THE HUMAN FOOT

T. S. ELLIS

THE

HUMAN FOOT

THE

HUMAN FOOT

ITS

Form and Structure

FUNCTIONS AND CLOTHING

BY

THOMAS S. ELLIS

CONSULTING SURGEON TO THE GENERAL INFIRMARY
AT GLOUCESTER

MUSCLES, IN EFFECTING THE FUNCTIONS, SUPPORT THE STRUCTURE
AND INFLUENCE THE FORM

LONDON:
J. & A. CHURCHILL
11 NEW BURLINGTON STREET

1889.

JOHN BELLOWS, GLOUCESTER 195855

AS AN EXPRESSION OF GRATITUDE

OF ADMIRATION, AND OF AFFECTIONATE REGARD

I DEDICATE TO

SIR JAMES PAGET, BART.

THIS ILLUSTRATION

OF A PRINCIPLE IN PHYSIOLOGY

EARLY IMPRESSED UPON ME BY HIS TEACHING

AT ST. BARTHOLOMEW'S HOSPITAL

THAT MORE THAN ONE EFFECT GENERALLY RESULTS

FROM THE EXERCISE OF A FUNCTION

ERRATUM

On page 56, for *pollicis* read *digitorum*.

INTRODUCTION

A book by a Surgeon on a subject closely related to his profession, but not intended exclusively for members of it, may call for some explanation as to origin and object.

The City and Guilds of London Institute for the advancement of Technical Education, have, for some years past, conducted examinations in a variety of subjects: in these is included, under the head of Boot and Shoe Making, "*The anatomical construction and natural functions of the human foot.*" On every subject but this, "Works of Reference" are given, the list being often a long one, of books in English, French and German. On this subject not one is named.

The want thus plainly indicated is felt also by those who, in military or in civil life, or as regards either sex, desire to understand the principles of Physical Education, and who, knowing that the form of the body is influenced more by the manner than by the amount of muscular exercise, seek to learn how to direct it. Evidence is offered that, in at least one respect, the ordinary mode of using the feet, although supported by military authority, is wrong.

Reasons have also been given why some ideal forms, as represented by artists, do not accord with a true appreciation of the "essential character"* of the human foot.

If the need of such a book be recognized, it will be admitted that no one but a Surgeon would be likely to write it.

* Murray's *Greek Sculpture.*

Any special fitness I may have for the task is due to the circumstance that, more than twenty years ago, one of my own feet was very much damaged by an accident, in consequence of which I was, for six years, always lame, frequently in severe suffering. I owe my recovery to an independent study of the structure in relation to the functions of the feet, and the interest, thus strongly excited, has been kept up, although the personal stimulus has, happily, long ceased to operate.

Details of Anatomy have, as far as possible, been avoided. Such as appeared to be necessary are given in the form of explanations to the plates, so arranged that the figures and the explanations may be seen at the same time. For these illustrations I have been glad to rely on works of recognized authority and I am indebted to my old teacher and friend Mr Holden, for permission to copy from his *Osteology;* to Messrs Longman, for the same kindness in respect of *Gray's Anatomy*, and to Mr Marshall, who very generously placed at my disposal the specially beautiful drawings in his *Anatomy for Artists.* For other illustrations I am responsible.

To the printer, Mr Bellows, a "man of letters, or, rather of words,"* whom I have the privilege of regarding as a personal friend, and to his staff, particularly to Mr Huntley the artist, my best thanks are due.

Not without careful study, over many years extending, has my book been produced. Not without hope that it will prove to be useful, is it now presented.

6, *Clarence Street, Gloucester,*
May, 1889.

* Oliver Wendell Holmes—*Our Hundred Days in Europe.*

POSITION OF REST

PLATE 1.

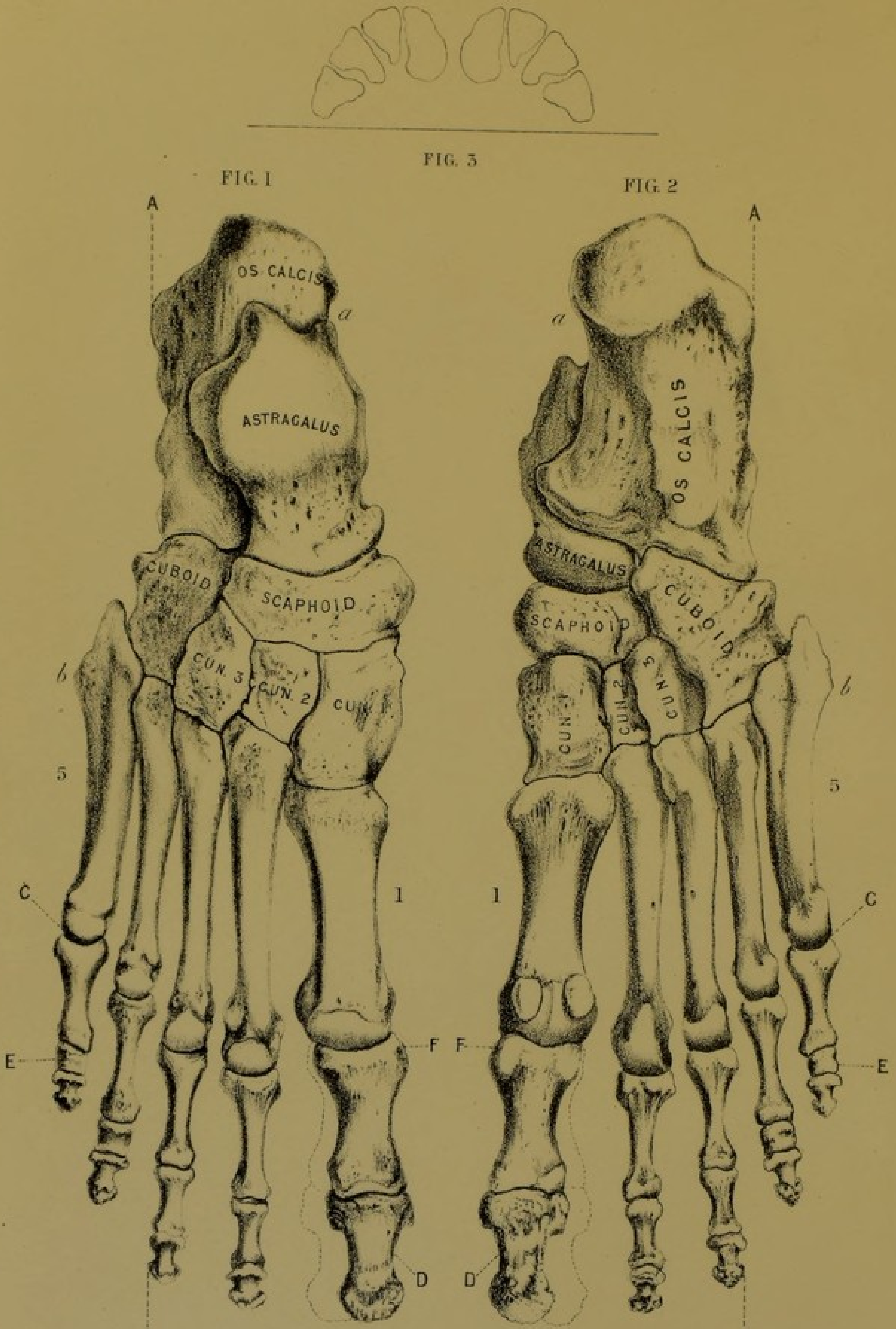


FIG. 3
FIG. 1
FIG. 2
A
OS CALCIS
a
ASTRAGALUS
CUBOID
SCAPHOID
CUN. 3
CUN. 2
CUN. 1
b
5
1
C
E
F
D
B

EXPLANATION OF PLATES

Plate 1, Fig. 1 is a view of the upper surface of the skeleton of the right foot. The bones are named as follows:—The **Astragalus (Talus or Huckle bone)** connects the foot with the leg, the large bone of which (**Tibia**) rests upon it where the name is written, clipping it on the inner side by a projection downwards as shown, in section, by fig. 16, pl. 5, where the **Fibula**,* or smaller bone of the leg, is seen to clip it on the outer side. The Astragalus rides on the **Os Calcis (Calcaneum or Heel bone)** beyond which it projects, hanging over on the inner side in front of the letter *a*, while a large portion of the latter bone is, on the outer side, unconcealed by it. The two bones named come up to a fairly even line across the foot. A division at the joints is shown by fig. 9, pl. 3. The smooth rounded head, elongated in one direction into an oval form, fits into a corresponding hollow in the **Scaphoid** bone, so called from its boat-like form.† On the outer side is the **Cuboid**, having the form of a cube, though somewhat irregular. Extending from it to the inner margin of the foot are three wedge-like or **Cuneiform** bones.

The seven bones of the foot, named, form the **Tarsus**, corresponding to the wrist or **Carpus** in the hand. The body of the foot is completed in front by five long **Metatarsal** bones, forming the **Meta-tarsus**, and fixed to the *tarsus* by an irregular line receding backwards and outwards. They are numbered 1 to 5, the fifth having a point projecting backwards by the side of the *cuboid* bone. This point is concealed in the living foot, but a rounded projection outwards (*b*) can always be felt.

* The bones of the leg, Tibia and Fibula, are so called from their supposed resemblance, the former to a pipe or flute, the latter to a clasp.

† For the same reason, sometimes called navicular, a name better avoided, because, in the horse, applied to an altogether different bone.

The *Metatarsal* are united to the *tarsal* bones by their bases, while their heads form the supports at the roots of each of the five toes. Each bone of which the toes consist is called a phalanx, from a fancied resemblance to a *phalanx* of soldiers. These phalanges, two for the first or great toe, three for each of the others, have their *bases* or *proximal* ends towards the foot, their *heads* or *distal* ends pointing forwards. They are numbered first, (next the foot) second or middle and third or final; in the case of the great toe, first and second, or final, only. In the smaller toes, especially the fourth and fifth, the *phalanges* are often indistinct, being fused together.

The smooth articular surface on the first *metatarsal* bone which helps to form a joint with great toe should be noticed. It extends farther back on the side next the second toe, so that the great toe in moving upwards moves towards the position indicated by the dotted line. In the position as seen in the drawing it is supposed to be flat on the ground.

A line from A to B is seen to pass by the side of the heel, and to cut off from the rest of the foot the two outer toes and their metatarsal bones. The lines C D and E F mark the irregular lines of hinges formed by the joints. Their significance will be explained in the text.

Fig. 2 shows the same (right) foot turned over and the under surface seen. The very irregular projections of the bones contrast strongly with the smooth surface on the upper side. These exist for the attachment of muscles, for the guidance of tendons, and for the protection of blood vessels and nerves. The deep groove on the *cuboid* bone for a tendon, shown in fig. 14, pl. 5, is to be noted.

The manner in which the *astragalus* overhangs is clearly seen as well as the bracket-like projection of the *os calcis* to support it. The greater part of the head of the *astragalus*, as seen where the name is written, is unsupported by bone, and rests in the complete foot on a ligament only. Compare fig. 11, pl. 4, with fig. 5, pl. 2.

Fig. 3 is a section, in outline, of the three *cuneiform* and of the *cuboid* bones, taken obliquely across each foot. It marks a transverse arch in each foot, the two combining to form a larger arch.

Figs. 1 and 2, (adapted,) and fig. 3, (given in duplicate,) are taken from Holden's *Osteology*.

PLATE 2.

