effect seems to be produced principally through the agency of the nervous system, for an account of which we must refer to Section VIII.; but when the application of cold produces its injurious effects, the blood that is forced, by the constricted vessels, from the surface, upon the internal parts, probably also overloads them, and impedes the due performance of their functions. When the body is exposed for some time to a great degree of cold, the tendency to sleep becomes almost irresistible. Under these circumstances, to use the words of Dr. Solander, quoted by Captain Cook, "whoever sits down will sleep, and whoever sleeps will wake no more." These words were used by Dr. Solander during an excursion in Terra del Fuego, with Sir Joseph Banks and nine other individuals, when the cold was intense. Notwithstanding Dr. Solander gave the precaution, he was the first to feel the effects of the cold, and his companions were obliged to yield so far to his entreaties as to allow him to sleep for five minutes. With the utmost difficulty he was roused. Two black servants also slept, and perished. Exposure to a lesser degree of cold acts differently. Every one knows the power of cold draughts of air, of cold or damp feet, the wearing of damp clothes, or sleeping in damp sheets, in giving rise to inflammations, even in persons whose surface has a vigorous circulation, and is therefore not easily chilled. When the circulation on the surface is languid, these causes act with tenfold force; and hence in all such constitutions it is of the utmost moment, 1st, that the skin should at all seasons be protected from sudden chills by warm (the best are flannel) coverings; and, 2dly, that sea-bathing, a generous diet, and all other means that give permanent vigour to the circulation, should be specially attended to. Under all circumstances, indeed, frequently cleansing the skin, by removing noxious excretions, and allowing the proper exercise of its functions, has a much more important influence on health than is generally imagined.

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201. Effects of exposure to cold; illustrations.
202. Danger of applying heat to frozen parts.
203. Practical suggestions.

Good views of the lymphatic vessels will be found in Lizars's Coloured Plates, page 99, and of the skin, at page 82 of the same. Connected with the subject of the skin, the teacher may introduce some instructive lessons on the five varieties of the human species and their distribution. We have found that these lessons are rendered much more impressive by having drawings of these varieties, and also a skeleton map of the globe, of a large size (say six feet by four), coloured so as to indicate their different localities. Thus, the European, or Caucasian, may be left white, the Mongolian coloured yellow, the American red, the Malay brown, and the Ethiopian black. The drawings, and the requisite information as to localities in making this map, will be found in the latter part of Lawrence's Lectures on Man, 8vo edition.

SECTION VII.

LOCOMOTION—THE BONES, MUSCLES, &c.

122. Having now given a short account of the most important functions of the organic or vegetative life, we shall here consider shortly the parts that are immediately concerned in producing the motion of the body. These are the bones and their articulations (joints), and the muscles.

123. The most important of the hard parts in animals are shells, crusts, and bones. The two former, however, are void of vitality, while bone gives every indication of possessing life. In shells, almost no animal matter is found; they are nearly the same in composition as a piece of marble. Crusts (as the lobster's) have a larger proportion of animal matter; and in the composition of bones there is much more. Not only, however, is the earthy matter less in bones; it is also differently combined. In shells and crusts the earth is carbonate of lime (chalk), while in bones the lime is principally united with an acid composed of phosphorus and oxygen, forming phosphate of lime; and it may be remarked, that it is from bones that phosphorus is usually obtained.

124. The quantity of animal matter in different bones, and, consequently, their hardness, varies. In infancy and

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204. Name the hard parts of animals.
205. Composition of these.

youth the animal matter predominates; in old age the earthy matter. On an average, perhaps, in mature age, about two-thirds are animal (mostly gelatin and albumen) and one-third earthy matter. Mere hardness, however, is not all that is wanted, for the hardest are often the most brittle substances. The composition of bone, therefore, is such, that the earthy matter may give stability to the framework, on which all the other parts are to hang and work, while the animal matter imparts to it adhesiveness and toughness.

125. It is found that all the parts which afterwards become osseous (bony) are originally in the state of cartilage or gristle; that this is gradually removed, and bone deposited in its stead; and that ultimately, in its highest state of development, the bone is hollowed out internally, and is filled with marrow, or, in birds, with air.* Some of our bones are completely ossified at birth, as is the case with the bones of the ear; most of the others become more or less so in a few years afterwards; but some parts continue cartilaginous even in manhood, and become perfectly ossified only in old age. This is the case with the cartilages that join the ribs to the breast-bone; and as the elasticity of the cartilage materially assists in breathing, it is easy to understand that the change is not an advantageous one.

