation, and which proceeds even where the muscles fail to afford that pressure whence the tendency had originated. Whether this hypothesis be true or false, be thought plausible or absurd, it is certain that the cellular membrane terminates in periosteum and in capsular ligaments which are continuous with it, that all the accessory ligaments and the tendons are intimately connected with the periosteum, and with the bones from which they can scarcely be scraped after maceration and boiling, and that the tendons are quite separable from the muscles which lay hold of them without regard to the direction of their fibres. Bones, ligaments and tendons, then, must be viewed together in their formation of the inert part of that mechanism by which animal motions are performed. On opening those capsular ligaments by which the joinings of the bones are enclosed as in a purse, we find a glairy fluid for lubricating the articular surfaces of the bones, in order to make them slide more easily upon each other; and we find the articular surfaces themselves tipped with smooth polished cartilage, and so shaped as to allow all the necessary motion, and at the same time to gain all possible security. This mucilaginous fluid is secreted by glands and poured into the joint by their excretory ducts; so that the glands are safe from pressure but are in the way of receiving excitement to secretion by those very motions which require it. Dr. Paley, in his luminous work on Natural Theology, is of opinion that the cartilaginous covering on the articular surfaces "looks more like the plating with a different metal, than like the same metal kept in a different state by the action to which it is exposed." His great business is to shew that parts were expressly made for particular purposes, as if a designing cause would be better proved by a particular adaptation for a particular end, than by a general law whereby parts bring about their own adaptations. Wherever two bones move against each other, there we find gristly surfaces. Bones and bony processes which come into contact with each other in some skeletons, in others are separate; in the one case the surfaces are tipped with gristle, in the o her are covered with periosteum. If the two ends of a broken bone be allowed to move against each other they become both surmounted with gristle. No matter whether the articular surface be covered with new gristle or the calcareous substance of the bone be merely absorbed in consequence of pressure, still the rubbing together of the two bones produces cartilaginous surfaces, and in the case of natural joints, keeps the surfaces in a cartilaginous state. But not only is a joint formed by one bone rubbing against another, but also the configuration of the joint is by its very motions rendered suitable for them. When two surfaces work against each other with equal force or motion they shall be both plain, but when with unequal force or motion, the one which acts with the greater shall be convex

—the other which acts with the less shall be concave; in other words the articulating bone which works with the greater force or motion shall hollow out the other. Thus a bone which, from being unequally opposed, is liable to displacement, is so far secured against it by being lodged in a hollow, and so much farther by the retaining effect of the very muscles whose powerful or extensive motions would otherwise have been so apt to produce dislocation. The surface sustaining impulse or pressure is broadened by the very pressure or impulse sustained, and a greater depth of bone is thus broadened in proportion to the degree of pressure or impulse, so that the surfaces shall not only be sufficiently broad, but also sufficiently strong. Now the formation of gristly surfaces by the rubbing of one bone upon another is peculiar to animal bodies; but the configuration of the surfaces becomes adapted to the force and direction of the motion according to a mechanical law which obtains over all nature and art. That Nature thus conducts her operations, not by particular adjustments, but by general laws—nay, by laws no less than universal, could we view them thoroughly—so far from affording any legitimate argument for materialism, is rather calculated to exalt our ideas of creative power—that Power which created bones and all matter, and ordained the laws by which it shall assume order in the general, and symmetry in particular instances.

The human foot is an instrument of twenty-six bones, connected together by twenty-three complete joints, strengthened by ligaments extending from bone to bone, and still farther strengthened as well as moved by tendons running close along the general structure to be laid hold upon and drawn by contractile muscles situated partly on the foot itself, and principally on the leg where they have more room, more exemption from pressure, and more mechanical advantages. All these bones, joints, ligaments and tendons, together with their more important muscular appendages, are useful not only in emergencies, but also in every step which the foot performs, and in every position which it assumes. A piece of wood supplying the place of all this apparatus, may as an apex to a triangle whereof the other foot is the base, suffice for standing, or as a resting and turning point may, at great muscular expense, suffice for walking; indeed mere standing and stepping may, in virtue of the balancing powers of the rest of the body, be performed upon two pieces of wood instead of feet, or upon two stumps, nay, may be accomplished without limbs at all, but such standing and stepping would ill serve the purposes of an indolent, much less of an active life. The human feet are not merely designed for supporting and carrying forward the body upon plain ground, but for taking the sure station upon the most precarious footing, and for pursuing the indefatigable journey over the roughest surfaces of Nature. Unlike the best artificial foot that human ingenuity can devise or human art can construct, the natural foot improves by use to an indefinite degree. Human feet, although they are all constructed of the same materials, and upon the same plan, and for the same definite function, yet present as great variety as human faces. But the variety in the external appearance is not to be compared with the marked variety in those articular surfaces which work against each other during a long life. A surface that in one foot is nearly plain, in another rubs itself into a convexity, or is rubbed into a concavity. What serves much to conceal the difference of human feet is their accurate adaptation to the character of their possessor. Where the feet are naturally of a flimsy structure, and disqualified for the arduous journey, there the character is nowise enterprizing, nor the mind troubled with longings to roam over the extensive regions of the earth. A man whose limbs are sound, and who is actuated by no other but his own natural bias, has seldom true cause to complain that his spirit is willing but his flesh is weak. Thus no feet can be called bad when viewed in relation to their possessor or to their giver. The most awkward feet may readily accomplish all the duty to which they are spontaneously called by the spirit of him to whom they belong, but would soon fail on the regular march, and loiter on the perscribed journey. To walk is one thing—to walk well is another. The feet of all animals, from the zoophite which must be watched ere its locomotion can be perceived, to the deer which puts the promptest of the senses at defiance; from that being who can with difficulty waddle through his little domestic round, to the hardy traveller whose route is fit to be sketched on the map of the world, are all suitable to the respective individuals whose subservient instruments they are, and therefore must be all considered perfect in their kind. Men only who have the feet of a Park will venture over the dreary deserts of Africa, or the feet of a Kinneer will traverse the extensive regions of Asia, or the feet of a Humboldt will set out to explore the boundless wilds of America. A Johnson may from his closet be conveyed round the Hebrides, without either limbs or spirit for rightly examining these remarkable islands, or for estimating the character of its more interesting inhabitants. The supine listless charioteer may detail his equipage and accommodation, may divert us about postillions and landlords, about caravans and caravansaries, may relate the heights and hollows and habitations visible from the vehicle upon which he lolls; but it is only the pedestrian, the able and indefatigable pedestrian, who is able to penetrate through woods and thickets, to pass defiles, and to trace out the windings of rivers and glens, and to scale mountains of everlasting snow, whence he may take a copy of Nature's map stretching beneath and around him, who can extend the boundaries of geography, or enlarge our knowledge of human character. It is in such a traveller, and after such journeying that the human foot can be seen in all its surpassing mechanism. In the structure of such a foot, the best mechanician that ever pondered or practised mechanical powers, may be defied to suggest an alteration that could prove in the slightest degree advantageous, that would not prove decidedly detrimental, either to motion or to security. The human foot is perhaps the best argument in the whole volume of Nature for proving a design, and of course a designer, and for this simple reason that here we can best apply the test of mathematics, the surest of all our sciences. But while we measure the workmanship of Nature by our scanty knowledge of the grand science of lines and surfaces, let us recollect that beyond the mere mechanism of the foot, there is a vitality—there is a contractility—there is a sensibility—there is a presiding intellect, which neither man nor his boasted mathematics can pretend to explain, or about which he can arrange one single thought, or has ever broached a single hypothesis, which when stripped of technical terms and reduced to the plain words of common sense, has conveyed the semblance of a meaning.

The foot has the same general arrangement of bones as the hands; both have a cluster of bones behind; both have five longitudinal bones in the middle; both have five moveable members before. But whereas the bones of the instep extend to about the middle of the foot, those of the wrist constitute little more than a fifth of the hand; and whereas the fingers constitute about the half of the hand, the toes scarcely exceed a fifth of the foot; while the five metacarpal bones extending between the wrist and the fingers are nearly equal to the five metatarsal extending between the instep and the toes. Thus the difference between foot and hand lies in the extreme parts, just as the difference of limbs in general lies in the thigh and foot; while the tibia and fibula in the middle are comparatively uniform in all animals. On inspecting the skeleton of the foot this transverse division readily suggests itself as the easiest for the memory, and is therefore adopted by all descriptive anatomists. But the facility and distinctness which this division at first sight promises, turns out to be delusive; for the seven bones of the instep, viewed in connection, present an intricacy which perplexes description, and renders distinctness impracticable—form a circle of bones and articulations, which puzzles one at what point to commence, and in what direction to proceed. The bones and joints may be all described in any order or succession, for what difficulty can any person find in writing down what he sees, but those of the foot as a cluster he cannot describe so as to exhibit a distinct or even a correct idea of the mechanism, much less to make a lasting impression on the memory. The parallelism of the metatarsal bones and toes gives them a distinctness which but ill atones for the confusion which this arrangement leaves in the instep behind. Our best plan in description is to follow that order which Nature has adopted in her construction. Let us therefore revert to the ramification already noticed, which we fonnd to be so distinct in the simple foot of the reptile, and still traceable in the more complicated foot of man. Viewing the heel bone then as proceeding from the fibula and the astragal as proceeding from the tibia, we have the foot proceeding from the ankle in two longitudinal divisions. The outer division, consisting of the heel bone, of the cuboid bone, and of the two outer metatarsal bones and toes, is the first to rest upon the ground in every step of walking. The inner division, consisting of the astragal bone, of the scaphoid bone, of the three cuneiform bones, and of the three inner metatarsal bones and toes, is the first to receive the superincumbent load, and the last to raise it from the ground. Thus the apparently complex cluster of bones composing the human foot, becomes simplified by a natural division into two longitudinal rows—into an outer, extending from the heel to the two external toes, into an inner, extending from the astragal bone to the three internal toes. But although these two divisions are traceable in the human foot, and demonstrable from comparative anatomy; yet they are closely united into one compact instrument, the foot, and intimately co-efficient in one indivisible function, the step.

The heel bone extends from the posterior part of the tuberosity, forward to the junction with the cuboid bone, along nearly one third of the whole length of the foot, and is by far the largest of the eight and twenty bones of which it is composed. The tuberosity, at its posterior, inferior, and exterior side, projects downwards into a bump, which is the first to reach the ground, in every step of walking; and at the posterior and superior part, gives attachment to the strong tendon of Achilles, ascending into the calf of the leg. The farther this tuberosity juts backwards, the better is the animal calculated for bounding, which seems to be the principal purpose served by it in quadrupeds. In man, however, it serves the double purpose of a resting point, and of a lever. The advantage of this tuberosity as a resting point, may be seen in the firmness, and composure of the human walk, so unlike the tottering, bouncing step of that best of other bipeds, the ourang-outang, whose heel does not fairly rest upon the ground, and in the greater steadiness and ease of the human walk when the heels are regularly pitched upon the ground, than when the step is performed entirely upon the fore part of the foot. The advantage of this tuberosity as a lever, shall be more fully shown when the calf of the leg comes under discussion; but, in the mean time, may be strikingly seen in the frequent rupture of the strong tendon of Achilles, by dancing, and other exertions, when the person instantly falls to the ground, and continues unable to perform the slightest walk, until the tendon has had time and opportunity to re-unite. In tracing the heel bone forward, we find upon its inner and anterior part, two articular surfaces, facing obliquely forwards, inwards, and upwards, constituting a seat for the astragal bone, and seeming as if they had been formed by its pressure. The anterior of these two surfaces, which is concave, is separated from the posterior which is convex, by a deep, rough groove, whence a strong ligament passes to a corresponding groove of the astragal bone. Were the astragal bone of the human foot to bear directly upon the ground, instead of being thus hoisted upon the heel bone, the fibula would then, as in the reptile, come into complete contact and articulation with the heel bone. Instead of making each of the hind bones of the foot to articulate with the leg, and to bear upon the ground, nature has, in man more completely than in any other animal, instituted a division of labour, by committing the office of bearing upon the ground, to the one bone, and the office of articulating with the leg, to the other; so that the astragal bone is made to ride upon the heel bone. Passing for the present forwards, and outwards from these two inner articular surfaçes upon which the astragal bone leans, we come to an anterior articular surface facing obliquely forwards, outwards, and downwards, so as to be supported from falling downwards, and guarded from starting outwards by the cuboid bone, whose hind articular surface faces obliquely backwards, inwards, and upwards. Indeed this articular surface of the heel bone is, at the lower and inner part, scooped away for the reception of the lower and inner corner of the cuboid bone, stretching backwards in a peak. Thus the heel bone rising upwards, and forwards, from its narrow resting point behind, bears downwards, and outwards upon the cuboid bone, at the outer side, and is borne upon downwards, and inwards by the astragal bone, at the inner side—at once receives and gives support, upon the very plan of the hanging stairs of modern invention. These two articulating surfaces of the cuboid, and heel bones, as they lie adapted to each other, are waved in the transverse direction, in resemblance of the letter S, and are curved downwards, and a little inwards, in resemblance of the letter C—in other words, the articulating surface of the heel bone presents, in the transverse direction, two ridges, and one hollow, for the reception of the two hollows, and the one ridge, on the articulating surface of the cuboid bone; so that lateral shifting between the two surfaces is most effectually prevented: again, the articulating surface of the heel bone presents a single convexity running obliquely downwards, and inwards, for the reception of the single concavity on the articulating surface of the cuboid bone; so that the two surfaces are freely allowed to move against each other in that oblique direction—the very direction in which the foot, in treading, yields to superincumbent pressure.