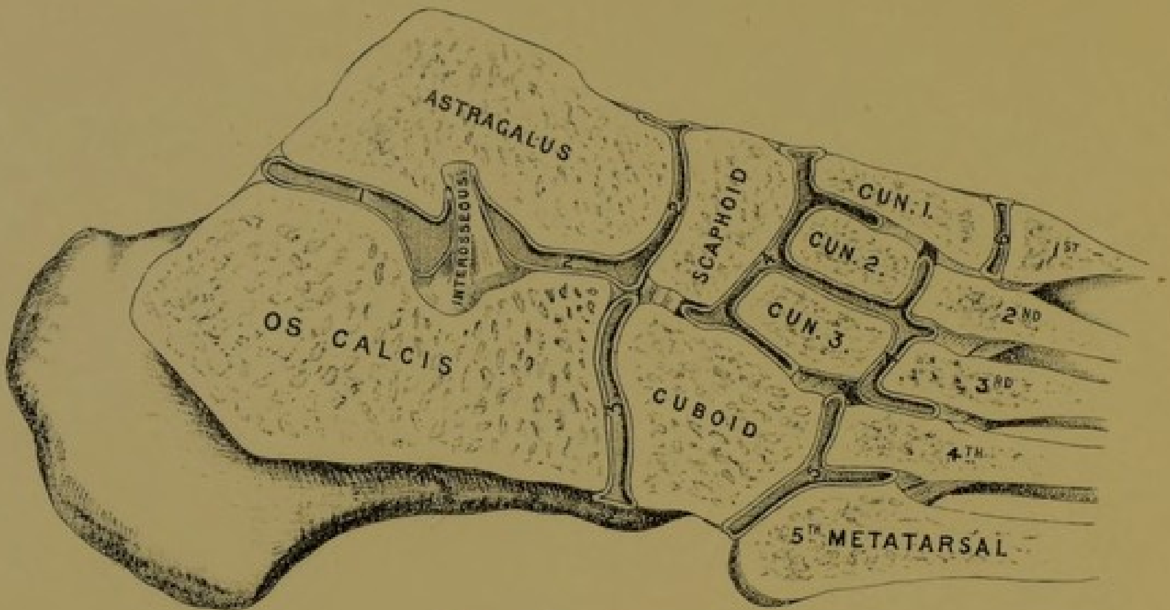


FIG. 4

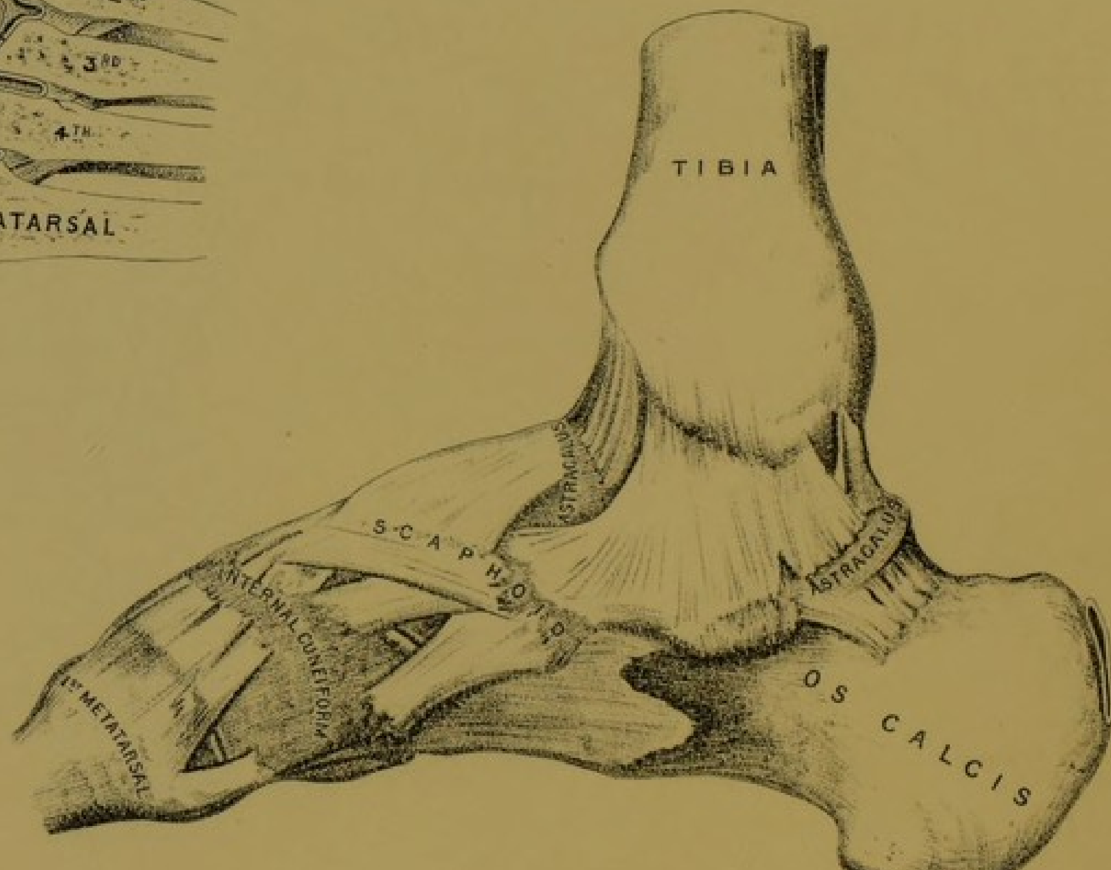


FIG. 5

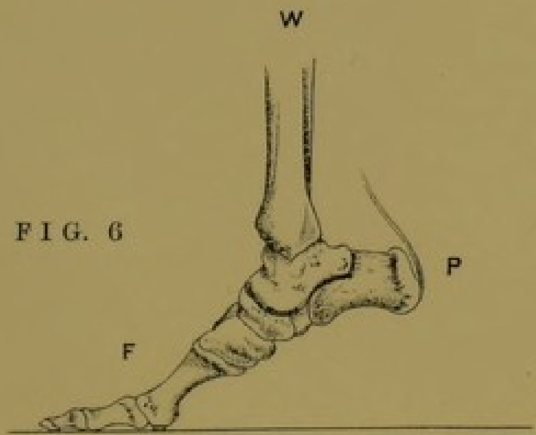


FIG. 6

PLATE 2

Plate 2, Fig. 4 shows the joints laid open as by taking a slice off the upper and outer surface of the foot. It will be seen that the *astragalus* and *os calcis* are united by two distinct joints. These are separated by a very strong ligament (*interosseous*) fitted into a groove in each bone so deep that, in the dried bones put together, the two grooves form a well marked tunnel between the two joint surfaces.

Fig. 5 shows how the bones of the tarsus, seen on the inner margin, are bound to the leg bone, to the metatarsus and to each other by strong ligaments. These it is not necessary to name. The positions of the bones are indicated, and it will be noticed that the head of the astragalus unsupported by bone, (fig. 2, pl. 1) is covered—it is in fact supported—by ligament. At the back of the *os calcis* is shown a small sac or *bursa*, which exists for the purpose of diminishing friction when the great tendon of the heel, attached below, slides over this surface.

Fig. 6 shows the heel uplifted. It is a sketch frequently given as expressive of the leverage of the foot, the power being the muscle acting on the heel, the body the weight and the ground the fulcrum. Taken alone, it conveys a wrong impression; other agency (to be explained) beyond the ligaments shown in fig. 5, are necessary to support the foot when in this position.

Figs. 4 and 5 are taken from *Gray's Anatomy*; fig. 6 from *Holden's Osteology*.

PLATE 3.

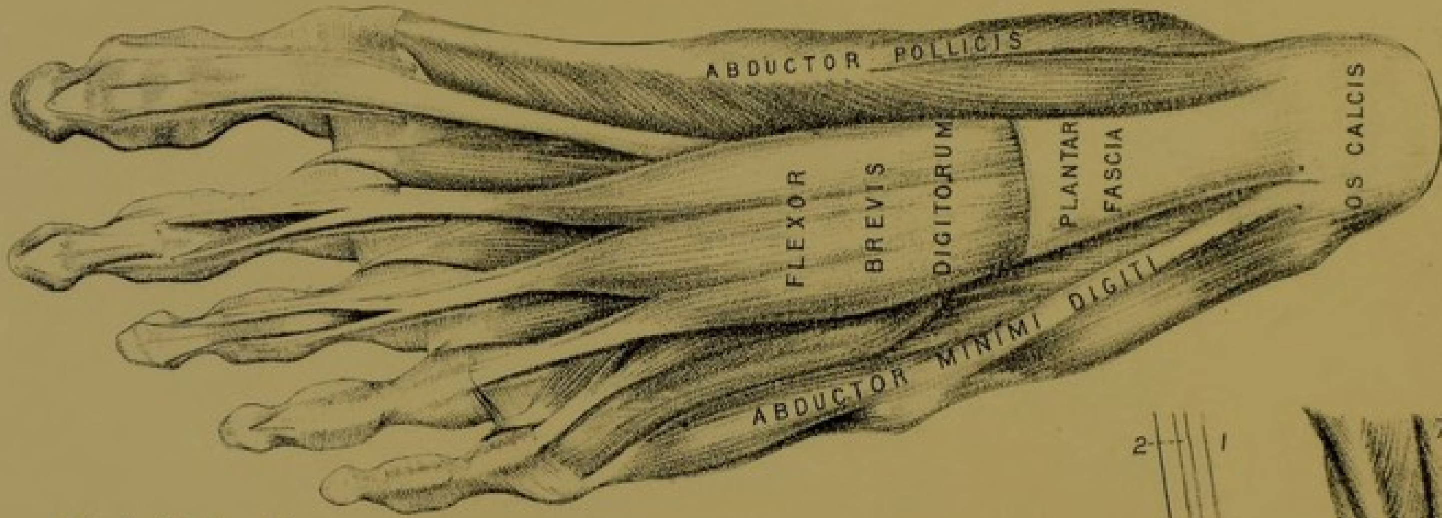


FIG. 7

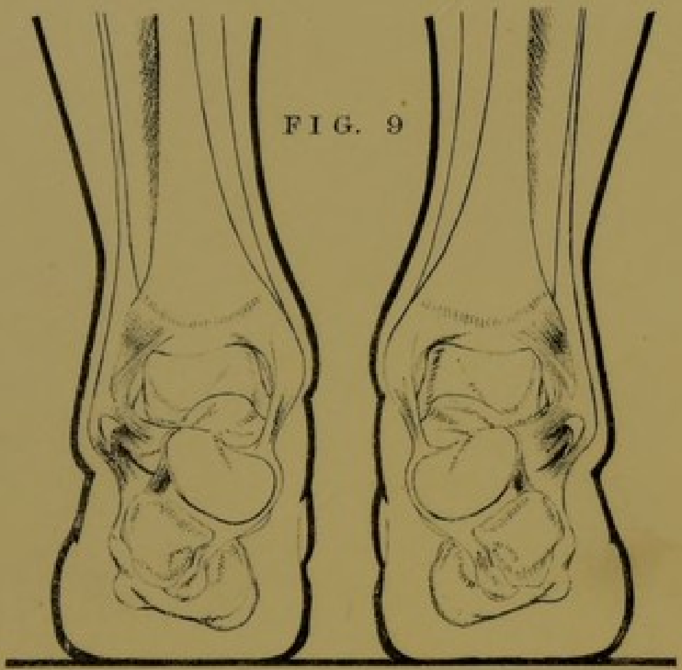


FIG. 9

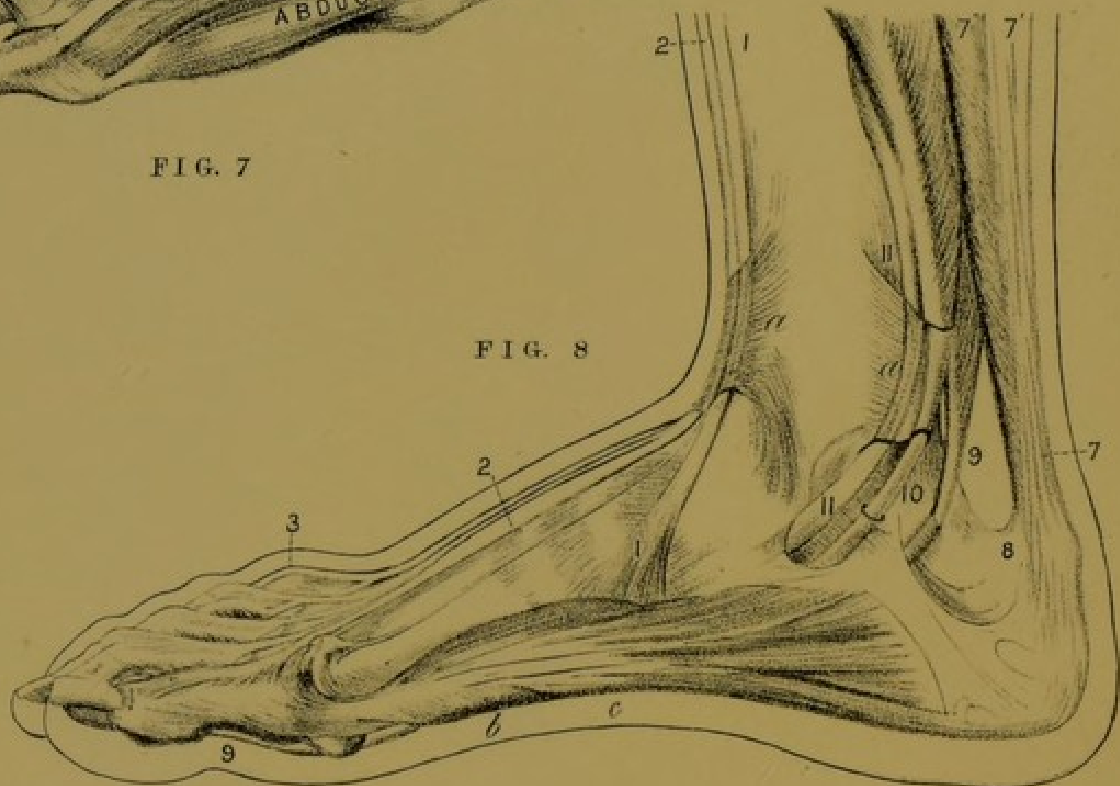


FIG. 8

PLATE 3

Plate 3, Fig. 7 represents the first or most superficial layer of the muscles* seen in the upturned sole. To give this view it is necessary to remove not only the skin, but also a cushion of soft tissue beneath and an expansion known as the *plantar fascia*. This consists of a strong layer of fibrous tissue, mostly arranged in a longitudinal direction, which covers in and protects the *muscles*, these latter being made up of masses of the fleshy substance familiarly known as lean meat, sometimes united to fibrous cords or tendons which connect them with the bones, sometimes directly attached to the bone. A portion of the *plantar fascia* is seen in front of the *os calcis* or heel bone with which it is closely connected; between it and its extensions between the muscles, on the one hand, and the skin, on the other, is a cushion of soft material, made up of fat and fibrous tissues binding the whole together. The muscle which occupies the middle of the foot (**flexor brevis digitorum**) serves to draw down, as it bends or *flexes*, the four smaller toes. Its fleshy or muscular attachment is to the *plantar fascia* and to the heel bone (*os calcis*) behind. The tendons go forward to the four smaller toes where they divide in order to allow another deeper seated tendon, that of the long flexor, (10, Fig. 8) to go between the two divisions. They re-unite and again divide, being ultimately inserted into the two sides of the middle phalanges.