126. Perhaps the most rudimentary form of an internal skeleton exists in the sepia, or cuttle-fish. It is merely a collection of bony plates, which gives support to its soft body, and forms a ring superiorly, through which part of its nervous system passes. The first object, in laying the foundation of the skeleton, appears to be to provide for the security of the brain and spinal marrow, as protection to these from injury, we shall afterwards find, is of the very highest importance. Accordingly, whatever other parts

* When thus hollowed, the bone is found to be much stronger than if the same amount of hard substance had been disposed in the solid form.

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206. Proportion of animal matter in bones.
207. Primitive state of bone in the formation of the body.
208. What bony structure is uniformly found?
209. The advantage of the bones being hollow.

of the skeleton are wanting, it has been already mentioned that the back-bone, or spine, is always present; and further, in the human race, and in all the other Vertebrata, this is invariably the first part of the osseous structure which nature developes.* It is composed of a series of rings or vertebræ, variously joined together in the different classes. Each side of a vertebra, in fishes, forms a cup, and, consequently, when the whole vertebræ are joined, two cups are always opposed to each other—the cavity left being filled by a thickish jelly. In reptiles, the junction is

* We may here mention, that the various organs of animals are quite different when first developed, from what they afterwards are in their perfect state. On this subject have, of late years, been made perhaps the most astonishing discoveries in modern science. It appears that the organs of the different beings, before they can attain to the rank assigned them in the animal scale, must first pass through many of the phases which the same organs assume in the classes beneath them. Thus, the whole body of man is at first little larger than a pin's head, and has the simple pulpy structure of the lowest zoophyte; the brain at first is wholly wanting, and is subsequently like a fish's, a reptile's, a bird's. About twenty-one weeks after its development, the human brain has a close resemblance to that of the Rodentia, (marmot, &c.)

The human heart also, as in animals low in the scale, is at first wanting; then it is like a fish's; and even at birth, we have already remarked that communications exist between the venous and arterial circuits, as in reptiles. In the same way, what afterwards become bones, are at first a mere jelly, like the bodies of the Radiata; subsequently they are gristly, like the skeleton of the Chondropterygii (shark, ray, &c.); and ultimately they pass through the different stages of ossification. The same happens with all the other organs. It has even been found that the human embryo, at one period of its growth, is furnished, like a fish, with gills.

The transformations of insects afford beautiful examples of the same law; and every one has observed that the frog, before it becomes a reptile, remains for some time as a tadpole in the lower class of fishes. It has then gills, and is indeed in every essential a fish.

These discoveries give a most satisfactory explanation of certain of the cases called monstrosities. For example, a person or quadruped born without posterior extremities, may be said, in regard to these, to have remained in the state of development represented by the Cetacea; a person with hare-lip or cleft pallet represents the condition, in these particulars, of the hare, birds, reptiles, &c.: and so on with the heart, brain, and other organs.

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210. Varieties in the vertebral structure.
211. Curious lessons of comparative anatomy, as in the note.

what is called, by mechanics, of the ball and socket kind—the ball of the one vertebra fitting into the socket of that above it. The surfaces of the vertebræ in the Mammalia are nearly flat, and between each, in man especially, there is placed a thick, tough, and highly elastic gristle, which is of great use in breaking the shocks that would otherwise be sustained in running, leaping, &c. The mode of articulation in the fish and reptile allows of much more extensive motion than that of the Mammalia; but some parts of the spine in the latter possess much greater capabilities of motion than others. Fig. 25 shows one of the lower vertebræ in man. *a* is the surface by which it is joined; *b* the ring through which the spinal marrow passes, which Mr. Earle has shown, is, in the various species, of a width proportionate to the extent of motion enjoyed by the part.

Fig. 25. A Vertebra.

127. The articulation of the spine with the skull, in the Mammalia, exhibits one of the most curiously artificial contrivances to be met with in the body. The object contemplated is to produce a hinge that will allow of two kinds of motion, namely, 1st, such a motion as takes place when we turn the head from side to side; and, 2dly, such a motion as we employ in nodding the head, or one backwards and forwards. The mechanism by which this object is attained is of a most admirable kind, but at the same time of a kind which does not readily admit of description. It involves a great regard for the protection of the spinal marrow at the top of the neck, this being perhaps the most vital portion of the whole body. Injury to it, or pressure upon it, is instantly fatal.