The cuboid bone, having thus articulated by its posterior surface, with the anterior surface of the heel bone, and having also, at the posterior and upper part of its inner side, articulated with the outmost of the three cuneiform bones, and occasionally with the outer edge of the scaphoid bone, when it happens to be within the reach of friction, at last receives on its anterior surface, the ends of the two external metatarsal bones, into one articulation. This is the joint in which the outer division of the foot branches into two; affording a specimen of that ramification upon which the arrangement of the foot into two longitudinal divisions, is founded. The fore end of the cuboid bone, although one uninterrupted articular surface, presents two different facets—the inner facing right forward, and having a slight degree of concavity in the vertical direction, and a slight degree of convexity in the transverse, for the reception of the metatarsal surface, which is vertically convex, and transversely concave—the outer facing forward, and a little outward, and having a slight, and rather irregular convexity for the reception of the other metatarsal surface which has, correspondently, an irregular concavity. Thus the inner of the two metatarsal bones has a vertical motion upon the cuboid bone, and would also have had a lateral, but for the other metatarsal bone, which on its part, being the outermost in the range, has, like the innermost, a very slight motion in all directions. This outermost metatarsal bone, from the lower edge of its articular surface stretching a little backwards, gives a degree of support to the cuboid bone, and from the general direction of the surface being a little inward, prevents that bone from starting outwards; while the outer edge of the foot is effectually strengthened by an *important* muscle, in its course from the heel, along the outer edge of the foot, to the small toe, laying hold, by means of a tendon, on that point which projects from the outer side of the root of this outermost metatarsal bone.

These two outermost metatarsal bones, in their conjoint articulation with the cuboid bone, articulate also with one another at the posterior and upper part of their interjoining surfaces. The internal of the two articulates with that on its inner side by a distinct joint, into which the corner of the external cuneiform also is sometimes admitted. This already is the second instance of extra-regular articulation from an unexpected attrition between two bones. On taking a comparative view of all the five metatarsal bones, we find that the depth, or perpendicular measurement of their articulations with the tarsus, gradually diminishes towards the outside of the foot; so that the roots of the two outermost metatarsal bones have the smallest vertical measurement, and the outer of the two has the smallest of all. Not only the roots, but also the bodies of the metatarsal bones become thinner towards the outer edge of the foot. These two outermost metatarsal bones, as if by habitual pressure, are not only thinned, but also broadened; and the outer of the two is the more thinned, and the more broadened. These two metatarsal bones terminate before in round knobs articulating respectively with the two outermost toes; but are not of the same length, for the outer is the shorter of the two. Indeed the metatarsal bones are successively longer from the outermost to the second innermost, whose knob is generally in the same transverse line with the ball of the great toe, as a coadjutor to that important point upon which so much stress is devolved.

Thus we have traced the outer division in so far as it enters into the body of the foot, reserving the two toes terminating the series, for a separate consideration. These four bones—heel, cuboid, and two metatarsal—form a small arch, resting behind, upon the bump descending from the tuberosity of the heel, and before, upon the anterior knobs of the two outermost metatarsal bones. This arch is not straight, but runs forward in a curve, whose concavity faces outwards, and whose convexity is connected by articulations, and ligaments, and even by tendons, with the inner division of the foot. Thus the two articulations—the one between the cuboid and heel bones, the other between the cuboid and metatarsal bones—lie to the inner side of a straight line extending between the posterior and anterior points of support. This arch, from its general shape, and from the configuration of its two joints, does not, under superincumbent pressure, yield perpendicularly towards the ground; but obliquely downwards and inwards. Under considerable pressure that point of bone projecting outwards, backwards, and a little downwards from the root of the outermost metatarsal bone, and giving fixture to the tendon of a muscle running along the outer edge of the foot, comes to bear upon the ground. In this outer division of the foot, then, there are three resting places—one behind, one before, and one, when necessary, in the middle. This middle point of support, on reaching the ground, helps to direct the farther yielding of the arch a little inwards, as well as downwards. Of the arch, and of the lateral curvature, into both of which these four bones are arranged, the cuboid is the double key-stone, and is so supported, so borne down, so pressed out, and so hemmed in—in short, lies so wedged between the adjoining bones, as, while affording secure fixture to them, to be itself by them so effectually fixed, that nothing short of a breaking up of the whole structure of the foot, can produce displacement.

Having thus traced the outer division of the foot from the heel to the roots of the two outermost toes, we must now return to the hind part of the foot, for the purpose of tracing its inner division from the astragal bone to the roots of the three innermost toes. That upper articular surface of the astragal bone, (the only articular surface to be seen in the conjoined bones of the foot,) elevated considerably above the general level of the back of the foot, and entering, in the complete skeleton, into articulation with the bones of the leg, must be reserved for the account to be afterwards given of the ankle joint. It is sufficient, in the mean time, to know that the tibia bears and rolls upon this surface. The astragal bone, by its lower part, articulates with the two articular surfaces situated on the inner, and anterior part of the heel bone, and by its fore part, with the hind articular surface of the scaphoid bone, in such a manner as to form two joints—one behind with the heel bone alone, another before with both the heel and scaphoid bones. These two important joints, by which the weight of the body, and whatever it may be carrying, is delivered over to the other bones of the foot, are situated considerably before the resting point of the heel, more especially at that juncture, when it is pitched forward in the taking of a new step: thus the impulse is lessened, and the centre of gravity is kept considerably within the circumference of the base, and a lever is afforded to those principal muscles of the foot, which compose the calf of the leg. One is at first sight apt to wonder how the astragal bone with all its load and impulse, can have so secure a seat, in a place so apparently precarious, as the inner side of the heel bone. But this wonder is converted into admiration, as the plan of articulation, and the line of motion between the two bones, become properly understood. The anterior of the two articular surfaces of the heel bone, extending from the inner margin of the articulation with the cuboid bone, inwards, backwards, and downwards, in a concave sweep, and the posterior passing from about the middle of the heel bone, inwards, forwards, and downwards, in a direction nearly straight, and in a shape nearly cylindrical, converge towards the lateral, or internal process, which, above, is tied by a strong ligament to the inner side of the astragal bone, and, below, is supported, by the tendon of the powerful flexor of the great toe, and by the tendon of the less powerful flexor of the other toes. Upon these two converging articular surfaces of the heel bone, as upon a side-saddle, of which the internal process, and the ligament ascending from it, may be considered the horn, the astragal bone rides with a sure seat. As the bones of the leg bear down upon the astragal bone, right above its hind articulation with the heel bone; so it is in this posterior joint, that the arched concavity of the astragal bone rocks from side to side, upon the cylindrical surface of the heel bone; whereas in the anterior joint, the articular surfaces merely shift, in accommodation to the rocking performed in the joint behind. Thus while the hind articular surface of the astragal bone rolls inwards, its fore articular surface must move outwards, so that the centre of the motion between the two bones, is situated in the ligament, ascending from the internal process of the heel bone to the inner side of the astragal bone. The direction of motion, which however, is very limited, is, therefore, curvilinear, round the point of the lateral process, and, although difficult to be described upon paper, is easily demonstrable upon the bones. These two articular surfaces of the heel bone, as they are jointed with a single bone, require both to have the same inclination for the sake of motion; and accordingly present two slopes, inclining obliquely forward, inward, and downward, along which the astragal bone, bearing down with the superincumbent weight of the body, and of additional loads, would descend with full force against the posterior concavity of the scaphoid bone, nor, under the loads and shocks to which the human foot is subjected, could be restrained by all the ligaments, for which room could be found, from forcing its way down throngh the structure of the foot. Mark the beautiful simplicity of Nature's consummate mechanics. Although the two surfaces have the same inclination, for the sake of motion, yet the anterior has a higher level, and a concavity frum side to side, while the posterior has a lower level, and a convexity in that direction. Thus the astragal bone is enabled to move upon a smooth, lubricated slope, without the risk of sliding downwards, forwards, and inwards, along the declivity. Between the two joints a powerful ligament crosses from bone to bone, not for the purpose of assisting to prevent the descent of the astragal bone, for which all ligaments would be utterly unavailing, but for holding the articular surfaces of the two bones in close adaptation, that the double check of opposite curvatures, and different levels, in the two articulations, may have full and constant effect. But this converseness of curvature, and this difference of level in the articular surfaces, offer no hindrance to the slipping of the astragal bone, in the line of motion, backwards, downwards, and inwards. Against this occurrence the tendon of the powerful flexor of the great toe, passing through a gristly and ligamentous groove, close upon the two bones, by the inner side of their hind articulation, offers an active check, more especially at that critical period, when the leg is bent forward upon the foot; for then the tendon is completely on the stretch. Thus the astragal bone, although it articulates with two bones—with the heel bone behind, and with the heel and scaphoid bones before, and seems, at first sight, to be poised between the two, yet bears with main stress upon the heel bone. This is demonstrable both from the double articulation with the heel bone, and also from the anterior of its two articulating surfaces having a different degree of concavity, from that posterior articular surface of the scaphoid bone which enters into the same joint. Thus the anterior articular surface of the astragal bone is by no means "a large round head, as regular as the head of the shoulder bone," as Mr. John Bell, Surgeon in Edinburgh, in his work on anatomy, has represented; but on the contrary, presents two facets, one less regular, and less rounded, for moving restrainedly upon the heel bone, the other more smooth, and more rounded, for playing more freely in the scaphoid cavity. It is here worthy of remark, that the heel, and scaphoid bones meet for the purpose of forming between them the socket for the anterior head of the astragal bone, exactly in a transverse line with the articulation between the heel, and cuboid bones, already described in the outer division of the foot. This then is the transverse line in which the foot gives the greatest yielding to superincumbent pressure, and is the only line in which joints traverse directly across the foot.

Thus another division of the foot is suggested into the astragal, and heel bones behind, which, in stepping, receive the weight from the other foot, and into all the other bones before, which, in their turn, receive this weight and deliver it to the other foot, in taking a new step.

The scaphoid bone, the inferior edge of whose hind articular concavity is bound by ligament, and held by the powerful grasp of the tendon of the hind tibial muscle, to the edge of the fore and inner articular surface of the heel bone, for the purpose of forming a socket for the anterior articular termination of the astragal bone, is the continuation of the inner division of the foot; and lying obliquely with its upper edge on a level with the back of the foot, and its lower edge on a level with the sole of the foot, presents its posterior articular concavity a little upwards, as well as backwards, for the reception of the anterior articular head of the astragal bone, which, from its seat upon the inner border of the heel bone, stretches downwards, as well as forwards into the scaphoid receptacle. This scaphoid bone, so named from its fancied resemblance to a boat, has been likened by Mr. John Bell, " to the dies with which we play at draughts;" but the dice used in the game of backgammon have no resemblance whatever either in size or shape, to the scaphoid bone; and the pieces used in both the games of backgammon and draughts, have no resemblance whatever in shape, though some out of the great variety, may approximate in size to this bone. It must indeed be confessed that these games can be played with scaphoid bones, as pieces, but can also be played with astragal or heel bones, or even, provided the board be large enough, with whole feet, which, by the bye, would give a more lively representation of contending armies, than turned pieces of wood. Being convex before, concave behind, and elliptical round about, the scaphoid bone actually bears a similitude to a boat in miniature, inclining obliquely on one side, with the prow dipping towards the inner edge of the foot, and the stern emerging in the back of the foot. But in thus vindicating the venerable, ancient anatomists, against the aspersions of this modern, who seems to delight in traducing, without troubling himself much with the perusal of their honest labours, we must beware of involving a subject naturally complex in farther artificial complexity.