The tendons are bound down to the toes by sheaths of interlaced fibrous tissue. These sheaths are shown entire on the *fourth* and *fifth* toes. In the *middle* toe the sheath has been laid open, and the tendon of the long flexor, passing between the two divisions, exposed. This *latter* tendon is, in the *second* toe, shown as cut through, revealing the smooth groove in which it runs.

The **Abductor pollicis** muscle, which draws the great toe towards the middle line of the body, away from the foot, and the **Abductor minimi digiti**, which draws the little toe outwards, are seen to be named with reference to an imaginary middle line of the foot, from which they *abduct*. Their muscular insertion is to the bones on the inner and outer sides of the foot respectively, and their tendons go forward to be inserted into the first phalanx of the great and of the little toe.

Fig. 8 gives a view, so far as can be seen from the inner side, of the muscles* which belong to the leg and foot. The tendons are all held close to the ankle by a band of fibrous tissue, (*a*) which encircles the ankle like a ring, the *annular ligament*. The fibres of the *flexor brevis pollicis* are seen

* A complete list of muscles is given after the description of pl. 6

above *b*, coming from the deep part of the sole to join the abductor pollicis. Taking the muscles by their numbers, the *anterior tibial*, (**Tibialis Anticus, 1**) has a muscular insertion into the shin bone or *tibia*, and, by a tendon, into the inner and under side of the *first cuneiform* and the base of the *first metatarsal* bone. The tendons indicated by Nos. 2 and 3 are best seen in fig. 15, pl. 5, where 4, 5, and 6 are shown. The great calf-muscle narrowed down as it comes towards the heel, consists of two parts, the **Gastro-cnemius and Soleus,** indicated by 7′ and 7″. These unite in the strong tendon of the heel (7), the **tendon of Achilles** or **tendo Achillis.** The number 8 indicates a tendon not distinctly seen, really a relic of a muscle which plays a more important part in animals, and is mentioned in the text—the **Plantaris.*** The number 9 lies in the opening between the *tendo Achillis* and the other muscles; which is, in the complete foot, filled in with fat. It refers to the **Flexor longus pollicis**, the muscle above it, whose tendon is seen at the root of the great toe in front of and behind the joint at the base, the interval being occupied by one of the small bones, known as **sesamoid**, of which two are placed, one on the inner and one on the outer side of that joint, as explained in Fig. 14, pl. 5. The Long flexor common to the smaller toes (**Flexor longus digitorum, 10**) comes next, which has an upper muscular attachment to the leg, and goes, by tendons, along the sole to the four smaller toes. The *posterior tibial* muscle (**Tibialis Posticus, 11**), also having a muscular attachment to the leg, is inserted by tendon beneath the inner margin of the foot, as seen in Fig. 14, pl. 5.

Fig. 9 is a view, seen from before, as given by a division of the foot through the joints immediately in front of the ankle. Above is seen the ankle joint itself exposed, the upper surface of the astragalus going up against and between the bones of the leg; this is better seen in a section taken a little further back (fig. 16, pl. 5), *through* the ankle. Below, on the inner side, is the head of the *astragalus*, which articulates with the *scaphoid* in front. On the outer side, nearer the sole, is that portion of the *os calcis*, which articulates with the *cuboid*. The tendency of the bones to become displaced inwards with the downward thrust caused by the weight of the body, a result (apparently) prevented only by the ligaments which bind them together, is obvious.

Fig. 7 is taken from *Gray's Anatomy*. Figs. 8 (the numbers being altered) and 9 (duplicated) are taken from *Marshall's Anatomy for Artists*.

* In the monkey tribes it tightens the plantar fascia (Fig. 7:) in man it is only rudimentary, and its tendon, merged in the *tendo* Achillis, does not even reach the sole.

PLATE 4.

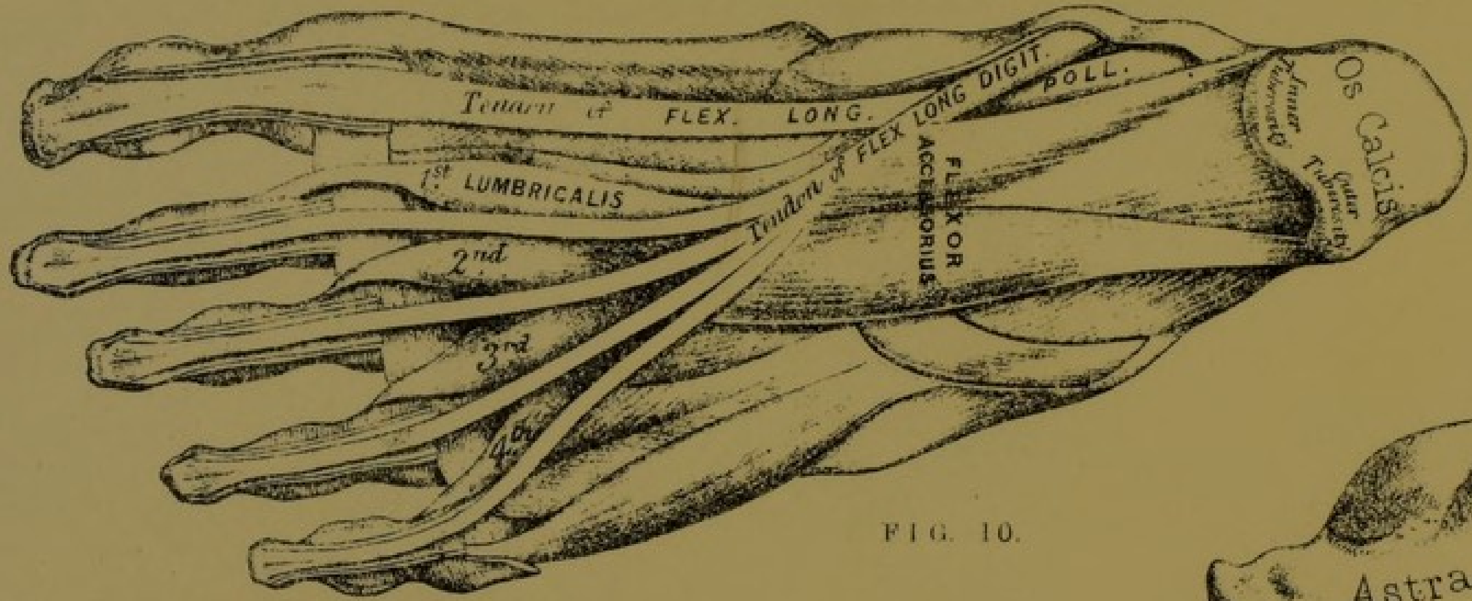


FIG. 10.

FIG. 12.

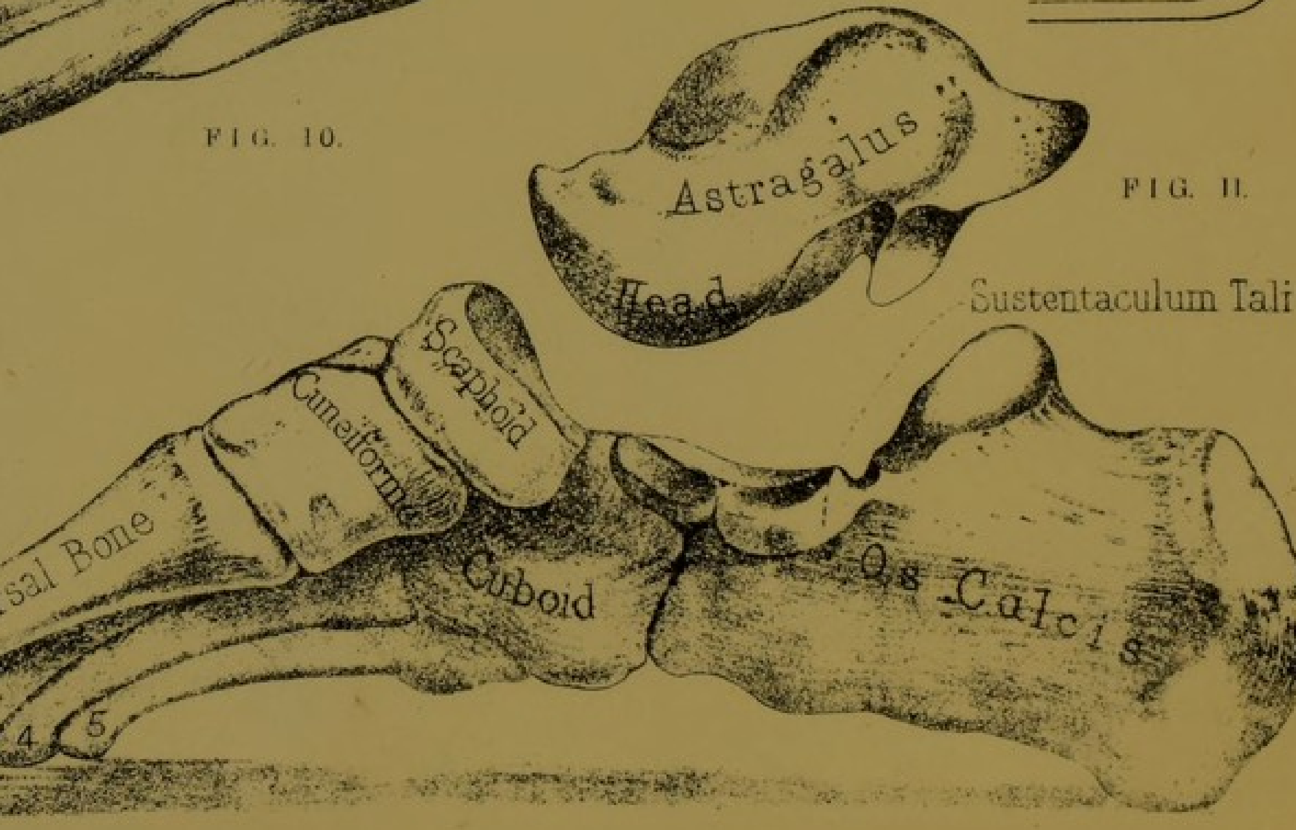
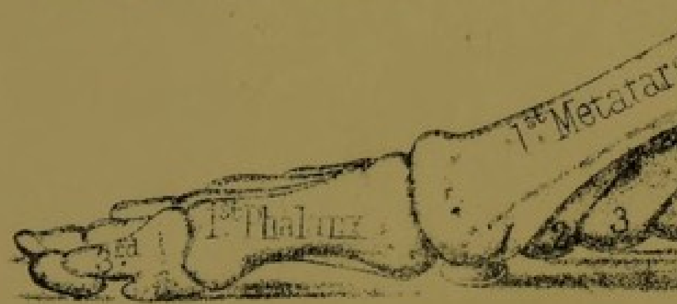



FIG. 11.

FIG. 13.

PLATE 4

Plate 4, Fig. 10 reveals a second layer of muscles,* the *flexor brevis digitorum*, *abductor pollicis*, and *abductor minimi digiti* having been removed. To the tendon of the *flexor longus digitorum* at its point of division is united a muscle which is attached by two heads to the two tuberosities of the *os calcis*. and to this tendon. In action it has the effect of throwing the tendon with which it is united into line with the long axis of the foot. It is an accessory flexor, **Flexor accessorius.** Outside this the tendon of the *peroneus longus* (pl. 5) muscle is seen crossing obliquely the sole from the outer to the inner side.

The four **Lumbricales** muscles, so called from their worm-like shape, are here marked : they were partly seen in fig. 7. These muscles are attached to the tendons of the *flexor longus digitorum* and, by means of tendons, to the base of the second phalanges of the four smaller toes ; they join with the long *extensor* muscle, (pl. 6) and represent muscles in the hand of much importance.