128. Taken as a whole, the human spine is a most curious and perfect piece of mechanical art. It combines the two apparently almost incompatible requisites of great

212. Varieties in the vertebral structure.
213. Describe the human vertebra.
214. Wonderful union of the spine with the skull.

strength and sufficient flexibility. The flexibility is principally produced by the number of pieces employed, which are so firmly knit together, that dislocation of them without fracture, is a very rare case. Let any one, as Dr. Paley observes, try, by main force, to separate the vertebræ even of a hare or rabbit, and he will soon learn how firmly they are united.

129. The spine is surmounted by the cranium, or skull (see Fig. 7), which consists of a number of separate pieces joined together, forming a strong case for the brain, constructed on the principles of the arch. Connected with the skull are the organs of the principal senses and of mastication, which, amounting, in the large animals, to a considerable mass, render necessary various contrivances. In the bird, the head is at the end of a long neck, but the skull is made extremely light. The skull and bill of a common fowl are only about the weight of a sixpence. In the cow, camel, &c., the neck, from the food on which they live, is necessarily long, and the head is heavy; and hence there are powerful muscles, that are attached to the skull, and to long spines projecting from the back of the vertebræ of the neck, and an elastic rope, or ligament, fixed also to the same parts, that assists to raise or to support the head.* In the elephant the weight of the head is so enormous, that nature has had, besides these contrivances, to shorten the neck so much as to necessitate the formation of a proboscis, or trunk. One of these sagacious creatures died of a lingering disorder a few years ago in Paris. It was never seen to lie down till the day of its death, and, when very feeble, what seemed to give it the greatest distress, was the effort requisite to support its head.

130. The other parts of the skeleton are less essential. They are modified in numerous ways in different species to suit particular purposes, and some are occasionally wanting altogether.

* Vulgarly called pax-wax, or maiden's hair.

215. How is strength and flexibility in the spine secured?
216. What is said of the skull in different animals?

131. The clavicle, or collar-bone (Fig. 7, *y*), is one which has obvious and interesting relations. This bone is perfect in man; it is imperfect in the tiger, &c.; and is wholly wanting in most of the herbivorous tribes. Now, what can be the reason for these differences? The reason is perceived from knowing the uses of the bone, for it is of service only where the upper extremities are much used in laying hold of objects, as in the monkey, squirrel, man, &c.; and to them it serves the important purpose of separating the limbs, and thus allowing sufficient extent of motion. Would it not, then, have been of service to the cow or the horse? Certainly not: quite the reverse. When, in running down a hill, we fall on our hands or shoulder, or stop ourselves with our hands against a wall, one of the most common accidents is dislocation or fracture of the collar-bone, because this bone is directly connected with the arm and breast-bone, and, of course, sustains a great part of the shock. But when a horse gallops down a hill, or leaps, the shock is greatly more violent, and yet no bone is broken. The reason of this is learnt by inspecting its skeleton, for we find that the fore-legs are not connected with the trunk by bones at all, but by two enormous fleshy muscles attached to the shoulder-blades (Fig. 7, between the situations of the letters *y* and *r*), between which the heavy body safely swings.

132. The breast-bone (Fig. 7, *x*) is almost rudimentary in fishes, as they have properly no chest, the gills and the heart being placed under the head. The same bone in birds is very large, to give an extensive surface on which the muscles that move the wings may be fixed. In the tortoise and turtle its size is enormous, forming a covering to the whole of the under part of the body.

133. The extremities are parts in which it is very interesting to trace the modifications which nature employs to fit the same bones for different uses. In Fig. 7 we see the human arm and hand, composed of the humerus, or princi-

217. What of the clavicle, and its presence or absence in different animals?

218. What of the breast-bone?

pal bone (*b*), the two bones of the fore-arm (radius and ulna, *d*, *e*), the bones of the wrist (*f*), and the fingers (*g*). Fig. 26 represents the paddle, or fin, of the porpoise, which might