Having thus found fault with the ancient anatomists, for comparing this bone with a boat, and having substituted a new comparison of his own, he seems to feel himself called upon, to make it appear good; and in labouring to make facts bend to this false pre-conceived comparison, he in most direct terms, contradicts himself, by first saying that the bone "is a flattened circular body," and that "each flat side forms an articulating surface," and in the very next sentence regardlessly adding that the "*concave* side which looks backwards is *pretty deep*," and that "the flat side which looks forwards has not so *deep* a socket." The truth is, there is no substance either artificial or natural, with which this bone can be compared, just because there is no substance which serves exactly the same purpose. The scaphoid bone, in short, is neither more nor less than an intermediate agent between the astragal bone behind, and the three cuneiform bones before, and serves the purpose of commuting their treble surface into a single, for the sake of simplifying the connexions, otherwise sufficiently complicated, of the astragal bone bearing down with so much weight and impulse upon the other bones of the foot. It is from the anterior surface of the scaphoid bone, therefore, that the inner division of the foot ramifies into three; but the three branches being of unequal strength, and acting with different forces, have formed upon the scaphoid bone three different facets, in virtue of which they are retained more steadily in their respective places. The difference of the three facets elucidates the law already noticed, that the motions of the bones produce the configuration of their joints. Thus the internal facet against which the cuneiform bone belonging to the great toe moves, is the most convex; the middle facet is slightly rounded; the external is nearly plane. Where the structure of the foot is very compact, the outer edge of the scaphoid bone rubs upon the cuboid, and, of course, articulates with it. This occasional articulation being the more distinct and extensive, the more the bones are arched and compact, may be held as a sure test of a good foot, but being hidden from observation during life, can be instructive only in posthumous physiognomy.

The three cuneiform bones are so named

from the wedge, which, however, only two of them properly resemble. They are articulated with one another behind, by joints communicating with that common joint by which all the three are received upon the convex front of the scaphoid bone, and are also connected with one another by ligaments passing between the rest of their contiguous surfaces. The outside of the outermost cuneiform bone articulates, as formerly noticed, with the inside of the cuboid, by the hinder and upper triangular half of their interjoining surfaces. As all the three cuneiform bones are of unequal lengths, the innermost upon which the metatarsal bone of the great toe is jointed being longest, the middle being shortest, and the outermost being intermediate; so the middle of the three correspondent metatarsal bones comes to be articulated with all the three cuneiform bones, into which it is in a manner dovetailed. Thus all the three cuneiform bones articulate with the roots of the middle and outermost of the three metatarsal bones by one common joint before, which communicates, through the medium of the articulation between the innermost and adjoining cuneiform bones, with the scaphoid joint behind; but the innermost cuneiform articulates by a distinct joint with the innermost metatarsal bone.

The two outer of these three innermost metatarsal bones, in articulating with the three cuneiform, articulate also with each other; and the outer of the two articulates by a separate joint, as already mentioned, with the inner of the two outermost metatarsal bones; but the innermost metatarsal bone proceeds from the innermost cuneiform, without acknowledging any articular relation to the other metatarsal bones, just as the metacarpal bone of the thumb refuses, as we shall afterwards find, to articulate with the metacarpal bones of the fingers. Although the great toe does not act in opposition to the other toes, (as the thumb does to the fingers,) but actually co-operates with them; yet the same plan of ramification is adopted in the foot as in the hand, without detriment to the functions of either. Indeed the great toe may be said to oppose the other toes as much as that unyielding surface which they all endeavour, as it were to grasp, will permit; nay, in those feet which have been trained to perform manual duty, the great toe assumes the opposing office of a thumb; and so similar to thumbs are the great toes of apes, that their whole tribe has been denominated four-handed. In nearly the same manner as the two outermost metatarsal bones, articulate with the cuboid bone, do we find the two successive metatarsal bones articulate with their respective cuneiform bones, but with a more complete interlocking between the tarsal and metatarsal surfaces, and with a jutting backward of the external articular margin of the middle metatarsal bone, and a proportional falling backward of the correspondent margin of the middle cuneiform, for the sake of rendering good the hold which that important bone, the innermost cuneiform, has, both by articulation and ligament, upon this second metatarsal bone. Thus, the innermost metatarsal bone, which may be considered the main branch of the three, even the continuation of the stock of the limb, has a distinct and a peculiar articulation with a bone that is not only large, but is also strengthened by both a tarsal and a metatarsal connexion. The articulation of the great metatarsal bone with the great cuneiform, must admit of motion downward and inward, but requires to be guarded against the possibility of rolling outward. Accordingly the large cuneiform bone presents on its anterior surface a ridge running vertically, which is secured in a correspondent groove on the posterior surface of the large metatarsal bone, so that vertical motion between the two bones is allowed: but the articular margin of the metatarsal bone juts backwards at its inner and upper corner, and at its lower and outer corner, so that the metatarsal bone, while it is allowed to roll inward as far as the ground, the adjoining metatarsal bone, the ligaments, and the nature of the joint will allow, is effectually prevented from rolling outward. These three innermost metatarsal bones, after stretching forward terminate in knobs which articulate with the roots of their three toes respectively. Of these three bones, the outermost is the smallest, the middle is the longest, the innermost is the largest, and although at the same time the shortest, yet from articulating with the greatest of the three cuneiform bones, extends as far forward as the second metatarsal bone, and farther than the third.

Thus we have traced the inner division of the foot from the astragal bone behind, jointing with the leg and especially with the tibia, to the knobs of the three innermost metatarsal bones before, jointing with their three respective toes. This inner division consisting first of single bones in succession, then dividing into three articulated bones, then into three distinct bones, and ultimately into three distinct members, spreads a little as it proceeds, and is attached on its outer side by articulations and ligaments and tendons to the outer division of the foot. This division spreading as it proceeds forward, and having its inner edge straight, must have its outer edge curved, in adaptation to the inner edge of the outer division. But having served our purpose with the division into two longitudinal rows, we must now view the whole twelve bones as intimately connected together by articulations and ligaments into the formation of the body of the foot.

Of these twelve bones composing the body of the human foot, the seven tarsal behind form a circle or ring of bones and joints, from whose front the five metatarsal bones proceed in a slightly divergent direction to the roots of the toes. This ring does not lie horizontally, but has the inner side elevated above the outer, as if at the hind part of the foot, the inner division had been twisted over the outer. Had there been only one tarsal bone in front of the astragal bone on the inner side, as is the case in front of the heel bone on the outer side, then the circle would have been distinct. On viewing the scaphoid bone in its proper light of an intermediate bone between the astragal and the three cuneiform bones, and them in their intimate articulation with one another, and with the scaphoid bone by one common joint, we then come to see the instep arranged virtually into a circle of bones, and actually into a circle of articulations. The accuracy of this view becomes evident on examining that centre where the tarsal bones are held by ligament in their circular arrangement. The heel bone from behind, the cuboid bone from the outer side, and the scaphoid, as representative of itself, and of the three cuneiform, from the inner side, present towards each other three vertical edges, which are powerfully bound together by ligament. The heel bone presents to this central bond that edge which divides its anterior articular surface from the anterior of its two lateral articular surfaces;

the cuboid bone presents that edge which divides its posterior articular surface from its lateral; the scaphoid bone presents that edge which divides its only two articular surfaces, posterior and anterior from one another By this fixture of the edge of the heel bone it is maintained in its position, and qualified to uphold the astragal; by the fixture of the edge of the cuboid it is held in its place, and enabled to support the two outermost metatarsal bones; by the fixture of the edge of the scaphoid, it is kept in its situation and rendered capable of sustaining the three cuneiform, and three innermost metatarsal bones: but as if the scaphoid bone, even with such a firm fixture were insufficient for so great a charge, the posterior and outer edge of the outermost cuneiform is, by means of a thin auxiliary ligament fastened directly to the centre. By this central connexion of three principal bones of the instep into a triad, the structure of the foot is as firmly supported as if all the bones had been bound to the most stable central pillar. The astragal bone, although it fills a niche in the circle of the instep, tends to break down, rather than support its structure, and is consequently excluded from a participation in the central bond. Of that circle into which the instep is arranged, this threefold ligament is the centre—of that arch into which the whole bones composing the body of the foot are arranged, this threefold ligament, and not a bone, must be viewed as the keystone. This central fixture, as if the principles of astronomy were brought down to the human foot, acts the part of centrepetal, against the centrifugal force of all the weights and impulses to which the human foot is continually subjected.

The instep at first sight appears to be a bone broken to pieces, in such a manner as the average of shocks would have shattered a solid tarsus, for its joints are situated in those very spots where the impulse would have spent itself in rents, had they not been anticipated by diffusive joints. The whole twelve bones composing the body of the human foot are all so firmly jointed together that their aggregate latitude of motions amounts to little more than an elasticity, which serves the double purpose of giving a spring to the step, and a diffusion to shocks. The better to serve this double purpose, as well as to afford a safe lodgement to nerves, vessels, muscles, and tendons, these twelve bones are constructed into an arched form, not into one single arch, composed of regular wedges as masons would construct a motionless bridge, but of materials of which two pieces are not alike, and only two have the form of the wedge, and into an irregular arcade consisting, according to mathematical strictness, of as many simple arches as lines can be drawn through a dome–as there are points in the compass. This arcade upon its inner and elevated border sustains the weight and impulse of the body, and by its posterior, outer and anterior margin, rests upon the ground. The two terminations of this resting line, the tuberosity of the heel behind, and the ball of the great toe before, constitute the two principal resting points. As the astragal bone and its articulations lie to the inner side of a straight line extending from the tuberosity of the heel to the ball of the great toe, so superincumbent pressure in tending to flatten the arch, must give an inward spreading to the foot. It is worthy of remark, that the outer division of the foot gives the principal resting point behind, and the inner gives the principal resting point before. The utility of this arrangement shall be adverted to, when we come to speak of the great toe. From the lateral expansion of the foot, under superincumbent pressure, the bones have formed lateral articulations with each other. As the force to which the arch yields, proceeds immediately from the resistance of the ground, so by superincumbent pressure, the sides of the bones are separated below, and pressed together above; hence, the lateral articulations are generally situated in the upper part of the interjoining surfaces, and ligamentous binding occupy their lower part. Here we find a virtue made out of a necessity, for mere articulations would have been quite inadequate to support these lateral motions, since none of the tendons run directly across the foot, and only some of them obliquely. But the fore and hind surfaces moving more freely and more powerfully against each other, and being traversed both above and below by the tendons of powerful muscles, are articular from side to side, and from top to bottom. Besides capsular ligaments holding the articular surfaces together, and ligaments crossing between the contiguous surfaces, we find additional ligaments traversing in every direction and complication from bone to bone over the general structure, and strong and numerous ligamentous sheaths, passing along the sole, and the great plantar ligament extending from the one extremity of the arch to the other,—in short, the joints of the foot are held together by as many, and as strong ligaments, as the motions and the organs of motion can admit. But the tendons passing from the toes along the foot, and from the different bones of the foot itself, to be laid hold upon and pulled by muscles, especially by those situated on the leg, are at once the grand instruments of motion and of security to the joints of the foot.