Fig. 11 is a view of the bones forming the arch of the foot seen from the inner side. The *astragalus* is uplifted to show the bed in which it lies, transmitting the weight of the body backwards to the heel and forwards to the toes. The view of the under surface of the sole in fig. 2, pl. 1, shows the *os calcis* projecting over to the inner side, a rounded point being particularly prominent. This is here shown as the **Sustentaculum tali**, so-called from giving support to the *astragalus* or *talus*. A ligament stretching from this point to the *scaphoid* bone completes the joint in which the head of the *astragalus* moves. It is shown at this point in fig. 2, pl. 1, as unsupported by bone.

A deep groove separating the two articular surfaces on the upper surface of the *os calcis* corresponds with another on the under surface of the *astragalus*. These, filled up by ligament, are seen in fig. 4., pl. 2.

The heads of the metatarsal bones, numbered 1 to 5, are seen to recede backwards, which gives the arch the shape of a half-dome. Upon these, the anterior pillars of the arch, the whole weight of the body would fall when in the tip-toe position but for the relief afforded by muscles.

In the act of rising to tip-toe the tendons shown in fig. 10 (*flexor longus pollicis* and *f. l. digitorum*) are tightened. This

* A complete list of muscles is given after the description of pl. 6.

draws the tips of the toes towards the points where the tendons turn below the ankle, (fig. 8, pl. 3) and so tends to throw upwards everything between those limits, as tightening a bow-string increases the convexity of a bow.

The effect of this action is to brace up the arch and to relieve the strain on the ligaments shown in fig. 5, pl. 2. But not only so ; it lifts up the heads of the metatarsal bones, the anterior pillars, so that they rest on so many tightened cords, and injurious pressure against the ground is prevented. All this is most marked in the case of the great toe, where a small bone is seen beneath the head of the metatarsal bone ; the use of this (sesamoid) bone is explained with fig. 14, pl. 5.

In this toe the phalanges are marked 1st and 3rd. This is the usual numbering. If, however, it be regarded in the light of the typical mammalian foot, the metatarsal bone is really a phalanx, although, as seen in pl. 1, it is ranged in line with the other metatarsals. Strictly, it is the first of these which is missing but it would be inconvenient to so consider it.

Fig. 12 marks the order in which the three tendons shown in fig. 8, pl. 3, come round the ankle. As seen in fig. 10, they cross in the sole, the second going below the third.

Fig. 13 marks the effect of this. The *flexor longus pollicis* being low down at the heel is picked up and drawn away from the sole line as *C D* is picked up by *A D*. Thus, as a greater space between *C D* and the ground line is obtained, so a similar effect results in the foot.

Fig. 10 is taken from *Gray's Anatomy*. Fig. 11 from *Holden's Osteology*.

The drawing on stone for this plate was used to illustrate my monograph on *The Arch of the Foot* in 1877, and has lost its softness.

PLATE 5.

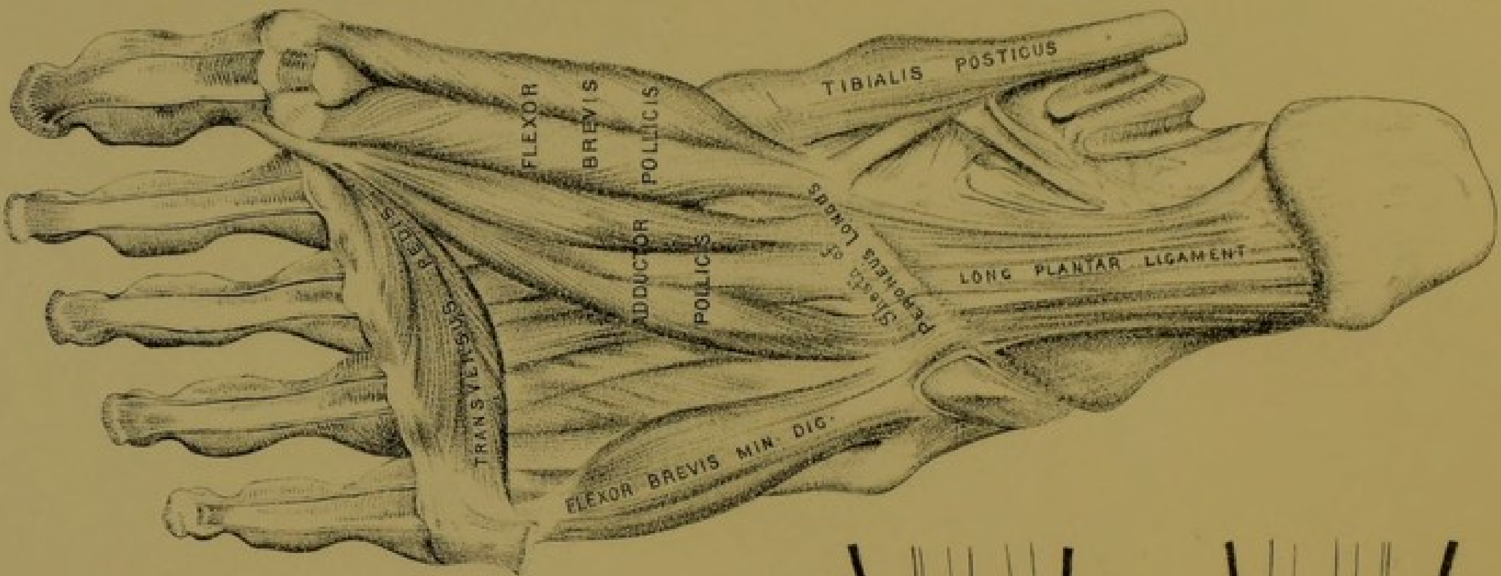


FIG. 14

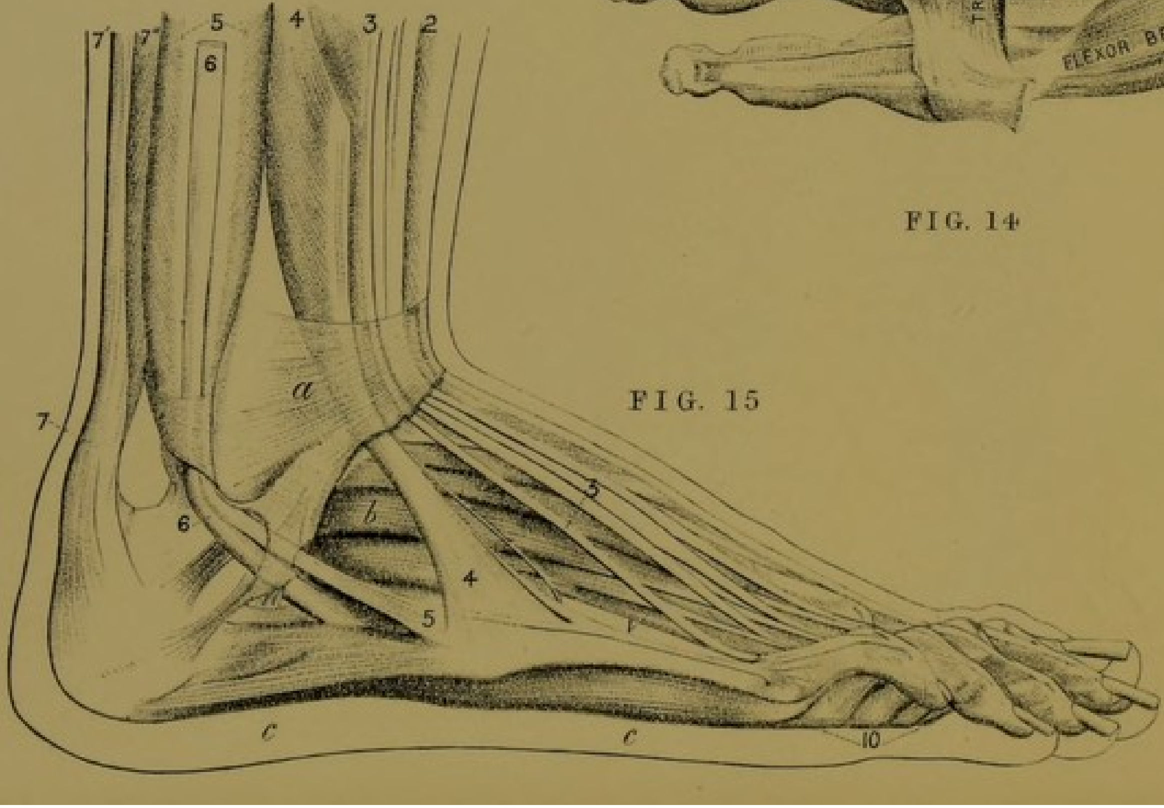


FIG. 15

FIG. 16

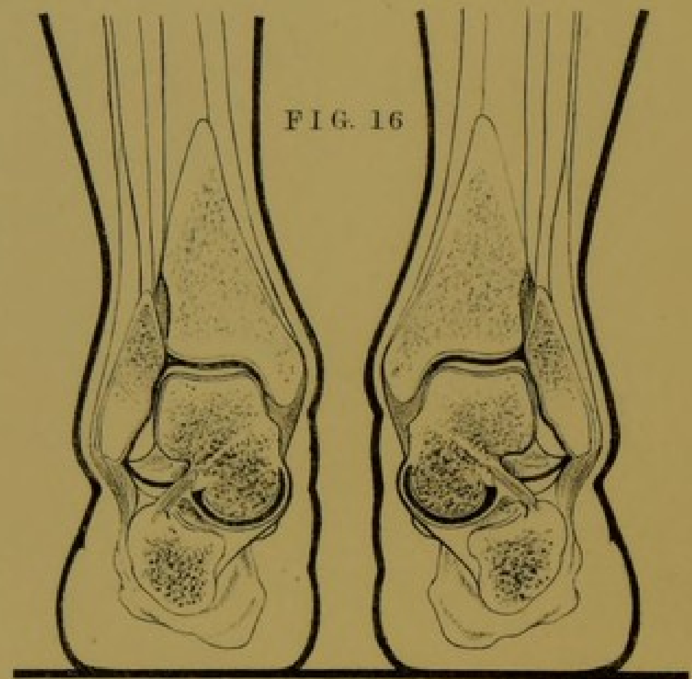


PLATE 5

Plate 5, Fig. 14 shows a third layer of muscles,* the *flexor brevis*, *accessorius*, and *lumbricales* having been removed. The manner in which the margin of the foot overhangs on the inner side is strikingly manifest. The tendon of the *tibialis posticus* muscle which has come down behind the inner ankle is shown. This tendon passes under the *sustentaculum tali* seen in fig. 13, supports the ligament which connects this and the *scaphoid* bone, and is inserted into that and the *inner cuneiform* bone. The groove next to it is for the *flexor longus digitorum*; the one next the heel for the *flexor longus pollicis*.

The sheath for the tendon of the *peroneus longus*, which, having come down behind the outer ankle, curves round the outer margin of the foot and crosses the sole, to be inserted on the inner side of the base of the *first metatarsal bone*, is seen across the sole.

Closely combined with this sheath is the *long plantar ligament* which unites the bones beneath in front with the heel behind. From this sheath attached to it, the short flexor muscle of the little toe (**Flexor brevis minimi digiti**) passes to be inserted into the first *phalanx* of the little toe. The tendon of the *abductor* (fig. 7, pl. 3) is seen cut through near its insertion To this sheath is also attached the **Adductor pollicis muscle**, which draws the great toe towards the middle line of the foot as the *abductor* (fig. 7, pl. 3) draws it from that imaginary line. The **Flexor brevis pollicis** is also united to the sheath of the *peroneus longus*, and, going forward, is divided : one half blends with the *adductor* to be attached to the one side of the base of the great toe, the other half blended with the *abductor* to be attached to the other side. A small muscle which crosses the foot **Transversalis Pedis** also blends with the *adductor*.

* A complete list of muscles is given after the description of plate 6.

The two little rounded eminences at these points of attachment represent two small bones embedded, one in each of the combined tendons, and serving to relieve the tendon of the *flexor longus pollicis*, which runs in the groove between them, from pressure by the weight of the body. They are called, from the resemblance to a grain (*sesamum*) *sesamoid bones*.

Fig. 15 is the outer view corresponding to fig. 8, but *b* here represents the short extensor muscle of the toes, better seen in fig. 18, pl. 7, and *c* indicates the *flexor brevis minimi digiti* already seen in fig. 14.

PLATE 5, continued

The numbers 2 and 3 indicate the long extensor muscles of the great and of the smaller toes, better seen in fig. 18, pl. 6. The **Peroneus tertius** (4) is also there seen. Attached to the leg above it is inserted, by a tendon, on the base of the Metatatarsal bone of the little toe. Close to this is the tendon of the **Peroneus brevis** (5) which, however, comes from its attachment to the leg *behind* the ankle, curving round the end of the *fibula*. So, too, does the **Peroneus longus**, (6) but the tendon passes into and crosses the sole as seen in fig. 14.