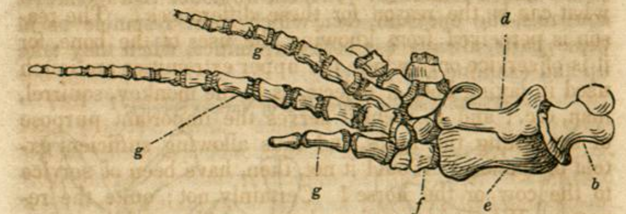


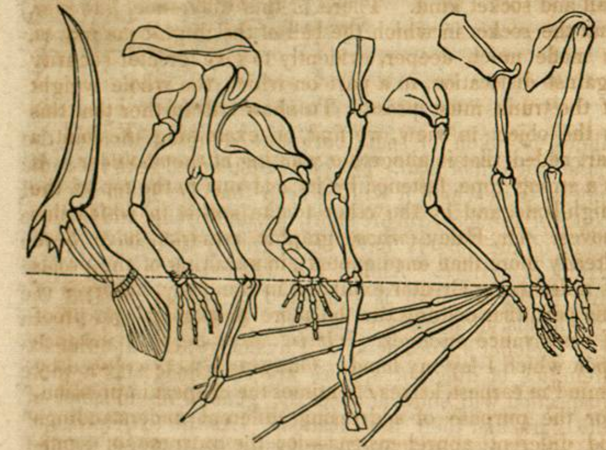
Fig. 26. Paddle, or fin, of the Porpoise.

almost be taken for some burlesque representation of the hand and arm of man. The parts are marked with the same letters, from which it will be seen that the humerus and bones of the fore-arm are short, flat, and strong, and that the joints of the fingers have been greatly increased to give extent of surface. Almost the whole body of the skate and of the ray-fish is composed of what represent the two hands, immensely expanded. In Fig. 27, taken from Dr. Fletcher's Rudiments of Physiology, the anterior extremities of different species are sketched, and a mere inspection will show at once the general resemblance of the parts and their modifications. As the extremities of the deer, horse, cow, &c., are formed for solidity, we find, in different parts, that there is only one solid piece for two, three, or more bones, in the corresponding parts of man, but even these solid pieces are found originally to have been several distinct bones, that have afterwards united. Of all the modifications which the different portions of the extremities undergo, the human hand is undoubtedly the most beautiful. Marks of the greatest care are everywhere visible in the formation of this most admirable structure; and whether we regard its fine sensibility, or the power, rapidity, and delicacy of its movements, we must acknowledge that no similar part in other animals can be compared with it. Its chief superiority, as an in-

219. Explain the diagrams.

strument of prehension, arises from the length, mobility, and strength of the thumb, which can act as an antagonist to all the other fingers, giving us something like the power of two hands conjoined. Indeed, we notice that monkeys, squirrels, the opossum, &c., which most resemble us in these parts, always use both extremities, when they take up and examine any object.

Fig. 27. Anterior Extremities of Various Species.



Fish. Frog. Bird. Dolphin. Deer. Bat. Ape. Man.

134. It is not possible, on the present occasion, to say more than a few words regarding the joints, although there are many things connected with them well worthy of attention. The bones forming joints are firmly knit together by parts called ligaments; the bones are covered with a smooth gristle at their extremities, that they may move easily on each other, and there is a kind of oil poured into the joint to assist this still further. We have various kinds of joints in the body. There is the hinge-joint at the

220. What of the modifications of the same bones in different animals.
221. What is wonderful in the human hand?
222. How are the joints constructed?

elbow, that admits of motion only backwards and forwards: the ball and socket joint at the shoulder, that allows of motion in every direction; as well as several other kinds. We shall only further observe, on this subject, that there is a part connected with the hip-joint which is worthy of particular notice. The bones of the lower extremity are constructed on the same plan as those of the upper, but are stronger; and the hip, like the shoulder-joint, is of the ball and socket kind. There is this difference, however, that the socket in which the ball of the thigh-bone moves, is made much deeper, evidently to give greater security against dislocation, in a part on which the whole weight of the trunk must press. To show still further that this is the object in view, we find, on examining the joint, a part added, that is altogether wanting at the shoulder. It is a strong rope, fastened by its one end to the top of the thigh-bone, and by the other to the socket in which this moves. Dr. Paley (whose graphic remarks have been already more than once quoted), in speaking of the proofs of a designing Creator exhibited in our body, observes of this part, that nothing can be more mechanical, no proof of contrivance stronger. "It is," says he, "an instance upon which I lay my hand. One single fact, weighed by a mind in earnest, leaves oftentimes the deepest impression. For the purpose of addressing different understandings and different apprehensions—for the purpose of sentiment—for the purpose of exciting admiration of the Creator's works, we diversify our views, we multiply our examples; but, for the purpose of strict argument, one clear instance is sufficient; and not only sufficient, but capable, perhaps, of generating a firmer assurance than what can arise from a divided attention."