The bony structure of the foot held together by the strongest possible inert binding, must have held the bones either too tightly for the diffusion of impulse, or too slackly for long maintaining their arrangement, nor would the most powerful ligamentous fastening have failed to become more slackened by every step, or the whole structure to be driven more and more asunder by every shock. But nature secures her joints by an active binding, which no art can imitate, and whose want no human ingenuity can supply. Let mechanicians lay aside the presumptuous task of rearing a whole automaton, and try to construct with all their mechanical skill, and with all their implements and materials of art, a foot that shall admit of, not to say perform, motion, and withstand shocks, like the human; and while engaged in the vain endeavour to imitate nature in her construction of the most mechanical part of the lowest organ in the body, let them remember that the materials and the implements, of whose inherent qualities they avail themselves, are the former constructions of nature, and that the very agency and ingenuity by dint of which they would accomplish the rivalship, are also her own production.

Inert ligaments have often of themselves held the motionless skeleton together for ages, and even during active life often go far in resisting dislocations; but to maintain the numberless bones and joints in their proper places, amid all the extensive movements, and vigorous exertions, and violent struggles to which the human body is subjected, the same kind of mechanism is employed—nay, the very same instruments by which these movements, and exertions, and struggles are themselves accomplished. The muscle in the very performance of the movement, dangerous to the joint, embraces and strengthens it against the risk incurred. Muscles then are at once the agents by which joints are moved, and the principal binding by which they are secured. The joints of the foot, more than any other joints in the body, are indebted to muscular action for their security. In preparation for receiving a shock, the muscles render the foot as arched as possible; and thus the joints are prepared to yield as far as the latitude of their motions will permit. There is no muscular apparatus peculiarly devoted to these joints, but all the mucles whose tendons are fixed into the foot for the purpose of moving the ankle joint, or pass along from the toes for the purpose of moving their joints also, and all the muscles which arise from the foot itself and receive tendons from the toes are subservient not only to this diffusive elasticity and to the security of the articulations, but also to the general compactness of the arch. It is to the muscles that the foot is indebted for its arch, as well as for the firmness of the step.

It is from a deficiency of vigour in these muscles, that the foot ever becomes plain, and that the plain foot is so unfit for the journey.

The more appropriate but not exclusive office of the body of the foot, whose firm but yielding structure we have been considering, is to form the basis of the standing position; that of the five moveable toes, whose structure we are now to examine, is to perform the ultimate part in stepping. Had the ramification been traced to its termination, the two outermost toes would have been discussed along with the outer division of the foot, and the three innermost toes along with the inner division. But as that order was adopted merely for the sake of giving facility and distinctness to our comprehension of a structure in which description, without the aid of method, would have been lost in the complication of parts, or been embarassed in the unity of the whole; so now, upon the very principle that the order was adopted, it must be abandoned, that the five toes, arranged in one row, and co-opering in one office, may be contemplated together. Reverting therefore to the five divergent metatarsal spokes proceeding from the instep, let us examine their five anterior knobs, constituting the fore boundary of the foot, and articulating with the roots of the toes. These five knobs have a double relation—to the ground upon which they rest and turn, and to the toes against which they turn and rest. It is this double relation of the knobs that renders the articular surfaces so extensive in comparison with the sockets in the roots of the toes. We have hitherto found bone articulating with bone; but in the knobs of the four outer metatarsal bones, we have an instance of bone articulating to a considerable extent with mere ligament, supported by the tendons of muscles, and cushioned by fat and skin. The head of a dislocated shoulder or thigh bone, if not replaced, forms for itself a similar ligamentous socket, by rolling in the cellular membrane, so that articular surfaces are not limited to bones, but may be produced by their habitual motion in any part of the body, out of that pervading and transformable material, the cellular membrane. In that part of the capsular ligament which is situated beneath the metatarsal knob of the great toe being in the progress of life gradually converted into two regular sesamoid bones, and in that part of the capsular ligament which is situated underneath the other metatarsal knobs being also by great pressure and much walking occasionally converted into sesamoid bones, we have a striking proof that ossification is the result of pressure. The knobs of the four outer metatarsal bones, from jutting considerably downwards, have a greater measurement in the vertical than in the lateral direction, and from being rounded with a smaller convexity from side to side than from top to bottom, are arranged into convex ridges, which, by rolling upwards and downwards against the roots of the toes, have formed for themselves concave articular grooves. From this conformation of the articular surfaces, and from the strong lateral ligaments, these first joints of the toes are neither of the nature of the ball and socket, nor yet of the hinge, but partake of the nature of both, and accordingly perform free flexion and extension, and admit of restrained rotation. Mr. Bell thinks that the joints permit "of a greater degree of rotation than our dress allows us to avail ourselves of, the toes being cramped together in a degree that fixes them all in their places, huddles one above another, and is quite the reverse of that free and strong-like spreading of the toes which the painter always represents." The best shoes in which the human feet can be enclosed must necessarily impair their springiness; but such shoes as are generally used, even with their late improvement into right and left, are very far from doing justice to the human feet, as is distinctly evidenced by the greater facility experienced in walking,running, or leaping, when they are disincumbered. This superiority does not arise from the *strong-like* spreading of the toes; for the toes of a well-formed foot, although it has never been confined by shoes, keep in juxta-position, and admit of very little lateral motion. All the little rotatory motion, however, possessed by the toes, is performed in their first joints, just as all the rotatory motion of the limb in general, is performed by the hip joint. By thus limiting the rotatory motion to the first joint, the rest of the limb has all the comparative steadiness of a jointless instrument. Had the toes been articulated to the foot by hinge joints, then every pressure acting in a lateral or oblique direction, and exceeding the strength of the joints, must have either ruptured the ligaments or broken the bones; but from being articulated by joints which admit of being moved a little to either side, not so much by the contraction of muscles as by pressure from the ground, the toes yield rather than break, and at the same time are sufficiently firm for performing their share in the sustaining and throwing forward of the body. But it is in the great toe, towards which the other toes in turning upon the ground give way, and in the powerful structure of its first joint, that they all have their main security. Four bones enter into the first joint of the great toe—the knob of the great metatarsal bone, the root of the first phalanx of the great toe, and the two sesamoid bones. These two sesamoid bones, in consequence of their diminutive size, have never yet excited that attention, or obtained that rank, to which their important office gives them an undoubted title. Anatomists, being like the rest of mankind the dupes of show and of noise, and forgetting the minuteness of several bones of acknowledged importance, have actually refused to these two important sesamoid bones, a place in the skeleton. That size is not always a fair criterion of value is strikingly verified in these two little bones, whose length is only about one third of an inch, and whose breadth scarcely exceeds the half of their length. Mr. Bell having, (in imitation of other writers from whom he endeavours to show that he has not copied,) taken a decided part against these bones, informs us that they are " like *peas*," that they " do not enter into the joint," and " that they almost seem to be produced by chance." If these bones are casual, their casualness has been such that they have just occurred in every adult foot that has yet been dissected. Whether "produced by chance," or by the regular laws of Nature, they are never wanting in a complete foot. That they do not however in the slightest degree resemble pease, and that they do not only enter into the first joint of the great toe, but also perform an important and indispensable part in the functions of the foot, are points, not of belief, but of perception. In pointing out the situation of these bones, he says, " we find two small sesamoid bones, one on each side of the ball of the great toe." Now on the sides of the ball of the great toe you will in vain seek for sesamoid bones, and for this simple reason that they themselves constitute the ball of the great toe. Even allowing that, in his utter contempt of these two bones, he chose to mean by the ball of the great toe, the knob of the metatarsal bone, still on each side of the knob you will search in vain for sesamoid bones, for they lie right below the knob, in close articulation with it, so close indeed, that they seem at first sight to be the knob itself, for which he himself may possibly, in the rapidity of dissection, have mistaken them. These two sesamoid bones jut downwards into two bumps, between which a groove is left for securely transmitting the tendon of the long flexor, and increasing its lever. A similar groove is formed for like purposes upon the lower surfaces of the knobs themselves of the other four metatarsal bones. These two oval sesamoid bones lying close together, are bound to each other and to the lower edge of the hind articular surface of the first phalanx of the great toe by a common ligament, so as to present one articular surface for the reception of the metatarsal knob. The articular surface of the sesamoid bones consists of a middle groove formed by the ligamentous junction of the two bones, and of a ridge on each side, formed by the bones themselves. Upon this groove, and these ridges, the metatarsal knob, arranged into a middle ridge and two lateral grooves, rests and rolls.

Thus the metatarsal knob plays backwards and forwards upon the sesamoid bones, with a treble ridge and groove of security against lateral displacement. The posterior articular surface of the great toe is smooth and concave, and the anterior surface of the knob is correspondently smooth and convex. Here, therefore, rotatory motion is performed. While the sesamoid bones guard effectually against lateral displacement, the toe is permitted to move in every direction, as far as the ligaments and tendons will allow. As that metatarsal surface, below which the sesamoid bones glide backwards and forwards, is rounded in that direction, so the tendons inserted into them gain lever, as by contraction they lose power, and at the same time afford an increase of lever to the long flexor. We can scarcely fail to remark, that the first joint of the great toe performs a similar duty on the small scale, as the instep, and is therefore constructed on the same principle. Thus the metatarsal knob, like another astragal bone, bears with the weight of the body upon the sesamoid bones, as upon another heel, and rolls against the root of the great toe, as against another scaphoid cavity. This first joint of the great toe, and its anterior hinge joint, which we are about to examine, are therefore a repetition on a smaller scale of the plan and process of the body of the foot. It is in vain for Mr. Bell to say of two bones, however small, that perform such important and indispensable duty, that "they are so far from being regular bones, that they are found only in adults;" for the same argument could be turned to a certain degree, and with equal justice, against the importance of the whole skeleton. Indeed, the gristly condition of these two bones during infancy, and even during a considerable period of youth, by enabling them to become more and more evolved according to increasing requisition, marks out the great estimation in which they are held by nature herself; just as the slower and more gradual ossification of human bones, than of bestial, designates what completer evolutions and what higher purposes, she has to serve with man than with the lower tribes. But we need not the arguments of plausibility for proving these bones to be as regular and determinate as any in the whole skeleton, for that metatarsal surface to which they are applied is accurately and distinctly prepared with ridge and grooves, long before the cartilaginous rudiments of the sesamoid bones have begun to be ossified, That in the feet of great travellers, bones, receiving the same name from resembling the seeds of the sesamum, "sometimes are also found under the other toes," gives an enhancement to the two never-failing sesamoid bones, which are never situated elsewhere than in their proper place, or are otherwise engaged than in their arduous task.

The anterior articular surface of the first bones of the toes are arranged into horizontal ridges, which are waved in the lateral direction into a concavity in the middle, and a convexity at each end, and rounded in the vertical direction into one convexity. The posterior articular surfaces of the second bones are correspondently waved in the lateral direction into a convexity in the middle, and a concavity on each side, and hollowed in the vertical direction into one concavity, whose inferior edge extends a little backwards, for the sake of affording a degree of support to the first bones. This configuration of the articular surfaces is most distinctly marked in the second joint of the great toe, but is also observable in the second joints of all the other toes. In virtue of this configuration, and of the lateral ligaments, and of the situation of the tendons, these joints are complete hinges, admitting only of flexion and extension.

The four smaller toes are furnished with a third joint and a third bone. The fore termination of the second bone presents a horizontal ridge, nearly straight to a correspondent groove in the hind termination of the third bone. This horizontal ridge and groove held by the lateral ligament at each end, and moved by means of tendons passing above and below, limit these joints also to flexion and extension. The great toe has only two joints, and only two phalanges. This paucity of bones and joints in the great toe, seems to arise from so great stress devolving upon it; for sometimes in consequence of laborious walking, the two extreme bones of the two outermost toes, which in turning upon the ground receive more pressure than the other two small toes, are consolidated into single bones.