The tendons of the *flexor longus digitorum* (10) are seen *under* the smaller toes.

Fig. 16 is a vertical, transverse section through the ankle. The *interosseous* ligament, shown in fig. 4, pl. 2, is seen filling up the groove in the *astragalus* and in the *os calcis*. The two leg bones, the *tibia* on the inner and the *fibula* on the outer sides, are also shown with the expanded lower ends cut through. The inclination inwards, showing an apparent disposition to give way, is very manifest.

Fig. 14 is taken from *Gray's Anatomy*. Figs. 15 (the numbers being altered) and 16 (duplicated) are taken from *Marshall's Anatomy for Artists*.

PLATE 6.

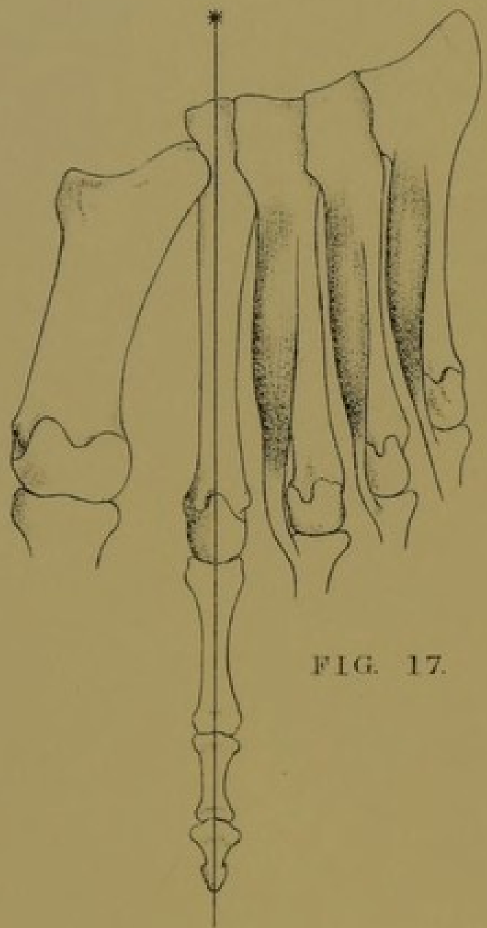


FIG. 17.

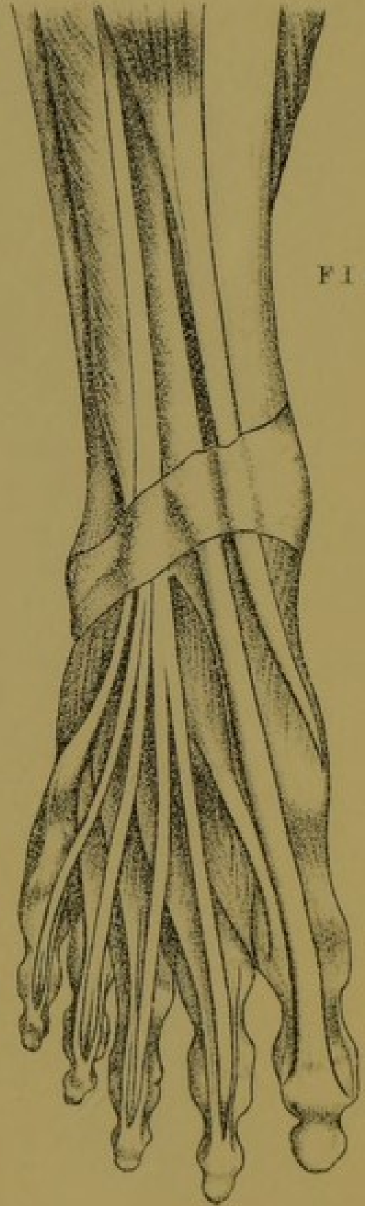


FIG. 18.

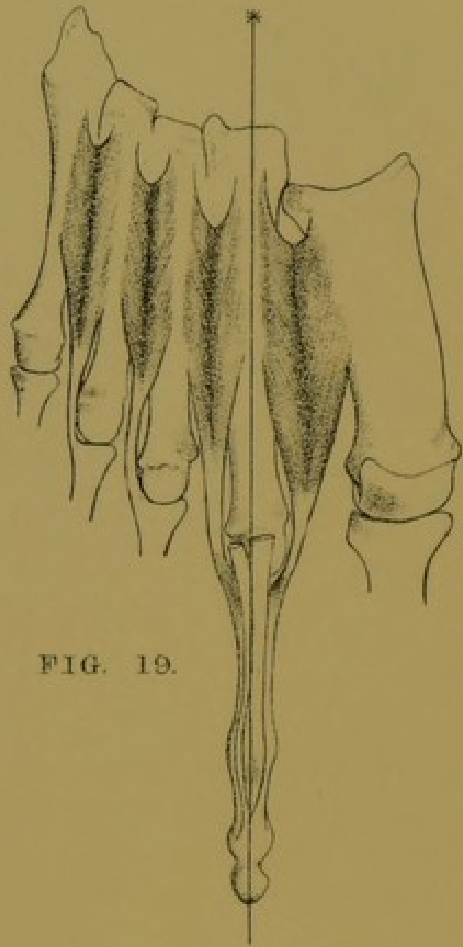


FIG. 19.

PLATE 6

Plate 6, Fig. 17 represents the fourth layer of muscles * found in examining the upturned sole, all those shown in figs. 7, 10, and 14 having been removed. Three small muscles, between the Metatarsal bones, or *interosseous* (**Interossei**), are here seen. They are distinguished as *plantar*, because found in the sole, from the dorsal seen in fig. 19. The tendons are inserted on the inner side of the base of the first phalanx in the three outer toes. The action of these muscles is to draw the respective toes towards an imaginary line, shown, running along the middle of the second toe.

Fig. 18 shows the muscles of a foot of the same (right) side examined from above. The encircling band or annular ligament is seen as at *a* in figs. 8 and 15. On the inner side is the tendon of the *tibialis anticus*, going down to be inserted on the inner side of the foot. Then the (special) long extensor muscle of the great toe, **Extensor longus (proprius) pollicis**, with its tendon inserted into the final phalanx. Outside this is the extensor muscle common to the four outer toes, **Extensor longus digitorum**, also going down to be inserted into the final phalanges. Finally, a tendon really coming from a part of this muscle, but known as the **Peroneus tertius**, numbered 4, fig. 15, pl. 5, is seen to be attached to the base of the fifth metatarsal bone. Below the annular ligament, and beneath the tendons mentioned, is the fleshy mass of the short extensor muscle common to all the toes, the **Extensor brevis digitorium**—there is no *special* short extensor to the great toe—the tendons pass, one to the first phalanx of the great toe, and three others which unite with the tendons of the *long extensor*, going to the three middle toes. It has no connection with the little toe.

In fig. 19 all the superficial muscles seen in fig. 18 have been removed. Four *interosseous* muscles (**Dorsal Interossei**) are seen, each attached to two *metatarsal* bones by muscular or fleshy attachments. The tendons of the two first are inserted one on either side of the base of the first phalanx of the second toe. The third tendon goes to the outer side of the first phalanx of the third toe. The fourth has a corresponding relation to the fourth toe. They all draw in a direction from an imaginary line down the middle of the second toe, just as the *plantar* muscles in fig. 17 draw the three outer toes towards it.

Figs. 17, 18, 19 are taken from *Gray's Anatomy*.

* A complete list of muscles is appended.

MUSCLES OF THE FOOT AND OF THE FOOT AND LEG.

Latin Names	English Equivalents
Of the foot (*figs.* 7, 10, 14, 19)—	
Abductor pollicis	Abductor of the great toe
Abductor minimi digiti ...	Abductor of the little toe
Adductor pollicis	Adductor of the great toe
Flexor brevis pollicis	Short flexor of the great toe
Flexor brevis digitorum ..	Short flexor of the smaller toes
Flexor Accessorius	Accessory flexor
Lumbricales[1]	Lumbrical
Transversalis pedis	Transverse muscle of the foot
Interossei	Interosseous—plantar and dorsal
Extensor brevis digitorum ...	Short extensor of the toes
Of the leg and foot (*figs.* 8, 15, 18)—	
1 Tibialis[2] anticus	Anterior tibial
2 Extensor (longus[3]) proprius pollicis	Extensor of the great toe
3 Extensor longus digitorum...	Long extensor of the toes
4 Peroneus[4] tertius	Third peroneal or fibular
5 Peroneus brevis	Short peroneal "
6 Peroneus longus	Long peroneal "
7′ Gastro-cnemius,[5] and 7″ Soleus,[6] uniting in the 7 Tendo Achillis	Calf muscles, uniting in the Tendon of Achilles
8 Plantaris[7]	Plantar or sole muscle
9 Flexor longus pollicis ...	Long flexor of the great toe
10 Flexor longus digitorum ...	Long flexor of the smaller toes
11 Tibialis[2] posticus	Posterior tibial

[1] Or worm-like.

[2] Attached to the tibia.

[3] There is no *special* short extensor of the great toe.

[4] Attached to the περόνη, Greek equivalent of fibula.

[5] γαστήρ belly and κνήμη leg; from its prominence in the calf.

[6] Flat or sole-like, deep in the calf.

[7] In man, only rudimentary.

PLATE 7.

FIG. 20.

FIG. 21.

PLATE 7

Plate 7, fig. 20 represents impressions, taken with printer's ink, and reduced, from the sole of a boy æt $11\frac{1}{2}$, in duplicate. The awkward look of a single sole print is not apparent when the two are seen together, the curves round the toes running into each other gracefully. The line, known as Meyer's line, is seen to run through the centre of the heel and along the middle line of the great toe. A line from the inner side of the heel to the inner side of the great toe will be found to pass clear of the joint at the root of the latter. The form of the area covered as by a dome or bell-shaped covering, when the two ankles are joined, is also evident.

Fig. 21 is from a photograph of the same feet as in fig. 20. Each of the inner lines indicates the tendons of the *tibialis anticus* muscle coming down to be inserted, and to fix the *creasing point* on the upper surface of the inner margin of the foot. The outer line (corresponding to Meyer's line in the sole) represents the *leading line* on the back of the foot, following the crest of the ridge.

The buttress-like appearance of the part of the foot corresponding to the two outer toes is clearly shown. See the lines *A B* in pl. 1.

THE HUMAN FOOT

OF the two feet with which man is endowed, each may be regarded as the counterpart of the other, in every respect corresponding. It is, however, impossible to understand the feet, from whatever point of view they be regarded, unless we consider them in combination.

I might have chosen *The Human Feet* for my title, but it would, possibly, have conveyed an impression that the *varieties* of human feet would be discussed, which would be foreign to my purpose. We are concerned with elements and characters common to the feet of mankind in general, or, at least, to all of the higher races. Little reference will be made to differences in type or in details as found in the feet of different races or of individual persons.

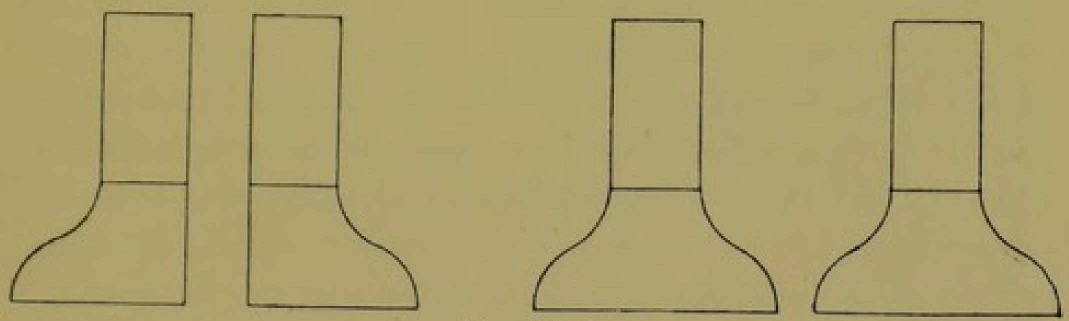
The two feet are perfectly symmetrical : a description of the right foot would serve equally well for the left, by the mere change of words having reference to the inner and outer sides in relation to a line between the two. Each fulfils a precisely corresponding purpose in respect of the two sides of the body, and each is necessary to the other in completing the support afforded by the two together. Thus, each, in relation to its fellow, is the complement as well as the counterpart.

On the other hand there is a marked difference between the two sides of either one, taken singly, and it is most important that they who seek to understand the mechanism of the foot should fully realize the utter absence of symmetry between the inner and the outer side.