135. Having got the solid skeleton, the agents employed in producing its motion are the muscles. By a muscle is meant a fleshy body, possessing the peculiar property of contractility, or of shortening itself. When we cut a piece of meat, it is the flesh we notice which is the muscular

223. Name some of the varieties.
224. Reflections of Dr. Paley.

part. When we move our fingers, and look at our fore-arm, we can see the muscles that move them contracting; or we can feel the muscles in strong contraction when we press a finger on each side of the cheeks, near the angles of the lower jaw, and firmly close the jaws; or when we place one finger in the armpit, and the other on the breast, and then draw the arm downwards and across the chest with a jerk. This contractile power of muscles is quite different from elasticity. The first is an original source of power, while elasticity merely modifies its distribution. Thus, it is the elasticity of the mainspring of a watch that keeps it going for twenty-four hours, but the muscles of the hand which winds it up is the true moving power.

136. The muscles are generally collected into bundles, which are found, when examined, to consist of lesser and lesser bundles, bound together by firm sheaths. Those employed for moving the skeleton are fixed by their ends to the bones, and are very various in their shapes, but commonly terminate in tendons, or sinews, which are of a very intricate structure, and of great strength. Taken together, the tendon may be viewed as a strong rope, and the muscular fibres, when contracting, as so many hands that are pulling at it. Fig. 28 shows the bundles of fibres of which a muscle is composed; Fig. 29, the zigzag state into which these are thrown during contraction, and which, indeed, is the cause of contraction.*

Fig. 28.

Fig. 29.

137. Professor Ehrenberg states, that even in animalcules, when these minute creatures are darting through the fluid, he has seen parts contracting which he thinks are muscular bands. The bodies of the other Radiata seem almost wholly contractile, but no distinct muscles have

* Prevost and Dumas, two eminent French physiologists, describe this as the appearance of the muscle when contracting, but the accuracy of their description has lately been rendered doubtful by other researches.

225. What is a muscle? and its use, properties, &c.?
226. Peculiarities of the muscles.

hitherto been discovered, and their powers of locomotion are generally very limited. Except in the highest of the Mollusca, the locomotive powers are not much greater; but many of these have distinct and strong muscles. It is by powerful muscles that the oyster and the mussel so firmly close their shells. The muscular system of the Articulata is particularly well marked, and their activity and power are proportionately great. Lyonet has counted, in some species of caterpillars, not less than 4000 muscular bands. A beetle, placed under an ordinary candlestick, is able to move it; a fact which shows a wonderful degree of muscular energy in so small an animal. Ants will carry loads forty or fifty times heavier than their own bodies; and a small insect, called the *Cicada spumaria*, will leap five or six feet—at least two hundred and fifty times its own length. Dr. Roget remarks, that this, if the same proportions were observed, is equal to a man of ordinary stature vaulting through the air a quarter of a mile.

138. It is, however, in the vertebrated division that the action and arrangement of the muscular system have been studied with the greatest care. Anatomists have given names to between 400 and 500 muscles in the human body; but the parts of what is called a single muscle by anatomists, often have different and even opposite uses. Professor Grant states, that, in the proboscis of the elephant alone, there are nearly 1000 muscles.

139. The covering of the skin hides from our view the busy scene beneath. Could we behold properly the muscular fibres in operation, nothing, as a mere mechanical exhibition, can be conceived more superb than the intricate and combined actions that must take place during our most common movements. Look at a person running or leaping—or playing on a harp or piano—or watch the motions of the eye! How rapid, how delicate, how complicated, and yet how accurate, are the motions required! Think of the machinery necessary to articulate distinctly 400 words, most of them requiring several separate move-

227. Number and force of muscles illustrated.
228. Name some of the wonders of muscular action.

ments, in the space of a minute; or of the endurance of such a muscle as the heart, that can contract, with a force equal to sixty pounds, eighty times every minute, for eighty years together, without being tired.

140. To muscular contraction are principally owing the infinitely varying shades of expression in the human countenance; and even in the lower animals, we see that the feelings to be expressed, and the parts that are to express, are in unison. A cow or a horse not only does not snarl like a dog or a tiger, but is absolutely incapable of doing so; and for this plain reason, that the latter are furnished with express muscles for drawing up the sides of the mouth, which the cow and horse altogether want.

141. The muscles are generally arranged in sets, which are opposed to each other, like workmen in a saw-pit. We have thus a set that bends the limbs, and a set that extends them; sets that lower the body or head, and sets that raise them up; and it is even in the same manner that the mouth is kept in the centre of the face. When palsy affects the muscles on one side of the face, those opposite, having no counterbalancing power, draw the mouth to that side.