We have already viewed the body of the foot as the principal basis of standing, and the heel behind, and the ball of the great toe before, as the principal points of support. We come now to view the whole foot and toes as an instrument for turning upon the ground. The weight of the body is first pitched upon the heel, then is transferred along the outer edge of the foot, and across the metatarsal knobs, to the ball of the great toe; then the heel rises, and the tips of the toes press upon the ground; then the metatarsal knobs successively rise, beginning at the outermost; then as the ball of the great toe rises, the charge is fairly committed to the tips of the toes, which successively and rapidly leave the ground, the ultimate spring being given from the tip of the great toe. All this successive action takes place every time the foot turns upon the ground in walking; but in running, the inclination of the body, renders it impossible that the heels shall reach the ground, and the diminished weight of the body, from its being a projectile, renders any support from the heels unnecessary. The weight is pitched at once upon the fore ridge of the sole, from thence is transferred to the toes, and ultimately thrown off from the tip of the great toe, which is at once the apex of the foot, and the pivot of the step. The direction of a well formed foot ought to be such, that the tuberosity of the heel, and the ball of the great toe in the one foot, shall be parallel with these two points on the other foot; for the ridge of support running along the outer edge of either foot, and across the first joints, and the tips of the four outer toes, serves merely to transfer the weight gradually and imperceptibly from the heel, and to assist the great toe in making the spring. This successive action of the metatarsal knobs and toes calls into recollection the successive movement of the feet of multipedous animals: nay, the number of the toes calls into recollection the row of five claws ranged on each side of the crab, and the three feet and two wings on each side of the great proportion of insects; nor do the cuticular nails refuse to support the analogy between the human toes on the one hand, and the crustaceous claws of the crab, and the horny feet of the insect on the other. The ten claws of the crab, if not analogous to the human toes, at least illustrate most beautifully their apparently simultaneous, but really successive movement. So accurate, indeed, is this illustration, that there is no great stretch of fancy required, or breach of philosophy committed in contemplating the human foot as a series of simple feet comprised into one complicated, but effective instrument; and in contrasting the simple feet of rude animality sprouting by so many distinct stems from the whole range of the body, with the human limb gathered into one trunk, and ramifying towards its termination into the requisite number of branches. In the five metatarsal bones we see the foot making preparation for toes; and in the five toes we see five distinct members co-operating in one office; so that what enables the crab to crawl, qualifies the human foot to turn with safety and regularity upon the ground. Indeed the human foot, without rising from the ground, can, in virtue of the toes, perform locomotion of the crawling sort. Thus we have not only the two limbs, as two moving spokes, constituting a wheel upon which the body rolls along; but we have also the five metatarsal bones and toes, as moving spokes, by which the foot turns upon the ground—we have a wheel as it were within a wheel. While the two limbs in general, represent the larger wheels, upon which the progress of the carriage principally depends; the toes represent the smaller wheels, by which its steadness upon the ground is regulated. Thus art, in the construction of her vehicles, has been unconsciously imitating nature.

In order to show the importance of the toes, it is not enough that we contrast the ordinary walk of feet that are complete, with the ordinary walk of those that are destitute of toes; for a man can get forward at an ordinary rate, even upon wooden substitutes. We must mark the difference of what the defective, and what the complete feet with their utmost exertion can accomplish. It is when a person is eager in his pursuit, whether by walking or running, that the toes come into full play, and challenge for themselves over the rest of the foot that preeminence which has never been refused to the fingers over the rest of the hand. The incalculable superiority of the great toe above all the other four put together, may be computed from its comparative size, and from the number and size of its muscles, but is strikingly proved by how much more the step is impaired from the loss of the great toe, than of all the other four. The horse may be said to perform its step upon a great toe; and towards the human great toe there is a concentration of the step, so that the weight of the body is transferred from the heel by a circuitous route to the great toe, and from thence to the heel of the other foot. From the resting point of the heel being situated on the outer side of the foot, the line of transmission is rendered shorter, and more direct; and from the great toe being situated on the inner side of the foot, lateral motion, or waddling is as much as possible prevented, for the point whence the body is thrown forward is thus situated as near as possible to the point upon which it is pitched. Thus the march is comparatively evenly, and all the great muscles which have the charge of balancing the body, are saved from much exertion.

The foot and toes, although they are merely the termination of the leg, and without it are unavailable in the step, yet are furnished with a muscular and tendinous apparatus, peculiar to themselves, and thereby enabled, independently of the leg, to move their own joints, and to perform locomotion of the crawling kind. While the long muscles situated in the leg, which principally enable the foot to perform its part in the step, do little more than bend and extend the toes upon the foot, and the foot upon the leg; these short muscles situated in the foot itself, enable the toes to move, though with comparatively little force, in every direction, and to every extent, which the latitude of their joints will allow. Having already examined the joints of the toes, and marked their capability of motion, we might, from a knowledge of the combination of muscular action, deduce, with tolerable accuracy, the number and arrangement of the muscles. Having noted the motions of which the bony instrument is susceptible, and the configurations which they have actually produced upon the articular surfaces; a very cursory description of the tackle of muscles and tendons may suffice, more especially as they vary considerably in different feet,—undoubtedly from reasons of utility, not from the sportiveness of nature, as the name given to these variations impiously implies.

The toes are extended, or drawn upwards by a muscle called the short extensor, which arising from the upper and external part of the astragal bone, and passing obliquely inwards divides generally into four, seldom into five portions, of whose tendons one is inserted into the first bone of the great toe, three into all the three bones of the three middle toes respectively, and the fifth, when it exists, into the small toe. It is probable that the original arrangement was a division into five portions, of which the fifth may have so generally disappeared from disuse. For bending or drawing downward the great toe, and at the same time for drawing it to either side, as far as the nature of the joint will permit, musculous fillets arising from the lower and inner part of the heel bone, and from the lower edges of the scaphoid, and large cuneiform bones, proceed to be inserted by tendon, partly into the external sesamoid bone, and partly into the inner and lower side of the first bone of the great toe; while other musculous substances arising also from the scaphoid and great cuneiform bones, and from the lower surface of the three middle metatarsal bones near their bases, and from the neighbouring ligaments, proceed to be inserted partly into the external sesamoid bone, and partly into the outer and lower side of the first bone of the great toe. In the pages of anatomical works we find all this musculous substance arranged into three muscles—an abductor, a flexor, and an adductor—with a distinctness which is not to be found in the foot itself. The tendon of the long flexor of the four outer toes, in passing from their tips back through the foot, in order to turn behind the inner ankle, and ascend the leg, is seized, about the middle of the sole, by a mass of flesh proceeding from the lower surface of the heel bone. As the tendon of this long flexor of the four outer toes is connected, in the sole of the foot, with the tendon of the long flexor of the great toe, so this fleshy mass is enabled by tendons not its own, to bend all the joints of the five toes. In the ape this fleshy mass takes direct hold of the tendons of both flexors. A little farther forward than the insertion of this mass of flesh into the long flexor tendon, and just where it is dividing into four separate tendons, the four lumbrical muscles, so named from resembling earth worms, originate, and, having proceeded forward, are inserted by means of slender tendons, into the inner and upper parts of the first bones of the four outer toes, and thus draw the four outer toes, when they are extended, towards the great toe, and when they are bent, bend them still more. These four outer toes are also bent by the short flexor, which, arising from the tuberosity of the heel bone, and from the plantar ligament, and being inserted by means of a quadrifid tendon, into the second bones of the four outer toes, a little to their inner side, belongs exclusively to the foot and toes. The outermost of these four toes, as it bears with the greatest pressure upon the ground, is furnished with an additional flexor, which arises from the posterior half of the lower surface and outer edge of the outermost metatarsal bone, and is fixed into the lower edge of the root of the first bone of the little toe, by means of a tendon which is incorporated with the capsular ligament. Into the lower surface of the root of the outermost metatarsal bone, just where the former muscle originates, another, proceeding from the anterior part of the great tuberosity of the heel, is inserted. These two, although distinct muscles, co-operate in the same duty,—the one by drawing downwards the outermost metatarsal bone, the other by drawing downwards the outermost toe. To move the little toe outwards, as well as to support it, and the whole outer edge of the foot, against so great pressure, a muscle arising from the outer and lower surface of the heel bone, and running along the outer edge of the foot, is ultimately fixed, by means of a tendon, into the posterior, inferior, and exterior corner of the little toe. As a counterpart to this muscle, in its capacity of drawing outward the outermost of these four toes, a muscle, called interosseous from taking its origin between the first and second metatarsal bones, is inserted into the inner side of the root of the second toe, for the purpose of pulling it towards the great toe, which on its part possesses too much strength, and receives too much stress for such suppleness, and is seldom moved in common with the other toes. From between the four outer metatarsal bones, six other interosseous muscles originate, of which the three inferior, having their tendons inserted into the inner sides of the roots of the three outer toes, and pulling them towards the two inner toes, act in concert with the interosseous muscle already mentioned: while the three superior interosseus muscles, having their tendons inserted into the outer sides of the roots of the three middle toes, and pulling them outwards, act in concert with the abductor of the outermost toe. For assisting to draw the little toe towards the great toe, and thus bringing all the five into a transverse arch, an indistinct musculous substance arises from the root of the great toe, traverses below the roots of the three middle toes, being attached in passing by three separate digitations to the interosseous ligaments, and is finally inserted into the inner side of the root of the little toe. This muscle, although its fibres are loose and scanty, must have considerable effect from acting at right angles.

Thus we find that although all the tendons of the long muscles were divided at the ankle joint, and the foot and toes thus disabled for moving as a whole, in relation to the leg, yet the toes would, in virtue of the smaller muscles, retain the power of moving in relation to the foot; accordingly the foot and toes possessing an independent motive power within their own structure, deserve a separate investigation before being contemplated as a part of a larger instrument, the leg and foot, and as a mere fractional part of that whole instrument of motion, the human body. All these muscles peculiar to the foot, which render it, taken by itself, an instrument of motion, we will soon find to be no other than directors and moderators of those greater, and more powerful muscles situated on the leg, which in the performing of the step, act upon the whole foot and toes, as one complicated structure terminating the limb—a structure so admirably calculated from this very complication, for standing with steadiness, for stepping with uniformity, for springing with alacrity, and for saving the body, to such a degree, from shocks by a diffusion so immediate.

The foot, in common with the rest of the body, is covered with a sensitive skin, but the tips of the toes are endowed in a more exquisite degree with the sense of touch, whose more appropriate organs, however, we will afterwards find to be the fingers. As the toes do not form the basis of standing, and undergo but a momentary pressure in stepping, and suffer a considerable degree of friction in springing from the ground, so their cuticle is rendered sufficiently thick and dense for mechanical purposes, and sufficiently thin for sensitive duty, upon objects so rough, and with contact so hard. The production of cuticle to supply the wear in those who walk on their bare soles, may be estimated from the number of shoes worn by each individual in a life-time. By a single law in the economy of Nature mankind are furnished with a regular supply of natural shoes, exactly equal to the consumpt.

THE HUMAN LEG,

IN ITS CONNEXION WITH THE FOOT.