It is for the purpose of assisting in this that fig. 3, pl. 1, fig. 9, pl. 3, fig. 16, pl. 5, and figs. 20, 21, pl. 7, are given in duplicate form. One derives a very different impression on regarding the contour of a foot, however beautiful, if it be seen singly or in combination with its fellow. Take, for instance, the outline of the sole as left in the foot-print of a naked foot. It is unmeaning, not to say awkward-looking, and can hardly strike one as elegant at all. But if we look at the two together, as shown in fig. 20, pl. 7, we see at once how the outer line of one gracefully falls into the corresponding line of the other; and a single foot-print, when next seen, leaves a mental impression far more favourable, because it is associated with the fellow foot necessary to complete the figure. In form, then, each is the complement as well as the counterpart of the other. But this is not all: the two sides differ materially in structure and in function, as well as in form. Nor can we determine the true principles on which foot-clothing should be made, with due regard either to comfort and utility or to artistic effect, unless the elementary facts that the two sides are not symmetrical, and that each foot is the complement of the other, be kept constantly in view. The two sides of any form of foot-clothing should not be made to match; the real beauty lies in the well-marked difference which is essential to utility, and this should be expressed rather than effaced in the clothing.

It is from these four points of view—Form, Structure, Function and Clothing—that the human feet will be considered. How closely they are all four connected together and bound up in each other will appear as we proceed.

Feet are too commonly regarded, or at any rate treated, as if they were pedestals or plinths on which the legs, as pillars, rest in standing. Their great complexity of structure and the great variety of movement of which they are capable would seem to forbid any such idea ; but if it be permissible to regard them in such an aspect at all, it must be not as two pedestals or plinths, but as the two halves of one divided, and the divisions separated. A front view or elevation, as seen in fig. 21, pl. 7, would, if represented in diagram, be like fig. 22 rather than like 23.



Figs. 22, 23

Marking the difference between two halves of a single plinth, and two whole plinths.

In the one there is expansion on both sides ; in the other on the outer side only. But if the hinder part of the foot be taken, as shown in a section through the ankle, (fig. 16, pl. 5) there is no lateral expansion at all. This is entirely in front. and, as shown in fig 21, pl. 7, is confined to the outer side.

In the front or expanded part of each foot the inner margin is or should be straight, while the outer margin describes a bold curve. The straight inner margin is nearly in line with that of the heel, the two sides of which, fairly parallel, are directed forwards, or rather, very slightly outwards.

All this is seen in pl. 7, where, in fig. 21, the outer parts of the feet have somewhat the appearance of being tacked on to the rest of the foot. This appearance is still more manifest in the skeleton, as seen in pl. 1. A line drawn from A to B passes on the outer side of the third toe through the foot and along the outer side of the heel bone. This cuts off the two outer toes with the part of the foot behind them and in front of the heel. The area cut off by this line forms a kind of set-off in the ground-plan outside the main structure enclosed between it and the inner margin. Across the line of separation only one bone (the cuboid) projects, and this serves to connect the two outer toes with the part receiving the downward pressure of the body. The outer side of each foot does, in reality, act as a kind of buttress to the main structure. No such influence is needed on the inner side : an equivalent is more than supplied by the other foot. Here is a striking illustration of the statement that the one foot is the complement as well as the counterpart of the other.

The prominences which the expansion of the leg bones form at the ankle should here be noted, and the observation made that the outer is narrower, that it comes lower down and that it is situated farther back than the one on the inner side.

The inner margin differs from the outer in greater height as well as in absence of lateral expansion. This, however, is not attended with fully corresponding increase of thickness. In great part the inner margin is raised up as well as thickened, so that a hollow is left beneath from the heel to the base or root of the great toe. An arch is thus formed, visible only on the inner side of the foot. The posterior pillar consists of the projecting heel, which abuts on the ground without lateral expansion on the ground line. The anterior pillar, formed by the heads of the metatarsal bones, (fig. 11, pl. 4) is unevenly extended on the ground line by the varying length of the toes. This expansion on the ground line is most solid and most extended in a line with the inner margin of the foot where it is formed by the specially developed great toe. The heel, the arch, the great toe, and the straight inner margin contrasting with the curve on the outer side, are striking characteristics of the human foot.

The same figure, (pl. 4) shows how very deep the hollow beneath the sole on the inner side would be if everything but the bones were removed, and how very shallow it is on the other side. In fact, the hollow parts of the two feet form the two halves of a dome, which, however, is shaped somewhat irregularly. The vault is more expanded in the longitudinal than in the transverse diameter, and the longitudinal diameter more extended in the anterior than in the posterior direction. The outer expansion, as seen in the drawing, touches the ground along a part of its margin only, the part formed by the heads of the metatarsal bones at the roots of the five toes; but, when the sole is filled up and the bones are covered with their usual covering of soft tissues, it is only in very highly arched feet that any opening is left beneath. Thus the dome-shaped character of the two feet, taken together, is made even more complete, if less conspicuous, when the foot is in the ordinary condition than it is in the skeleton. The extent and form of the area which, when the two feet are close together in standing, is not pressed upon but covered in by a dome or bell-shaped covering, is seen in fig. 20, pl. 7.

The inner margin of these semi-domes will be the subject of frequent reference. Each forms the visible portion of the arch already mentioned, which is not only a striking feature but plays a most important part in the mechanism of the foot. Formed by a rising of the sole or *planta*, it is frequently called the plantar arch ; sometimes from the fact that it consists mainly of the bones of the *tarsus* (the name applied to the bones collectively forming the body of the foot or instep) it is spoken of as the tarsal arch. This structure has been regarded as a weak point in the construction of the human body ; an eminent surgeon, distinguished as a practical and philosophical anatomist, speaks of it as one of nature's hardest tasks to make and maintain well and strong. I do not concur in that view : my contention for many years has been that, given fair play to the functions of the foot, the arch will, even in respect of provision against deformity, bear comparison with any structure in the body. Taking the astragalus, (pl. 1 and 4) on which the legs directly rest, as the key-stone, the posterior division is composed of one bone only, and the downward pressure from the leg is transmitted through it to the ground while the bone is inclined at a slightly diverging angle. Thus the maintenance of the structure in this part presents no great difficulty : it is the part anterior to the astragalus where the weakness is most apparent. A failure or sinking of it causes the ankles to topple over, as often seen in weakly children, the condition being well known as " weak ankles." A still greater sinking constitues flat-foot.

The object for which the arch of the foot exists is generally stated to be that of giving elasticity by yielding to pressure. It is supposed to afford something of the up-and-down movement of a carriage spring, but this element, although sometimes very useful, is very much over-rated, Elasticity of tread depends on a very different cause. The best feet have the arch the most rigid and unyielding. Special provision, to be hereafter described, is made to prevent the arch from yielding in active exercise, and in good feet it gives way but little, even in standing, provided it be for a moderate period only. Such elastic property as it possesses would be beneficial in breaking the shock of a fall from a height, if the weight should come directly on the *foot* rather than on the toes, as it ought to do ; but the main purpose which the arch serves is, in my view, that room is provided in the hollow for various important parts, including blood vessels, nerves and a number of small muscles, which are thus preserved from the injurious influence which the weight of the body pressing them against the ground would occasion. The injurious effects of such pressure, when the arch has sunk and flat-foot has resulted, will be seen when that deformity is explained.

If to the description given it be added that the legs which rest on the arch, that is to say, on the inner sides of the sections of the divided dome, have the lines of downward pressure directed inwards towards the margin of each section rather than outwards towards the circumference of the dome, and that these semi-domes are constructed of yielding material, the statement may well lead one to exclaim that bad construction, from a mechanical point of view, could not be more forcibly illustrated. And yet such a description would be strictly true of the structure before us : the weakness is, however, apparent only. Such disposition to yield as there is exists for very good reasons, and the provisions against undue yielding are as complete as could be desired.

The foot is arched not only in the longitudinal but also in the transverse direction. Fig. 3, pl. 1, is more than a diagram ; it accurately represents in outline a transverse section of the bones in about the middle of the foot passing in an oblique direction through the three cuneiform and the cuboid bones. It will be seen that while each foot forms in itself a transverse arch, the two, if joined together, would also constitute an arch. This figure gives another illustration in support of the statement that one foot is the complement as well as the counterpart of the other. The transverse arch, thus represented, can have but little of this supposed carriage-spring action, being unsupported by any solid bearing at either end. It must, however, be obvious that blood vessels and nerves lying in the hollow are much better protected from injury than if the bones presented a plane surface from side to side.

The contour indicated by the bones of the transverse arch, as seen in this figure, is not that seen in the foot. On the outer side of the slope rests the fleshy mass formed by the *extensor brevis digitorum* muscle, (fig. 15, pl. 5) which gives a roundness of outline to the well developed foot. The well-known cast of the Venus di Medici has this feature very strongly marked, a little too strongly, as I think, for a foot which has little to suggest muscular vigour. This muscle lies on the top of the foot, free from injury by pressure in walking or standing. The more complex arrangement of muscles in the sole require the longitudinal arch to protect them.

The very existence of this arch suggests the fact that the weight of the body falls on the two abutments, the heel and the expanded front part of the sole. The two parts do not, however, serve precisely similar purposes. We rest on the heel, but we tread on the front part. This latter, on which the weight of the body falls when the heel is upraised, is, therefore, conveniently called *the tread* of the foot.

Much of the difficulty which is felt in any attempt to describe the form of the foot is due to the circumstance that it has no well-defined dividing lines : there is certainly no middle line. It will be seen hereafter that there is some reason for regarding the middle line of the second toe as, functionally, the middle one, but there is nothing in the visible form to mark this.

Professor Meyer, of Zurich, more than thirty years ago, pointed out the important fact that, in a natural, healthy foot, the middle line of the great toe continued backwards passes through a central point in the heel. He might, I think, have gone further, and said that all the toes radiate from that centre. This line, which should always be called Meyer's line, is shown in fig. 20, pl. 7. This plate is taken from a foot-print made by a foot, the sole of which had been covered with printer's ink, and drawn in duplicate. The subject was a boy of eleven, whose feet I know to have been preserved from injury by boots.

Meyer's line being on the sole is not, under ordinary conditions, visible, but, more than this, it has no surface mark to indicate its position. If, however, we continue the middle line of the great toe on the *upper surface* backwards to the ankle, we find that it runs along the highest part of the foot; it runs, in fact, along the crest of the ridge. Here we have something tangible, visible. This is a line to which reference may be made in studying the contour of the foot. It is shown by a black tracing in fig. 21, pl. 7, which is taken from a photograph of the same feet as those which gave the foot-prints in the adjoining figure. It indicates the course of the long extensor tendon of the great toe, just as Meyer's line follows the course of the long flexor.

This line, seen upon the upper surface, but having its counterpart in the sole, marks, as we shall presently find, the principal line of action in the foot. I therefore regard the visible representative on the upper surface as *the leading line* of the foot, and propose to call it so. To so designate that which really marks the line of the great toe will serve to stamp the essential difference which exists, visibly, structurally and functionally, between the great and the smaller toes.

The crest or ridge along which the leading line runs soon ceases to be marked, and in front of the ankle is entirely lost. It can, however, be traced by forcibly lifting up the great toe and feeling for the tendon going down to it.

This line must not be confounded with another visible on the inner side of the leg, and running down to the foot. This latter is very distinctly seen and felt when the foot is forcibly bent or flexed on the leg, as shown in fig. 24. It

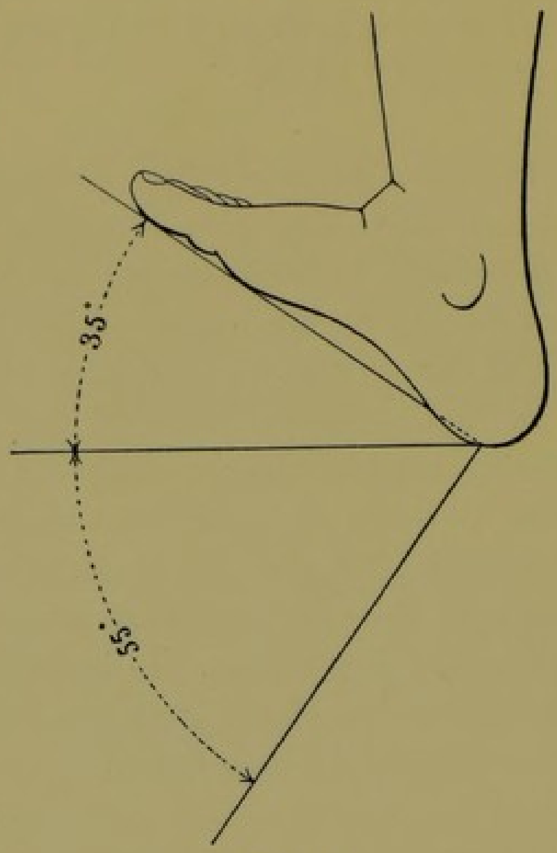


Fig. 24

Showing extreme range of flexion upwards and of extension downwards. The lower of the two short lines marks the *creasing point* on the back of the foot.

marks the course of the tendon of a muscle (*tibialis anticus*, fig. 8, pl. 3), and the point of insertion into the inner margin of the foot is one of some importance to note, first, because it is a point always to be found, and secondly, because it marks a line *across* the foot where a crease or bend must occur in any form of foot clothing. I propose, for the sake of a name, to call it the creasing point.