142. It is exceedingly interesting to note the many modes nature employs to accomplish progressive motion among the Vertebrata—making use of two legs in man, four in quadrupeds, the legs and tail in the kangaroo, the tail in fishes, &c. &c. We can say only a few words as to her greatest achievement in locomotion, that of flight—a feat which it has foiled all man's ingenuity to imitate. When an animal has to pass rapidly through the air, nature seems to have bestowed her chief care upon two circumstances; 1st, to lighten the whole fabric as much as possible, which is principally accomplished by making the solid parts thin and hollow, at the same time that the whole body is filled with air like a sponge. Thus, the skeleton of a pelican, five feet long, was found to weigh

229. Influence of the muscles on the face.
230. Symmetrical pairs of muscles, antagonists.
231. Differences in locomotion among animals, and corresponding structures.

only twenty-three ounces. And, 2dly, by concentrating the muscular power in those parts that are to be the chief instruments of motion. The two pectoral muscles which move the wings of the swallow, have been estimated to possess more power than all the others in the body put together. A flap from a swan's wing has been known to break a man's leg, and a similar blow from an eagle has been instantly fatal. This great power will appear absolutely indispensable, when we consider that a swallow, as well as many birds of prey, will probably often pass through not much less than 1000 miles daily. All the functions, indeed, contributing to locomotion, exist in the highest intensity in the bird. Its skeleton, of all animals, is the most highly ossified; its muscles act with the greatest energy; its blood, to support this energy, is richest in red globules, and the respiration, to arterialize the blood, in it alone is double.

143. Perhaps no ordinary circumstance has so much influence on the general health, as due attention to the state of the muscular system. We may be convinced of this in two ways; for, 1st, we see persons, whose system no means can prevent continually running into disorder, evidently because they persist in leading an indolent, inactive, or sedentary life, in which the exercise of the muscles is totally neglected; and, 2dly, we see others, who neglect almost all the rules considered essential for securing health except this, that they incessantly exercise their bodies in the open air, and who yet pass through life almost without a bodily ailment. Under ordinary circumstances, and with a moderately good constitution, in a country like our own, we may say, that the condition above all others which can secure and preserve the inestimable blessing, health, is varied exercise in the open air. With this, our food, however plain, is sweet, our body is light, our digestion easy. Without it, the salt that gives relish to every dish is absent—we live the prey of a thousand tormenting sensations—our diseases become

232. Importance of muscular action to health.
233. Practical suggestions, and results.

intractable, our secretions morbid, our children are weakly and stunted, and the term of life is materially shortened.

144. Among the poorer classes, those who suffer most from neglecting muscular exercise, are the various artisans who follow sedentary occupations, and females who are constantly employed in different kinds of needle-work, &c. Among the more wealthy classes, literary persons, and those engaged in engrossing occupations, suffer much

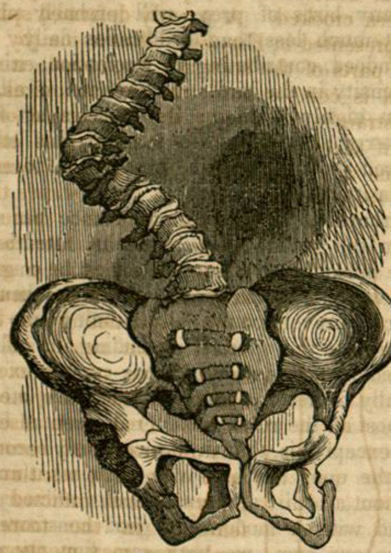


Fig. 30. Deformed Spine.

from neglect of it; but, above all, females suffer from this cause, and especially young females attending school, who are often at once enormously overtasked, in acquiring what are considered the necessary branches of education, and denied those playful sports, which alike nature and com-