The astragal bone, seated upon the inner side of the heel bone, and bearing forward against the scaphoid bone, presents upwards to the leg, an articular surface, considerably elevated above the general level of the back of the foot. About half an inch behind the articulation of the astragal bone with the scaphoid, this upper articular surface begins to rise backwards in a rounded form, and having described nearly a semicircle, terminates behind about the same distance from the posterior articulation with the heel bone. This upper articular surface, although rounded from back to front, is yet not cylindrical, being a little hollowed in the transverse direction, all the way round, in the manner of a pulley. The two ends, internal and external, of this articular surface, are not quite perpendicular, for they both slope a little outwards; nor are they quite plain, for both of them, but especially the external, are a little convex in the horizontal direction, and the external is concave in the downward direction; nor are they of equal dimensions, for the external is the much more extensive; nor are they parallel to each other, for this elevated articular portion of the astragal bone is narrowed both behind and above. For the reception of this elevated articular portion of the astragal bone, the ends of the two bones of the leg are arranged into a corresponding articular groove—of which the roof hollowed into an arched concavity from back to front, and rounded into a slight convexity from side to side, is formed by the tibia—of which the inner side hollowed into a slight concavity from back to front, and descending a little obliquely towards the inner side of the foot, is formed by a process of the tibia,—and of which the outer side rendered slightly concave in the horizonal direction, and convex in the vertical, and descending obliquely outwards, is formed by the fibula. In short, the two bones of the leg, in conjunction, ride upon the elevated articular portion of the astragal bone, with an ankle on each side; and if that rounded surface articulating with the scaphoid bone be the head of the astragal bone, and what extends from thence to this elevated surface be the neck, then this elevated surface must be the back, and thus the personification of the astragal bone into a horse, and of the crural bones into a rider, becomes nearly complete, Thus the inner ankle descending from the tibia, and articulating with the inner side of the astragal bone, guards the joint on one side; and the outer ankle descending beyond the tibia and articulating with the outer side of the astragal bone, guards the joint on the other side, at the risk of fracture; while two thirds of the inferior surface of the tibia, being hollowed into an arched concavity from back to front, and rounded into a slight convexity from side to side, rolls and turns freely and securely upon the elevated portion of the astragal bone. This articulation formed between the astragal bone on the part of the foot, and the tibia and fibula on the part of the leg, is the ankle joint, which is enclosed by a more extensive capsular ligament, than has yet been described, and bound on each side by lateral ligaments, so arranged as to strengthen the joint, without impeding its motions. For the purpose of holding the ends of the tibia and fibula down in close articulation with the astragal bone, a ligament descends in a radiating form from the inner ankle, to be fixed into the inner sides of the astragal, heel, and scaphoid bones, and from thus resembling the Greek letter Δ is called deltoid; a threefold ligament also descends in a radiating form from the outer ankle—one division proceeding downwards and forwards to be fixed into the outer side of the neck of the astragal bone—another downwards to be fixed into the outer sides of the astragal and heel bones—a third downwards and backwards to be fixed into the posterior rough edge of the astragal bone. Of these two lateral ligaments, those portions which stretch backwards, have the effect of preventing too much flexion, as well as dislocation forwards; while those portions which stretch backwards, have the effect of preventing too much extension, as well as dislocation backwards. But against these occurrences the bones themselves offer a more effectual check, for at the utmost degree of flexion the anterior edge of the tibia is received into a hollow in the neck of the astragal bone, and at the utmost degree of extension the posterior edge of the tibia is resisted from getting farther backwards and downwards by that part of the astragal bone extending behind its upper articular surface. Upon the whole, then, the ankle joint, from its conformation, is capable of free flexion and extension, and of limited rotation—may be said to combine the wedge with the hinge. Thus while the weight of the body is turning forward over the joint, the astragal bone by being pressed upwards and backwards between the two ankles, becomes comparatively locked against lateral motion, becomes firm when supporting the weight of the body; whereas, while the foot is raised and extended, the astragal bone from its wedge-shape, has room to allow the toes to turn a little obliquely inwards or outwards, and the whole foot to bend a little to either side. Indeed, the astragal bone even while sustaining the weight of the body, requires a little lateral rocking, in order to accommodate itself to the inward yielding of the foot.

That the two bones of the leg may form one firm articular surface for the reception of the astragal bone, the fibula is received into a notch of the tibia immediately above the ankle joint, and firmly bound there by four ligamentous bands. This lower junction between the tibia and fibula is so close and immoveable, that on wrenching asunder the two bones, the one surface is found covered with periosteum, while the other is naked and rough—in other words the two bones are prevented from a complete union merely by the intervention of periosteum. Between the two bones therefore, at their lower junction, no motion whatever is permitted. Mr. Bell, however, is "well assured that this motion, though slightest and imperceptible, is very constant, for these *jointing* of the fibula with the tibia are always found smooth and lubricated."

Having viewed the bases of the two crural bones in their immoveable connexion with each other, and in their moveable, but scarcely less secure, connexion with the foot, we must now contemplate their long bodies, ascending and gradually divaricating as they ascend, until at length by expanding into two heads, they again come into contact without making any turn towards each other. The tibia, after taking the principal share in the articulation with the foot, forms the main pillar of the leg, and then enlarges into the broad articular basis of the knee joint; whereas the fibula, having formed merely the outer boundary of the ankle joint, ascends as a slender bone at the average distance of about an inch from the tibia, at its external, and a little towards its posterior side, and at length is fixed by an irregular head, to the outer, and lower, and a little to the posterior side of the expanded head of the tibia, and is thus excluded from any participation in the knee joint. Immediately above the ankle joint, the tibia is somewhat cylindrical, but soon becomes triangular, having one of the angles directed towards the fibula, and continues that arrangement even to the knee joint. Above the ankle joint the fibula is irregularly quadrangular to about its middle, when by the gradual conversion of a side into an angle, or by the gradual coalescence of two angles into one, the triangular shape is assumed, having one of the angles directed towards the tibia. From the external of these three longitudinal angles of the tibia, a sheet of interosseous ligament composed of oblique fibres crossing each other, stretches outwards to the fibula to be fixed to its nearest angle, or side, all the way down from the upper to the lower tibial connexion. The purpose of this sheet of interosseous ligament is not to bind the bones together, otherwise the fibres would have run directly across from bone to bone, but to increase the surface for muscular attachment, and to form a partition between those muscles which extend from those which bend the foot. The connexion between the tibia and fibula at their bases we found to be such as could not admit of the slightest motion between the two bones; the connexion between their heads, however, is a complete joint, having smooth gristly surfaces, lubricating fluid, and a capsular ligament. The articular surface of the fibula is slightly concave, and looks obliquely upwards and inwards; the corresponding articular surface of the tibia, consequently, is slightly convex, and looks downwards and outwards. The heads of the bones, therefore, although bound together by four ligaments, as strong as those which held their bases so immoveable, must move against each other, and that motion must proceed from the tibia, since its articular surface is convex, against the fibula, since its articular surface is concave. We now perceive both a purpose and a cause for so great a disparity between the two bones—a purpose in the slenderness of the fibula, allowing it to yield a little to impulse, and thus so far to mitigate those shocks communicated from the thigh bone upon the head of the tibia—a cause in the pressure occasioned by the contraction of those muscles with which the fibula is on all sides surrounded, producing, and at the same time, supporting its slenderness. So completely is the fibula surrounded by muscles that only its head and base can be felt; whereas the triangular tibia is pressed by muscles only on two sides, while the third, or shin, facing forwards and inwards, may be felt through the skin, from the knee down to the ankle. Thus the fibula, serving as a diffuser of impulse, as a splint for augmenting the strength of the limb, and becoming a substitute for the tibia, when it may have suffered fracture, to which it is so much exposed, and as a stretching pin to the interosseous ligament, may be viewed as a mere appendage to the tibia. The two bones being so intimately connected in structure, and function, might almost be contemplated as a single bone; nay, in some animals they are partly united, in others wholly; in some the mere rudiments of fibulae are to be found, in others they are entirely wanting. The two bones with their interosseous ligament extended between them, present two surfaces for the attachment of muscles,—one before, for the flexors of the foot, facing forwards and a little outwards, in the direction of the range of toes—the other behind, for the extensors of the foot, facing backwards and a little inwards, in an opposite, but parallel direction with the range of toes. This obliquity of the two surfaces, whence so many powerful muscles originate, enables them to run more directly to their destination, and to avail themselves of the rotatory motion permitted in the extended ankle joint, by turning the foot (which, in consequence of the spring from the ground, is extended when passing the other leg,) a little outwards, that it may not be tripped; hence the sides of the upper articular surface of the astragal bone are convex, and the corresponding articular surfaces of the ankles are concave, in the horizontal direction. It is not so much for the sake of giving height to the body in general, or length to the limb in particular, as of enabling the great muscles of the foot to take the penniform arrangement, that the tibia and fibula are always of considerable length, and in all animals preserve a greater uniformity, in dimensions and arrangement, than the other bones of the limb. In the lower animals, in general, the thigh bone is considerably shorter than the leg bones; in apes, however, it is nearly of the same length; but in man, the knee is situated nearly at the middle of the limb, so that there is nearly the same extent from the hip joint to the knee, as from the knee to the sole of the foot. This leads us to contemplate the leg and foot in their connexion with each other, as the lower division of the limb, and the ankle joint, in its capacity of giving the concave sole so adapted for standing, all the virtue of the segment of the convex felloe of a wheel, for the purpose of turning smoothly, and of giving the lengthened foot all the virtue of a pivot, for the purpose of turning rapidly upon the ground.