The inner margin of a good foot shows a well marked line, that of the arch, but this, even in a healthy well-formed foot, is liable to vary according to position. Figs. 25 and 26 mark this. They are copied from photographs, taken at the same time, of the same foot, as shown on pl. 7, the black line being previously marked on the skin. The only difference made was that which is shown. In the first the foot was resting on the ground, bearing the weight of the body; in fig. 26 the body was raised to tip-toe, still supported on the one foot. The two photographs were taken one directly after the other, and the drawings are faithful representations of the change in the curved line due to the change of position alone. This curved line is also found to vary according as the feet are turned outwards or the toes inclined towards those of the opposite foot.

Before the changes of contour and the movements on which they depend can be understood, it is necessary to realize the *Position of Rest*—the position to which the foot always tends in repose, and which it instinctively seeks when in pain. This I have elsewhere described,* with reference to every part of the body, as one of the least stretching of the ligaments which bind the bones together, and most even adaptation of the joint surfaces to each other—of least tension and least pressure. This is always found in a mean between the extremes of motion. Thus, as regards the ankle, we might be quite sure that it would not be in the position of the foot, as given in fig. 24; nor would it be when the foot is fully extended. The presumption is that it will be not far from a point midway between the two extremes. Even this will bring it towards extension, beyond the right angle of the standing position. My impression is that it generally inclines still further towards extension, as shown in the frontispiece.

It is a curious circumstance, in connection with the position of rest in the foot, that the deformity with which

* "The Position of Rest, in Fatigue and in Pain."—*British Medical Journal*, 1878. Vol. I.

infants are not infrequently born, known as club-foot, is an exaggeration of this position. It is also remarkable that it involves a marked resemblance to the hinder-hand of some of the Quadrumana. Indeed the position of rest in the limbs generally involves a departure from the human character, most manifest in action, and a retrogression towards a primitive type, as seen in the lower animals.

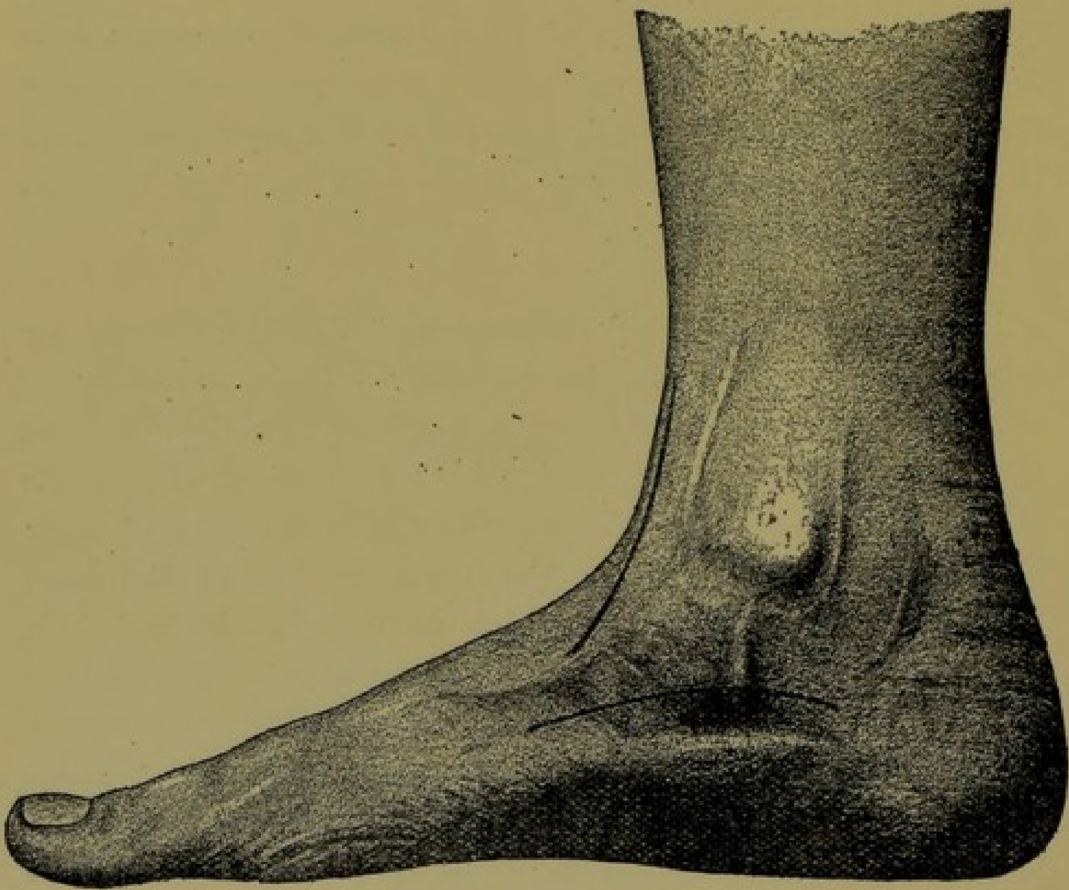


Fig. 25

A foot at rest is always more or less extended towards a line continuous with that of the leg; it is never at right angles with it, as in standing. The front part is inclined inwards towards the middle line of the body, and is slightly uplifted, with a corresponding depression of the outer margin. The great toe is inclined upwards, away from the sole line, and outwards, towards the other toes; lying in contact with the second. There is no bending; it maintains the straight line, as if on the ground. The smaller toes are all turned downwards, flexed, so that there is a marked difference between them and the great toe. The frontispiece is taken from a photograph of a plaster cast used in Art Schools.

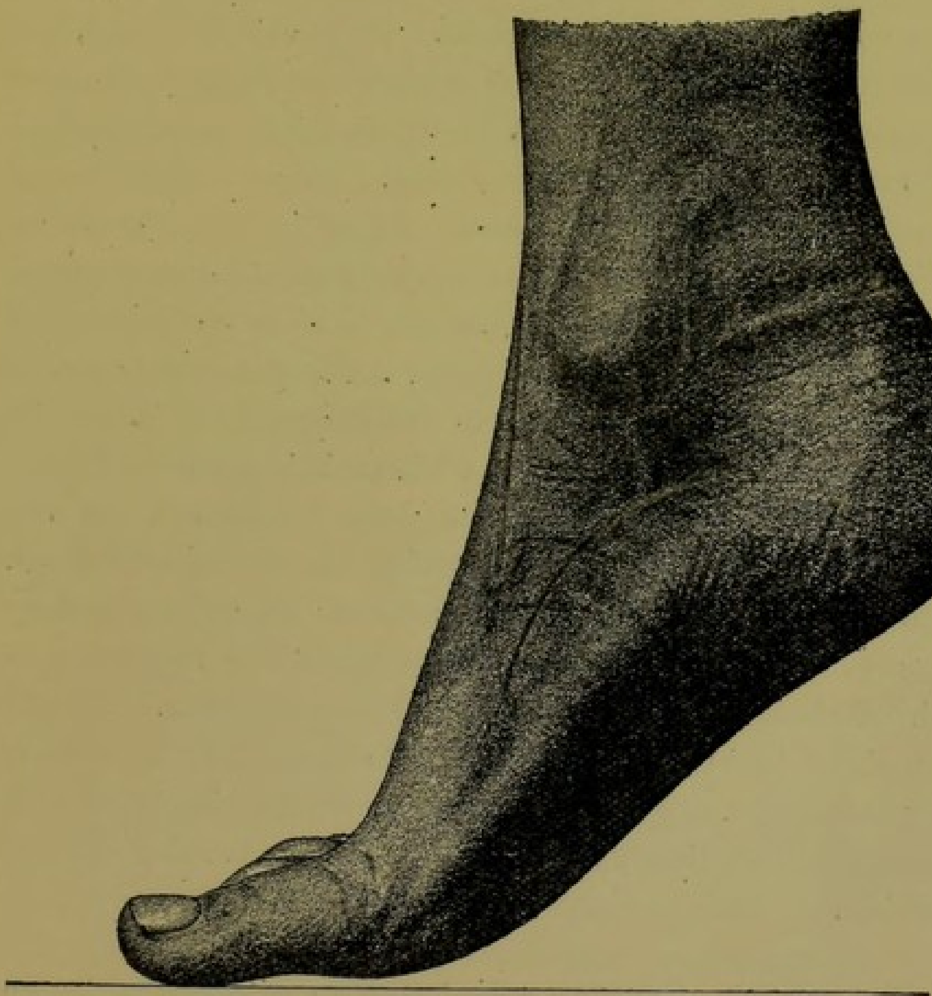


Fig. 26

These figures, (25, 26) show the increase in the curve of the plantar arch when the foot is raised to tiptoe, as indicated, by alteration in the curved black line previously drawn on the foot. The upper line marks the course of the *tibialis anticus* muscle coming down to the *creasing point.*

There is an important change which takes place in the great toe, in moving from the position of rest to one of activity, which involves an alteration in the horizontal contour line. Let us suppose that it has become necessary, to have a specially firm foot-hold, that some one sitting quietly in a chair springs suddenly to his feet and puts himself into an attitude of defence. Immediately the great toe leaves its fellows, going over towards the middle line of the body, and leaving a space between it and the second toe. The same action which presses it against the ground causes this movement also, but there is no bending, no flexion—it remains quite straight. On the other hand, the smaller toes, as they are pressed against the ground, become more bent, more flexed, and a series of prominent uplifted joints are conspicuous across the foot. These conditions of the great toe and little toes respectively are, for them, the *Position of Activity*. Action of the toes must be understood to mean here action when the feet are used *as feet*, not when used for purposes of grasping objects. In the latter case, of course, the great toe must bend as the others do if it is to be of any use. and in fact it does so. How it is prevented from bending in the former case can only be seen when the muscles and their action on the bones have been explained. It is obvious that the horizontal contour line described by the margin of the foot must materially differ according to which of these two positions is the one existing. At rest the straight inside line attributed to the inner margin is hardly complete. In action the inner margin is even a slightly concave line as opposed to the convexity on the outer side.

In fig. 20, pl. 7, it will be found that a straight line drawn on the inner margin of the foot will touch at the great toe and the heel only, and these figures, as stated in the explanation, are taken under conditions which do not admit of mistake. In action, too, the bending of the smaller toes is proportionate to the vigour with which they are pressed against the ground, but, however vigorous the action of the great toe, it does not bend ; it is pressed against the ground in all its length. To me it has long seemed very remarkable that these points have not been recognised more fully by artists, and especially so as regards those artists who, in classic times, had such abundant opportunity of studying the human form when unconcealed by clothing, both in repose and in gymnastic displays.*

This, perhaps, ought not to be said without giving illustrations. In the South Kensington Museum is a bronze cast of a statue of *Hermes resting*, seated. The original is in the Museo Nazionale at Naples. The toes of one foot, which rests on the heel, are raised from the ground, and manifestly the attitude is intended to be expressive of rest, as the Museum Catalogue, by Mr W. C. Perry, states it to be. The great toe in this figure is widely separated from its fellows; but a decided effort would be required to put it in that position; to hold it there would be difficult indeed. The position is incompatible with rest. On the other hand take the Discobolus of Myron. An ancient copy in marble stands in the second Greco-Roman room at the British Museum, opposite the Townley Venus: there is a plaster cast at South Kensington. As to this statute, Mr Perry, in the Catalogue of the latter Museum, says, "The artist has chosen the moment of pause and transition between two energetic actions, when the disc thrower has collected all his force for this supreme decisive effort. Every limb, every muscle partakes in and contributes to the main action of the body." Mr Perry also, in his larger work, points out, as expressive of the condition, that the toes are "dug, as it were, into the ground." If such an attitude were true to nature as regards any of the toes, it would still be difficult to understand why the artist so placed the great toe. That he could have so seen anything like it in his model is difficult to believe. The advantage of a great toe is lost if it be drawn up, as in this figure. We shall see, in considering

* "The sandal of the ancients was favourable to the natural growth of the foot. As a rule, therefore, this part is thoroughly understood by the antique sculptor, who admired the feet."—*Redford's Manual of Sculpture.* Reasons will be given for dissenting from this statement.

the bones which form, and the action of the muscles which move the great toe, that it cannot, in a good foot, (such as an athlete would have, and as this figure has) rise up in the manner shown. It might do so if the foot were of bad type or debased, as in acquired deformity.

Before going further it should be clearly understood that there is in the great toe an essential difference in the function as well as in the structure from that common to all of the other four. The former serves as a firm solid base from which the body can be propelled onward, while the latter grip the ground, not by any action of grasping—there is nothing to grasp—but by pressure of the under surfaces of the tips against the ground. These, in this act, are drawn backwards. Thus, if there be anything to lay hold of, it is by them seized and drawn beneath the upraised toes between the tips and the solid foot. In no case is there anything at all like digging into the ground, as the finger-nails might do. The toe-nails, in a struggle to get foot-hold, are never turned to the ground.