234. What of sedentary employments?
235. Illustrations in the diagram.

mon sense dictate as agreeable and proper. In all the classes of persons referred to, the effects of neglected muscular exercise are shown in a general increased susceptibility to disease; and in the females of the better classes, inability of the muscles to support the spine, and consequent curvature of it, are but too common. Dr. Forbes states, that in a boarding-school, containing forty girls, which he inspected, he did not find one, who had been at the school for two years, whose spine was not more or less crooked. A greatly deformed spine of this kind is represented in Fig. 30. The spine (by which all the upper parts of the body are supported), it should be recollected, is composed of twenty-four pieces, that are kept in a straight position by the contraction of its muscles; and if these are not exercised, like all other parts, they become weak and shrivelled, and are thence unable to support their burden. In Fig. 31, A shows the natural upright line the spine presents when viewed from behind; B shows the deviation a girl's spine sustained after the muscles had been weakened by a fever, but which went nearly off in a few weeks from proper exercises; C shows the line the spine then presented; D shows a case in which this deformity had become inveterate. To show what an extent of injury is thus inflicted on young females, in the more wealthy ranks, we may mention, that the late Mr. Shaw, of London, who had great experience in this disease, states, that for one poor child twenty rich ones are affected; that among the poor children, the proportion of boys and girls is about equal; but that, among the rich, for one boy a hundred girls have crooked spines. It must be

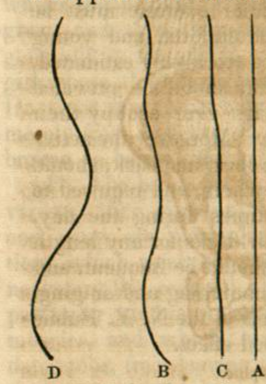


Fig. 31. Deformities of Spine.

236. Dangers of young females at school.
237. Pernicious effects of neglected exercise.
238. Danger of tight lacing.

obvious, therefore, that there is something greatly wrong in the system of training to which these girls are generally subjected.*

145. We can but very briefly refer to the kinds of exercise that are most proper. These, indeed, must vary with the condition, the opportunities, and the inclinations of individuals. In general, when the weather permits, three or four at least out of the twenty-four hours should be spent in some out-of-door exercise. Let this be persevered in, and there are few who will not acknowledge its benefits. Such exercises as engage the mind at the same time are to be preferred. Games and sports, gardening, botanical and geological excursions, hunting and shooting, &c., are of this kind. Where it can be had, perhaps one of the best, for both sexes, is exercise on horseback; but of whatever kind it may be, let this be remembered by all, that if it is wished to possess health, and properly to enjoy life, a sufficient amount of muscular exercise must be taken. [The value of exercise for children and young people, especially females, cannot be too highly estimated. In every school the seats at the desks should be provided with backs, nor should the scholars ever occupy their seats more than one hour at a time. Moreover the active exercise of the muscles of the arms, chest and back, should be a part of school discipline everywhere, and required to be performed in concert several times during the day, especially after being seated at their desks for any length of time. The intervals of study should be frequent, and cannot be better employed than by marching and singing, as is practised in the primary schools of the N. Y. Public School Society with remarkably good effect.

* No doubt, want of exercise is the main cause of this, but the pernicious fashion of lacing tight the stays also contributes to produce distortion of the spine; for besides that this prevents the natural supports, the muscles, being exercised, it is a physiological law that all parts much pressed on become absorbed. Perhaps, also, something is due to the false taste that prevails among the higher classes, as to a certain delicacy of habit being necessary to gentility. Nothing can be more unnatural, or more injurious in its consequences.

239. Importance of out-door exercise.

Among the recreations of children, those which call for active muscular exertion should be encouraged. Jumping the rope is admirably adapted to girls, and will be found preferable to swinging, and greatly to be preferred to dancing as an exercise, irrespective of the unhealthful and demoralizing associations usually concomitant with the latter.

But by far the most salutary and invigorating mode of exercise for young people is found in the cold plunging or shower bath, to which children should be trained by their parents, as a part of domestic discipline. The utility of this practice cannot be overrated.]

146. There is one state of the bones called rickets, in which the earthy matter is deficient, and which often proceeds from original weakness of constitution. The bones are consequently soft and yielding, and are sometimes bent in a most extraordinary way. There is another state, in which the amount of earthy matter in the bones is too great, and then they are very brittle. This happens generally in old and in young people. We lately saw a girl whose thigh-bone broke from merely turning in bed. Dr. Good saw an old lady who broke both her thigh-bones merely from kneeling in church, and who had her arm broken on being lifted up.

147. The bones, joints, and muscles, are all subject to various other diseases. In scrofulous habits, the bones and joints are particularly liable to low, obstinate affections, which wear out the constitution, and often render necessary the removal of the limbs. Rheumatism is a particular kind of inflammation that attacks the joints or muscles, and which occasionally becomes excessively dangerous, from leaving these and attacking the valves of the heart, and the bag (pericardium) in which it is contained.