In considering the muscles and tendons passing from the leg to the foot, for the purpose of moving them in relation to each other, it matters not whether the tendons be viewed as descending from the leg, or ascending from the foot. From the anterior and outer surface of the tibia, fibula, and interosseous ligament, four muscles originate, whose tendons pass down in front of the ankle joint, to be inserted into the upper surface of the foot, and toes. As the foot is placed at an angle with the leg, these muscles, by contracting, would have made their tendons start forward, had they not been bound in that angle by the annular ligament extending across the instep, in front of the ankle joint. Of these four muscles, the fore tibial muscle, arising chiefly from the tibia, for two thirds of its length, descends, passes through a peculiar annulet, or ring, of the annular ligament, and is inserted into the large cuneiform, and metatarsal bones of the great toe; the extensor of the great toe, arising chiefly from the edge of the fibula and neighbouring interosseous ligament, for about the upper three-fourths of the length of that bone, descends, passes through a ring of the annular ligament, and is inserted into the second bone of the great toe; the extensor of the four outer toes arising chiefly from the interosseous ligament, and from the side of the fibula for the upper three-fourths of its length, descends, passes under the annular ligament, and is inserted by four tendons, into the first bones of the four outer toes; the third fibular or peroneal muscle arising chiefly from the inner side of the lower half of the fibula, descends, passes along with the tendons of the extensor of the four outer toes, below the annular ligament, and is inserted into the base of the outermost metatarsal bone; so that two muscles bend the foot, and two both bend the foot, and extend the toes. These four muscles adhere to, and occupy all that tibial, ligamentous, and fibular surface facing forwards and a little outwards, and are so connected with each other, and with the ligamentous partitions, and with the fascia, as to be difficultly dissected, and therefore may be properly considered as one bundle of flexors, running in different courses to different destinations, for the purpose of turning the foot to either side, or lifting upwards either edge of the foot, or either toe, or the whole foot and toes at once, according as the different muscles contract separately, or successively, or simultaneously. On turning behind to that surface of the tibia, fibula, and interosseous ligament, facing backwards, and a little inwards, we find seven muscles originating, of whose tendons two pass along the hollow between the tuberosity of the heel and the inner ankle, to get forward to the toes, one behind and below the inner ankle, to get forward to the foot, two behind and below the outer ankle, to get also forward to the foot, and two stop short at the tuberosity of the heel. While the flexors on the fore and outer surface of the leg, have merely to raise the fore part of the foot, and to act as a counterbalance to the unexerted action of the extensors, they have to maintain the arch of the foot against superincumbent pressure, and to raise the whole weight of the body, and of additional loads, against the mechanical disadvantage of a lever extending from the ankle joint to the tip of the great toe; accordingly the extensors are more numerous, and out of all proportion larger than the flexors. The hind tibial muscle, so called from being situated upon the posterior side of the tibia, arises from nearly the whole length of that bone, from the interosseous ligament, and from the upper half of the inner edge of the fibula. As the musculous fibres pass from their origin at either side, obliquely downward into a middle tendon, like the barbs of a feather into a middle stem; so the muscle is styled penniform. The tendon having in this manner received oblique fibres from each side, down to within a little of the ankle joint, turns behind and below the innerankle, through an annular ligament, and passes forward, not according to Mr. Bell's fanciful description " in the hand-like form, to grasp the bones of the tarsus,"—not to be implanted into the sole " by a hand which sends down its fingers among the tarsal and metatarsal bones,"—but to take a sure hold of the lower surfaces of the scaphoid, and large cuneiform bones, and sometimes by a slip to take a hold also of the cuboid bone. This muscle, on account of its penniform arrangement, and its important office, deserves more than ordinary attention. The musculous fibres descending from both sides obliquely into the middle tendon, pull it upwards in the diagonal. The peculiar action of this penniform arrangement of fibres, has never yet been rightly understood. Dr. Barclay of Edinburgh, in his late ingenious, and laborious work on muscular motion, endeavours to show, that " carneous fibres that enter obliquely" into tendon " shorten" the muscle " more" than " carneous fibres continued by a straight line into tendon." In proof of this position, he produces two diagrams, followed up by demonstrations. In one of the diagrams, a tendon is represented by the diameter of a circle; and a carneous fibre by the semi-diameter. If the carneous fibre inserted at right angles into the middle of the tendon, whose extremities must be supposed to be moveable in the diametrical line, shall contract itself completely, the tendon is just doubled upon itself—the diameter is converted into a double radius. If the carneous fibre entering the middle of the tendon at an acute angle, shall contract itself completely, the centre of the tendon shall still be brought to the circumference of the circle, and the farther, as well as the nearer extremity of the tendon, to the centre of the circle, not "a little beyond the centre," as Dr. Barclay, forgetting that all the radii of a circle are equal to each other, has represented. As the tendon of a penniform muscle is not pulled into a zig zag form, but continues straight between the contending forces of the oblique fibres pulling from opposite sides; so this diagram is either not applicable at all to a penniform muscle, or perhaps is not sufficiently explained. In the other diagram, two carneous fibres passing from opposite sides obliquely into the tendon, are represented by the two equal sides of an isosceles triangle, and the fibre of a straight muscle is represented by a perpendicular line, extending from the apex to the middle of the base at right angles to it. Now, if all the three carneous fibres co-operate in bringing the apex or tendon down to the base, the middle perpendicular fibre would be exhausted, would have contracted its whole length, by the time the oblique fibres had merely contracted themselves to the extent of the difference between their own length, and the half of the base. If every two opposing fibres of a penniform muscle, represented by this diagram, in bringing themselves into right angles with the tendon, were to pull it upwards to the extent of the diagonal line, then the combined effect of the two opposing ranges of oblique fibres acting upon the tendon of the hind tibial muscle, would be quite incalculable, and impossible. The truth is, that Dr. Barclay's second diagram represents accurately the effect of two oblique fibres; but the mistake lies here, that what he represents as the effect of only two opposing fibres, is actually the effect, in point of extent of motion on the tendon, of the whole double range of fibres composing the longest penniform muscle, and would be the whole effect, in point of extent of motion, of a penniform muscle, though it should extend from Edinburgh to Glasgow. It is surely almost needless to remind the reader that musculous fibres never contract their whole length, as represented, for the sake of illustration, in the diagrams. As each and all of the oblique fibres of a penniform muscle can contract no farther than to the extent of bringing themselves into right angles with their middle tendon, so the effect of the penniform arrangement must be the very reverse of what Dr. Barclay has assigned to it. For the justness of this conclusion, I am happy to bring forward the high authority of Dr. Barclay himself, who with a candour peculiar to great minds, acknowledges the mistake, and purposes to rectify it in the future editions of his valuable work. Whereas those muscles whose fibres run in a line with the tendon, by contracting to their utmost degree, produce a greater extent of motion, but are disqualified for continuing this extreme state of contraction, for a great length of time; the fibres of a penniform muscle after having pulled themselves into right angles with their tendon, still reserve contractile power sufficient for maintaining the contraction gained. While those bundles of fibres which have a distinct origin, a free course, and a distinct insertion, represent a strong individual making a vigorous effort, and then taking a respite, the penniform muscles represent multitudes drawing assiduously by one rope. Indeed the two lateral rows of oblique fibres, although inserted into one tendon, are virtually two rows of small co-operating muscles, whose several indirect actions are small, but whose combined effect is considerable, and constant. The penniform muscle then is a most elegant contrivance for keeping up a persevering contraction to a small extent, nor is it ever found except where some constant sustentation is required, and in such order as to dispense as much as possible with extensiveness of motion. Accordingly, the hind tibial muscle, and the two other penniform muscles which we are about to examine, make their turn at either side of the ankle joint, closely behind its centre of motion, and have the effect of extending the foot, that they may the better sustain its arching, and maintain its standing. The long peroneal muscle arises from the heads of the tibia and fibula at their junction, from more than the upper half of the external part of the fibula, and from the tendinous partition which separates this from the adjoining muscles, then, having become tendinous, descends, passes through an annular ligament behind and below the inner ankle, runs obliquely forwards and downwards, creeps below the cuboid bone, and across the sole, to be implanted into the outer and lower part of the base of the great metatarsal bone, and into the neighbouring part of the great cuneiform bone. The other hind peroneal muscle arises principally from the two lower thirds of the external side of the fibula, and having become tendinous, turns round the outer ankle, in the same annular ligament with the tendon of the long peroneal muscle, then entering an annular ligament of its own, runs along the outer edge of the foot, and is finally inserted into the upper side of the base of the outermost metatarsal bone, and by a tendinous slip, into the base of the small toe. Keeping then in recollection the limited, but powerful, and constant action of these three penniform muscles, let us mark their separate, and their united action upon the foot. The hind tibial tendon, from passing along the posterior side of the inner ankle, in order to turn forward to its scaphoid insertion, must present a powerful resistance to the slipping back of the tibia, more especially when it is bent forward and thus most apt to slip back; from passing by the inside of the ankle joint, must turn the toes inwards; from passing below the ankle joint must extend the foot; from having a strong insertion into the lower surface of the scaphoid bone, must support that important articular surface formed by the heel and scaphoid bones, for the reception of the head of the astragal bone—must support the arch of the foot, at its most yielding part, by a re-acting power; and from taking hold of other bones, must also strengthen their structure. It is principally by the powerful and constant action of this muscle, that the inner side of the foot is so arched, and raised from the ground, at that very part where the superincumbent weight is pressing directly downward. The two hind peroneal muscles, from passing along the posterior side of the outer ankle, in order to turn forward to their insertions in the foot, must resist the slipping back of the fibula, more especially when it is bent forward, and thus most liable to slip back; from passing by the outer side of the ankle joint, must turn the toes outward; from passing below the ankle joint, must extend the foot; while the shorter muscle must, from the rest of its course, strengthen, and from its insertion, pull upwards the outer side of the foot; so the long muscle must, from the rest of its course, support the transverse arch of the foot, and from its insertion, prevent the great metatarsal bone from rolling outward, and bring the ball of the great toe forcibly to the ground. These three penniform muscles therefore, produce extension, and rotation of the foot, afford its structure a support which is not to be found in inert ligaments, and while giving the ankle joint a security which even bones could not have given without impeding its motions, are powerful agents in the motions themselves.

What has been said of the peculiar action of penniform muscles, applies, in a certain degree, to all the muscles which from a lengthened origin in the leg, descend into the foot and toes; for the musculous fibres, pass from their origin, less or more obliquely into the tendon, which for that purpose, ascends either in one string, or in subdivided slips, high up the leg. The long flexor of the great toe arises chiefly from the lower half of the posterior side of the fibula, and having become tendinous a little above the ankle joint, passes inward behind the base of the tibia, is transmitted through an annular groove, down along the posterior and inner part of the astragal bone, and below the internal process of the heel bone, and after sending a slip to the tendon of the flexor of the other four toes, and then running between the two sesamoid bones, is inserted into the second, or last bone of the great toe. The flexor of the four outer toes, lying to the inner side of the flexor of the great toe, arises chiefly from the back part of the tibia, having become tendinous, passes down in an annular ligament behind the base of the tibia, on the inner side of the posterior part of the astragal bone, and below the point of the lateral process of the heel bone, by and bye receives the accessory mass of flesh formerlydescribed, communicates bya slip of tendon with the flexor of the great toe, gives origin to the lumbrical muscles, and divides into four tendons,which, passing through the split tendons of the short flexor, are inserted into the last bones of the four outer toes. Of these two muscles, the flexor of the great toe is by far the most powerful; but the flexor of the other toes, after receiving its musculous accessions in the foot, is also no mean muscle. From passing down along the astragal bone, and below the internal process of the heel bone, these two muscles counterbalance the hind tibial, and the two hind peroneal muscles, by holding the leg bones back to their place in the ankle joint; and co-operate with these muscles in resisting dislocation of that joint backwards, when it is bent, and liable to that occurrence; also support the astragal bone in its utmost need; and besides all these secondary effects, extend the foot, and bend the toes. It is remarkable, that the three strongest of these muscles have their destination in the great toe, or in that line of bones from which it proceeds. To the great toe nature has given the charge and responsibility of the step, and to the small toes the office of mere auxiliaries; so mankind, as if the same law prevailed in morals, as in physics, generally find their interest in committing the charge of any matter, whether a petty transaction, or the government of a nation, to one individual, who may be aided, but not absolutely controlled, by the council and assistance of others.

These five muscles originating from that tibial, ligamentous, and fibular surface which faces backwards and inwards, are a counterpart to the four muscles originating from the tibial, ligamentous, and fibular surface which faces forwards and outwards; not only by bending the toes and extending the foot, but also by extending it either in a straight, or in an oblique direction, according as the five act simultaneously, or separately; so that the whole nine muscles are enabled to perform flexion, extension, and rotation of the foot, with a steadiness which no simpler arrangement, indeed no other could have accomplished. These five extensors, whose principal office is thus to support the structure of the foot, and to take the charge of its rotatory motions, and to counterbalance the flexors by extending the foot, are utterly incapable of extending it against resistance. They indeed do little more than prepare the foot for the powerful action of that large muscle composing the calf, whose size is so characteristic of the human leg. Of this muscle, that portion arising by two fleshy origins from the upper and posterior parts of the tibia, and fibula, has been named soleus, from resembling the sole fish; while that portion arising by two flat tendons from above either condyle of the thigh bone, has been named gastrocnemius, from appearing to compose the belly of the leg. The fleshy fibres, of the soleus descending obliquely from their tibial, and fibular origins, meet and swell into a large mass, then about the middle of the leg, begin gradually to taper into a strong tendinous cord, which descends, and is implanted into the hind extremity of the tuberosity of the heel. The anterior fibres, or those nearest the bones, having the penniform arrangement, and the posterior descending more in a line with the tendon, render the soleus at once capable of constancy, and promptitude of action — of promptitude for raising the heel smartly from the ground—of constancy for keeping it raised. It must be obvious that this soleus portion, from having its origin in the leg, and its insertion in the heel, can merely extend the foot, but in so doing is independent of the position of the thigh bone: whereas the gastrocnemius portion, from having its origin in the thigh bone, and its insertion by a strong belt of tendon into the tendon of Achilles about the middle of the leg, can move the thigh bone, and must depend upon the position of that bone for moving the foot. So long as the knee joint is bent, the heel must be lifted by the soleus; but the gastrocnemius, as soon as it is put upon the stretch by the extension of the knee joint, can support, and continue the elevation of the heel. It is idle in anatomists to dwell so much upon the power of the gastrocnemius to bend the knee joint; for it is the extension of the knee joint that enables this muscle to act in its proper capacity of giving the ultimate extension to the foot. It is worthy of remark, that when in walking the heel is first raised from the ground, the knee is bent; and that ere the spring is made from the great toe, the knee is extended. The gastrocnemius then may be viewed as an additament to the soleus,—for commencing where it ends, for finishing what it had begun. Thus the foot is extended by the soleus at a time when the gastrocnemius can do nothing, and is farther extended by the gastrocnemius when the soleus has done its utmost. These two portions then of the great muscle composing the calf of the leg, although they both conduce in the extension of the foot, have different effects, and therefore require to be carefully distinguished. In the lower animals the gastrocnemius is to be found large and powerful; but the soleus is always comparatively small, and often quite slender. It is the size of the soleus then that distinguishes the human leg from all other legs. It is in virtue of the large, and powerful soleus that the tuberosity of the heel is enabled to rest upon the ground, and thus to render the human step so firm, and composed; and is enabled to rise from the ground with sureness, and regularity, and thus to give the human foot the full advantage of an immediate spring from the toes. Thus the two tuberosities of the human heels when resting upon the ground, are equivalent, in affording a base of support, to the two hind quadrupedal feet, in the act of alighting upon the ground; and the metatarsal knobs and toes, when the heels are raised, are equivalent, in affording a spring from the ground, to the two hind quadrupedal feet, in the act of taking a new step. Thus all the advantages of the quadrupedal arrangement, so well calculated for stability, and speed, are comprised to a sufficient degree in the two human feet.—It is worthy of remark, that the human ears only, are possessed of lobes, and that the human heels only, have tuberosities resting upon the ground. As the lobe of the ear indicated a subsidence of the emotion of fear into sensibility; so the heel in its capacity of a resting point, at once gives composure to the walk, and indicates a subsidence of eagerness into deliberation, and firmness of character. Thus the heels of courageous animals generally approach the ground, and even rest upon it, though not by descending tuberosities; whereas the heels of timid animals are situated at a distance from the ground. Flight is metaphorically expressed by the term heel, in its capacity of a lever. In so far as the heel is exclusively devoted to the purposes of a lever, as in the timid of the lower animals, at all times, or in man, when his heels are kept aloof from the ground, in so far this metaphorical term receives the sanction of a kind of etymology. That step in which the heels do not reach the ground, bespeaks in the human character, volatility:—that step in which the heels take their due share, bespeaks deliberation and firmness: — that step which is performed too much upon the heels, bespeaks cautiousness. As the feet of all animals are adapted to their diversified modes of life, so the human feet are adapted to the diversified peculiarities of step, and the step to the diversified peculiarities of character.

Thus the muscles situated on the posterior part of the leg, and descending into the foot, for the purpose of extending it, are divisible into three sets, according to their respective points of insertion—into the large gastrocnemius and soleus muscle whose tendon descends directly to the tuberosity of the heel (accompanied by the slender plantar muscle which more properly belongs to the knee joint)—into the hind tibial, and two hind peroneal muscles whose tendons stretch forward into the body of the foot—and into the long flexor of the great toe, and the long flexor of the other toes, whose tendons are inserted into the extreme bones of the toes. Of these six extensors of the foot, that large muscle which descends directly into the tuberosity of the heel, is by far the most powerful, indeed is absolutely necessary to the human ankle joint; but without the other five to strengthen, and arch the foot, and to bend the toes, could not perform a step other than sluggish, or the most sluggish step, without soon relaxing and forcing asunder the whole bony and ligamentous fabric of the foot.

The other five muscles which creep close along the bones, and by the ankle joint, prepare the foot for the powerful action of the great soleus and gastrocnemius muscle, while it, in requital, covers and braces them in their action. They, while co-operating in extending the foot, have other duties to perform; it, however, being solely devoted to the single office of extension, has become, like an individual devoting himself exclusively to a single employment, comparatively perfect in that particular; and for this purpose has availed itself of an advantageous lever, with which other offices would have been inconsistent. It is on this account that large calves are not always accompanied by well arched feet. Indeed it is frequently observed that very large calves are seldom accompanied either by good feet, or by a sprightly step, and just for this reason that preponderation in one part is naturally apt to produce diminution in another. Where this double soleus and gastrocnemius muscle naturally preponderates, the step is chiefly entrusted to it, so that it comes to preponderate still farther; while the central muscles, whose tendons proceed forward in the foot, being comparatively unemployed, must become enfeebled. Calves of excessive size generally derive their magnitude from the soleus; and hence the grossness descends considerably in the leg. In calves of moderate size, whose greatest swell is a little below the ham, the gastrocnemius is generally in the most sizeable and vigorous condition. Indeed, in a well-formed leg the double belly of the gastrocnemius may be seen on the upper half of the calf, swelling into greater distinctness during that part of the step when the body is thrown forward. The lengthened calf therefore comes to indicate the cautious deliberate character, while the short calf, situated high in the leg, and assuming less or more, the shape of a ball, bespeaks the less cautious, but the more energetic character. The extensors of the foot, therefore, may be divided into three sets—into that large muscle which by an insertion in the tuberosity of the heel simply extends the foot, in the indirect method of raising the hind part for the purpose of pulling downward the fore part, and with a force proportionate to its own dimensions, (for whose enlargement there is indefinite scope,) and to the length of its lever, (for whose elongation there is also indefinite scope,)—into those three muscles which by insertion into the body of the foot, pull the fore part of the foot directly downwards, and at the same time increase its strength and its arch—and into those two muscles which by insertions into the toes, not only extend the foot and strengthen its arch, but also give the ultimate spring from the ground. The four flexors before, and the five central extensors behind, merely fill up the longitudinal vacuities between the two bones, and bring the leg to a cylindrical form of nearly equal diameter from top to bottom. The hind foot of quadrapeds, having little else to perform than support the weight and transmit it forward, is furnished, in addition to these muscles, with but a middling gastrocnemius, and with a diminutive soleus, so that the quadrupedal leg is deficient in a calf; whereas the human foot stretching along the ground, and requiring to elevate the weight before throwing it forward, is furnished, in addition to the other flexors and extensors, with both a large soleus and gastrocnemius, so that the human leg is characterized from all other legs by a sizeable calf, swelling as it descends from the ham, and then tapering towards the heel. As all these muscles are firmly bound by a strong fascia, and farther bound by the elastic skin, and as they are quite tendinous by the time they reach the ankle joint, so a good leg and foot ought to be trim and clean at their junction. The ankle joint serving to commute the lengthened sole into a ready turning point for the limb, and being necessarily surrounded by no other than ligaments, tendons, and skin, must be better adapted to its office in proportion to its neatness. But as the ankle joint in serving as a turning point, has to sustain the weight of the body, so a compromise becomes necessary between strength for bearing, and neatness for turning; and as the human limb and step require strength as well as alertness, so a good ankle joint ought to be neither very small, nor very large. The draught horse has large ankles calculated for strength, and the race horse has small ankles calculated for speed; but as strength and speed require to be as much as possible equalised for the sake of the diversified action of the human body, so the ankle of middling size, is best calculated for man. In estimating the ankles, regard must be had to the general size and make of the body; for the thick athletic form must have strong ankles: whereas small ankles are most suitable for the slender, delicate frame. Accordingly the female ankle can scarcely be sufficiently small. We have hitherto supposed the ankle joint to be closely braced by the strong tendinous fascia, and by the contractile skin. But in those lax habits which the ancients, according to their doctrine of humours, termed phlegmatic, the inelastic skin gives way to the subsidence of humours into the most dependent parts of the body. Along with the general laxity allowing these humoral depositions, there is generally also an accompanying slackness in the structure of the ankle joint and foot; and it is unfortunate that females whose ankles are naturally the neatest and trimmest, afford, owing to the unnecessary sedentariness of their lives, the most numerous instances of the relaxing effect of the phlegmatic temperament.

The ankle joint not only enables the foot, without detriment to its office of turning upon the ground, to assume that concave arrangement so conducive to stability, and enables the leg to make a rapid turn in the ankle joint, but also gains the whole length and spring of the foot to every step. We now, therefore, see the advantage afforded by small ankles, from enabling the leg to make a rapid and easy turn, and the advantage of a foot, that from being neither very long nor very short, gives as much length of foot to the step, as is compatible with a full command of the spring. As it has evidently been the intention of nature to comprise these two advantages in the human foot; so we must reason from a longer or a shorter foot, than is to be found in nature, before we can give a striking conviction that the middling size of foot is the best for the step, and that therefore a long and a short foot are equally inconsistent with handsomeness. The short foot is calculated for the rapid step; and the long foot for the slow, but cautious step; while the foot of middling dimensions is best calculated for making progress in the journey. As the muscles have less command of the foot in proportion to its length, so long feet, as well as plain feet, whose muscles are not even able to maintain their arched form, have generally a tendency outward, for the sake of making up for their comparative inability to grasp the ground, by widening the base of support, that the standing may be secured, though the progression should be diminished. This wide spreading outwards of the fore parts of the feet, being neither permitted by the joints which we have examined, nor yet by the knee joint which we are about to examine, must be traced to that rotatory joint by which the limb in general, is articulated with the body; so that in obliquity of foot, the whole limb is turned aside, and hence the muscles must act at considerable disadvantage. Thus, to the debility which rendered it necessary that the feet should be spread out into a broader base, there is superadded a mechanical disadvantage. Oblique, or even plain feet may suffice for trailing along upon a smooth pavement, but could ill accomplish a long journey, even upon the prepared and beaten road; but the straight and arched foot is that which can perform an easy walk with the utmost composure and firmness, and can best make its way over the rough, the arduous, the untrodden surfaces of nature. Progression is the proper office of the feet; and the direction most conducive to that office, is the straight, in which the tuberosity of the heel, and the ball of the great toe are parallel with the line of march. The straightest foot must, as the dance changes from the locomotive to the local, also change from the straight direction to the oblique. It is, therefore, highly preposterous in the dancing-master to force the feet, while sitting, or standing, or walking, into that oblique direction which they require, and which they naturally assume, for the lateral movements of dancing. It is no argument against the straight foot, that it is fashionable to keep the toes out; on the contrary, so great difficulty is experienced, in enforcing this unnatural direction, that even blocks have been contrived to keep the feet awry.

We have as yet, taken a view of the leg, and foot only, which are but the lower division of the limb—little more than its termination, and which have no power to get forward, but are entirely devoted to treading. The thigh joining below with the leg, and above with the body, remains for discussion. We will find the knee to be a secondary joint, highly useful, but not absolutely necessary to locomotion; we will find that the short formal military step in which the feet are never left much behind the line of the body, may be performed with the knees kept extended, and that even the full walk may be accomplished with extended knees, provided the hind foot, in coming forward, shall describe the segment of a circle outward from the body, or provided the body shall bend a little to the opposite side, while the foot is passing forward. Let us for the sake of illustration, suppose a wheel, to consist of two moveable spokes, capable of passing each other in their revolution round the nave. If the two spokes be equal, and the wheel even, and the ground unyielding, the hind spoke shall not be able to pass that which rests upon the ground, without bending either in a curve, or in an angle. All that is necessary, therefore, is to make a joint in both spokes, that each may be bent a little, and thus raised from the ground in passing forward. Now this joint would be entitled, by the very mechanic employed to construct it, the knee of the spoke; and would actually serve to the spoke, what the human knee serves to the limb. But the advantage of the knee is best seen in the mounting of a hill, for the body lying a little forward, that the progressive centre of gravity, may fall on the fore part of the base of support, forms an acute angle with the ground, so that the foot must be lifted considerably, in order to be pitched a step forward on the rising ground; and the knee must be extended with considerable power, in order to carry the centre of gravity at every step, upward and forward to the new base of support. Although the knee, like the ankle, is but a secondary joint, yet, its mechanism shall not afford us the less occasion for admiration. After contemplating the structure and functions of the knee joints, we shall trace the thigh bones upwards, and at length find them take a sudden turn inwards, backwards, and upwards into the sockets, which from either side of the basin look outwards, and a little downwards, and forwards; we shall find the neck and head of either thigh bone to be the axle of the limb; we shall find the round head of the bone to be held in its socket, by a strong ligament within the joint, and by a strong capsalar ligament around the joint, but principally by the oblique direction of the powerful muscles which, while moving the thigh bone backwards, and forwards, and round about, with a freedom enjoyed by no other joint in the limb, hold it securely in its socket. The discrepancy and contradictions amongst anatomical writers, in their several accounts of the actions of these muscles, afford the strongest proof of the high importance of this joint, and of the surpassing mechanism employed in its construction. After having thus examined the two limbs articulating with the body, and carrying it about; we shall come to examine the mechanism, of the trunk, balancing itself upon the two limbs—to examine that strong foundation work, the basin, upon which is reared that high, firm, and moveable pillar, the back bone, which is surrounded by muscles held out in front, by the ribs above, and by the basin below, into a capacious enclosure for the vital organs—furnished with an arm, as a balancing pole on either side—and surmounted by the ponderous head as a balance-weight. Thus we shall find that the whole human body, from the soles of the feet to the crown of the head, is subservient to locomotion; and that this instrument of locomotion possesses much to engage attention—much to excite admiration—much to extort from the most sceptical, an unqualified acknowledgement of the Divine framer. Still the best part of the mechanism and motions of the human body shall remain for discussion. The whole bony and musculous structure, while it is from bottom to top, adapted for locomotion, is likewise, from top to bottom, adapted for manual action. As either arm makes a swing in accompaniment with the step of the opposite leg, and as both arms labour with extended fingers to recover a slip, and perform more than the half of scaling and scrambling; so we shall afterwards find the legs, and the whole body, contribute all their powers to manual action, in thrusting forward the arm to the blow, or in bringing it back to the defence, in pushing, or pulling, or carrying the load, in seizing the prey, or in sending forth the missile, in performing the labours of the arts, as well as the experiments, and notations of the sciences; so that locomotion itself, shall appear to be just a reaching forth of the hands, and the whole body to be no other than a manual instrument.

THE END.

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