To show the animal without the earthy matter of bones, steep the rib of a sheep, or other slender bone, in one part of muriatic acid (spirit of salt), and eight of water, for a few hours. It will then bend

240. What of different modes of exercise?
241. Diseases of bones and joints.

in any direction. To show the earthy without the animal matter, place a bone in a clear fire for about ten minutes.

A vertebra or two of the horse or other quadrupeds should be seen, to form a proper idea of the spinal canal, &c.; and also the back-bone of a cod or haddock. A section of a cod's spine should be made to show the cup-like cavities in the bodies of the vertebræ. The articulations of the two upper vertebræ referred to in the text, can be well seen in the calf. Give the butcher directions to preserve attached to the head the two upper vertebræ; clear off the flesh from the fore part of these, cut into the first and second articulations, and separate the vertebræ from the head. The tooth-like process, the ligaments, &c., will then be seen. At the same time may be shown the ligament that supports the head, by cutting away the flesh behind the vertebræ.

To give a clear idea of what a muscle is, it is interesting to take off the skin from a pigeon's breast, and show the extent of its immense pectoral muscle. On the other side, the muscle may be cut through to show its thickness; and its attachment to the first bone of the wing (humerus) should be shown. A small muscle (lesser pectoral), having a different insertion, will be found beneath the greater pectoral. The comparatively small size of the muscles of the leg, the tendons going to the toes, &c., may also be easily shown.

A stucco cast, showing the superficial muscles of the human body, may also be made very interesting, when their uses can be explained.

The inspection of a few skeletons or parts of skeletons of any of our common animals—a dog, cat, squirrel, weasel, mole, cock, swan, cod, &c.—adds greatly to the interest of this section; and it is still better, where there is an opportunity, to visit such collections as the Anatomical Museum belonging to the University or Royal College of Surgeons in Edinburgh.

For appropriate figures to illustrate this section, see Penny Cyclopædia, vol. viii., page 57;* Roget's Bridgewater Treatise, vol. i., pages 129, 178, 333, 337, 411, 437, 441, 447, 465, 530, 559; Bell on the Hand; Dr. Smith's Philosophy of Health, vol. i., pages 171, 189, 196, 205, 237, 312, 321; Bell's Anatomy, vol. i., pages 254, 258.

SECTION VIII.

THE NERVOUS SYSTEM.

148. We have now to enter on the consideration of those parts that essentially distinguish an animal from a vegetable, and the organs of the animal from those belonging

* A figure taken from the London Fashions answers better than the "modern beauty."

242. What essentially distinguishes animals from plants?

to the organic life; or, in other words, we have to speak of the parts that give us the power of voluntary motion, and which enable us to feel and to think.

149. In all but the most simple animals, it is quite certain that sensation and voluntary motion depend on the nervous system. The nervous system of man consists of the brain, the spinal marrow, and the nerves. As these are all composed of nearly the same kind of substance, we may view the spinal marrow and brain as nervous matter collected into masses, and the nerves as the same matter diffused over every part of the body. The brain, as has already been mentioned, is contained in and protected by the cranium or skull. It is also enclosed in three layers of fine membrane, the outermost of which (dura mater) is strong and tough, and adheres to the skull at different points; the middle layer (arachnoid) is so fine as scarcely to be visible; and the innermost one (pia mater) not only envelopes the brain, but also penetrates into certain parts in its interior. The spinal marrow has similar coverings, and is contained in the canal formed by the rings of the united vertebræ, represented in Fig. 25, *b*. The nerves are cords, attached to the brain and spinal marrow, which are composed of brainy matter enclosed in numerous minute sheaths, bound together by a strong covering (neurilema), as seen in Fig. 36, *g*.

150. When we examine the outer surface of the brain, we observe it folded or convoluted, as seen in Fig. 32, *a a a* (which shows a longitudinal section of the brain and upper part of the spinal marrow, with the nerves attached to them); and when it is cut into, we find it composed, 1st, of a gray pulpy substance, mostly placed externally, and, 2dly, of a similar white substance, placed internally. The same materials exist in the spinal marrow, but the white matter is external, while the gray is internal. What is commonly called the brain, is divided by anatomists into the cerebrum or proper brain (Figs. 32, *a*, and 33, *a*), and the cerebellum or lesser brain (Figs. 32, *b*, and 33, *b*),

243. Describe the nervous system.
244. What is said of the brain and its membranes?
245. Difference externally and internally in colour.