The shape of the foot must, obviously, be varied according as the great toe is inclined upwards and outwards, in the Position of Rest, or downwards and inwards, towards the opposite foot, in the Position of Activity. The horizontal contour line or margin also varies, and with it the whole character of the foot, according as the first or second toe projects the further forward; not, be it said, according as the first or second is the longer; because the joint at the base or root of the second toe is always in advance of the corresponding joint of the first and third toes. If the tip of the great toe be most in advance then the curve on the outer margin of the foot may be continuous up to the inner margin, uniting with it by a right angle only very slightly rounded at the inner side of the tip of the great toe. If the tip of the second toe be most forward then the outer curve is interrupted at that point. This curve may be a bold one, or the smaller toes may recede so rapidly that the tips form hardly a curve at all, but rather a straight line from the great toe outwards to the little toe. Fig. 20, pl. 7, gives a bold curve running into the one in the opposite foot, the great toe being longer than the second.

A curious difference of opinion exists among observers whether the first or second toe does most frequently project the further forward. There is certainly a variety in individuals, and, probably, in different races one or other form may prevail. My own impression is that, in England, the great toe is generally the more prominent, and I am glad to think so. Professor Flower, in his excellent little book, *Fashion in Deformity*, states that among hundreds of bare and, therefore, undeformed feet of children which he examined in Perthshire, he was not able to find one in which the second toe was the longest.

Another difference of opinion exists as to how artists should in this respect represent the toes. It is usual to show the second as most prominent, and this course is justified as giving, on various grounds, a more artistic appearance; whatever that may be taken to mean.

Grecian Art is cited as an example in this respect, but Mr. Harrison, who has discussed the question very fully before the British Association for the Advancement of Science, contends that Grecian Art does not supply this authority. He distinctly states that a long second toe, though commonly met with in the works of Italian painters and sculptors, seldom occurs in the feet of *unrestored* Greek statues. Unfortunately, he says, the casts in use in most of our Art schools are derived from Roman or Greco-Roman statues—for instance, the Farnese Apollo. The Choiseul Apollo, in the Archaic Sculpture room of the British Museum, is not, as Mr. Harrison points out, an instance of a longer second toe, although it has, on authority, been so stated. The marble is a little broken, but examination shows that the first and not the second toe is the longer.

Whichever may be the direction in which the voice of authority among artists may on this question tend, it will surely be admitted that the artist should, as Mr. Murray puts it, in his *Greek Sculpture*, reproduce, so far as the material in which he works will permit him to do so, the "*essential* character of the object" which he portrays. The great size and special function of the first toe is one of the features most characteristic of the human foot. More, perhaps, than anything else, the great toe gives it a distinction from that of the lower animals. Is it possible that any artist would contend that the feature which more particularly gives the human character is not essential? Certain it is that as the human character of the foot is effaced, that which allies it to the foot of inferior animals must be accentuated. To deliberately and unnecessarily do this in the name of high art is not a course which would recommend itself to such judgment or to such taste as I possess. To me it seems that the artist who so "reproduces" a foot, going out of his way to efface the human and accentuate the animal character, cannot have that "perfect knowledge of the original" which Mr. Murray declares to be necessary.

In order to attain this "perfect knowledge," even so far as it is possible to do so, the relation of the human to the *typical mammalian foot* must be considered. This is a point of view in which human feet must be presented to those who seek really to understand them and their structure. Their relation to corresponding parts in the lower animals may seem to be not a very dignified aspect in which to place them, but, in truth, their real dignity cannot be realised any more than their structure can be fully understood unless they be viewed in comparison with the type or plan to which they conform and on which they are constructed. Elements exist in the foot of man as to which too superficial observers have been tempted to think that a better result might have been obtained in another way, and others where the utility is not apparent at all. These parts are to be explained only by reference to the original type, or some other variation of it, as seen in animals of lower grade. On the other hand, in these latter may be found elements or features of no apparent utility to them, which, in man, are essential, and which, as they occur in animals geologically long antecedent, would even seem to suggest a fore-shadowing of a higher development in the future. The more the human foot is studied the more will the absolute perfection of its mechanism be evident; but the wonder and admiration which this will excite will be felt the more as it is realised that the structure strictly conforms to one general plan or type, common to a very large group of animals very widely differing from man and from each other.

Throughout the Mammalian kingdom, of which man, albeit the head, is a member, the bones forming the solid basis or skeleton may be represented in plan or scheme as follows :—First, a long bone, attached to the trunk, the humerus in the upper arm, and the femur in the thigh. To this are attached two others, lying parallel to each other, the radius and ulna in the forearm, the tibia and fibula in the leg. Finally, comes the third or terminal segment, represented by the bones of the hand or foot, or, as the comparative anatomist would insist on terming them, the *manus* and *pes*. This is from no pedantic preference for a Latin rather than an English word, but as a necessary means of avoiding confusion in discussing four-footed and, in the case of the Quadrumana, four-handed animals. For the same reason, the arm or fore-leg and the hinder-leg of any mammalian animal would be called, respectively, the anterior and posterior limb.

The terminal segment, be it hand or foot *(manus* or *pes)*, is composed of two rows of short bones, more or less resembling cubes or cuboid in shape. These form the carpus, or as it is called in man, the wrist, in the one case, and the tarsus or body of the foot or instep, in the other. To them are attached a row of five long bones, with expanded ends, forming the meta-carpus and meta-tarsus, respectively. Lastly, come five digits, a term applicable to fingers or toes. The separate bones which form these digits are also more or less elongated in form, and are called phalanges from a fancied resemblance of the single bones to a phalanx of soldiers. They are numbered so that the one corresponding to the thumb or great toe ranks as first because, in the typical position of the limb, as, for instance, in the seal, it has an anterior position, pre-axial as it is called ; the fifth digit being posterior or post-axial. It must be remembered that the more primitive and more typical examples of animals included in the same type have been adapted for moving in water, which requires that the limb should have the expansion of its extremity in a line with the long axis of the body. For movement on land this is modified to a lateral expansion by altered direction of the long bones. The first digit, throughout the whole mammalian kingdom, differs from the others in that it consists of two divisions or segments only while, all the rest have three each. Why this should be is not clear ; it will be subject of comment hereafter being, for various reasons, a point of much interest in relation to the human foot. Each of the digits is not in every instance represented, far from it, but the first, when existent at all, has always this peculiarity.—A third bone is never found in the first digit, in the one represented in man by the thumb and by the great toe.

A glance at the skeleton (fig. 1, pl. 1,) shows that it would be inconvenient, as well as being apparently inappropriate, to regard the first metatarsal bone otherwise than as the first of a series of five, arranged in rank across the foot. There are however very good grounds for not regarding it as a metatarsal bone at all, but as one of three phalanges belonging to the first digit, and that the missing bone is the first metatarsal. In the thumb such an arrangement is more manifestly appropriate. The ordinary rule for names will, however, be observed.

Mammalian animals are classified, as regards their mode of progression, according to varied forms of the foot. Pinnigrade, if it be expanded like a fin or *pinna*, as in the seal, where it is adapted for moving in water. Plantigrade, where the whole foot lies flat on the ground, forming a sole or *planta*, as in the bear. Digitigrade, where the tarsal bones are raised so that the weight comes upon the digits or some of them, as in the dog. Unguiculate, where the whole weight comes on one digit, and the nail or *ungues* is expanded into a hoof, as in the horse. Man is classed as plantigrade, but in every step as he walks he becomes, alternately, digitigrade ; in running he remains so. This feature in man is unique.

The bony elements of the mammalian foot may be modified into great varieties of form. The metacarpal or metatarsal bones in particular may be exaggerated as regards one or more, and as regards the others attenuated until only rudimentary representatives remain, or these may be suppressed altogether. The relation to original type is however always evident.

No necessary purpose would be served by detailing instances of the many curious modifications which the mammalian foot undergoes to adapt it to the requirements of the great variety of animals which the mammalian kingdom includes. As however the horse will afford us an illustration of the practical advantage which may arise from a comparison between the foot of men and that of lower animals, a sketch may be given of that part of the horse's hind leg which corresponds to the foot of man. We call it a leg, the Comparative Anatomist would include the whole of it in the foot or *pes*. Here the hock represents the human heel, and some small bones immediately below it the tarsus. The leg is formed by the middle metatarsal bone with portions of the second and third in a rudimentary form on either side, the first and fifth being entirely suppressed. The fetlock is formed by the first and second phalanx of the middle toe, the exaggerated nail, in the form of a hoof, being supported by the third or final one.

To the superficial observer it may seem that the difference in external covering constitutes an essential difference between the foot of man and of the lower animals. In fact, however, the thickness and hardness of the skin, the amount and the kind of hairy covering, are all variations of degree rather than of essential character. Even nails and hoofs are to the anatomist obvious varieties of the same material, modified to suit particular purposes. The modification which more than anything else constitutes the special characteristic of the human foot is the formation of a heel and the unusual development of the great toe. Indeed it is not too much to say that, from the anatomical point of view, there is no more striking difference between man and the lower animals than is to be found in these two features.

This was the view expressed in my monograph on the arch of the foot, in ignorance that my old master Sir William Lawrence had said the heel is "an infallible characteristic of man," and that it would probably be a safer rule to say that man is known by his heel than it was to say that Hercules was known by his foot;* not knowing either that

* "*Ex calce hominem* would probably be a safer rule than *Ex pede Herculem*."—*Lectures on Man.*

Professor Humphry had said that, in the animal kingdom, "man literally stands on his great toe."

In examination of the skeleton of the human foot it will be seen that all the elements of the typical skeleton of the mammalian foot, as set out in the scheme, are there present. One modification however is seen,—two of the tarsal bones are united to form the heel; so that we find seven bones only instead of eight, as found in the hand. The bone of the heel or os calcis, sometimes called the calcaneum, consists of two tarsal bones fused, as it were, into one. The form which all these bones assume in the human foot and the manner in which they are bound together is shown in the plates 1 to 6 and in the explanations given.

In respect of the ligaments collectively, one point of great importance should be noted. They share the influence of a law, universal in all the tissues of the body, that constant pressure or constant tension causes wasting, while intermittent pressure or intermittent tension promotes growth and strength, with, consequently, increased capacity for resistance. Thus if ligaments be constantly stretched, as, in prolonged and careless standing, happens to those which bind together the bones forming the arch of the foot, yielding and consequent deformity ensues. The words constant and intermittent are here used in their relative sense only. The rest which the night affords is not enough to counteract continuous strain during the day. When the stretching is absolutely constant changes take place with great rapidity. On the other hand when stretching and relaxation follow each other in frequent succession of changes and in great vigour, then the full effect in promoting growth is seen. Not only do the ligaments become stronger but the attachments to the bones become more secure; projections of bone are thrown out, making the surface rough, and so giving a firmer hold.

It also follows from this law that ligaments will not hold bones together, with the greatest firmness of which they are capable, without intermission. If they did they would cease to be firm. In fact, no ligament of the body is equally tense in every position of the parts which it binds together : if it were, it would cease to be tense at all. Applying this to the arch of the foot, the ligaments must have a relaxed and tense condition, varying in accordance with change of position and, therefore, it will in one case be strong, in the other, weak, because yielding.

This has an important bearing on the question—In what position the arch of the foot is best adapted to bear the weight of the body when standing erect ? Sufficient to say now that the strong position of the arch is when the two great toes are inclined towards each other. The relaxed or weak position is when the feet are turned outwards.

The ligaments have a most important relation to the muscles and tendons, and the full extent of the provision against undue stretching of ligaments cannot be seen until the action of muscles has been considered. The remainder of the different tissues of which the foot is composed must, however, be first enumerated, and the movements between the different parts further noticed.

The tendons of the different muscles are all closely encased in fibrous sheaths which hold them close to the bone. These sheaths are lined by a smooth membrane lubricated with *synovia* (and therefore called synovial membranes) similar to that found in joints. Blood vessels and nerves are not shewn in the plates, having no relation to the mechanism of the foot : indeed, special plates would be necessary. All interstices are filled up by fat and fibrous tissue, very closely intermixed.

Bands of strong fibrous tissue pass downwards from the bones, and upwards from the skin, binding all the parts together. These bands and portions of fat intervening form also a soft cushion beneath the skin. A special expansion of this fibrous tissue is formed into a membrane or *fascia*. This, the plantar fascia, extends from the heel bone forwards and sends a prolongation to each toe. It is very closely attached to the first layer of muscles, and is seen, cut through in front of the heel, in fig. 7, pl. 3, at a point where it is specially thick and strong.

The fibrous bands which connect the skin to the plantar fascia and to the more solid framework of the foot, have the effect of limiting the movement of the skin upon the foot when the foot is free, of the foot upon the skin when the skin is pressed on the ground.

Very different is the skin of the back of the foot, which moves freely and is so loosely connected with the structure which it encloses that it might be stripped off; but, to remove the skin from the sole, it would have to be cut, bit by bit. Like the palm of the hand, the sole has no grease-forming or sebaceous glands: like it too, the perspiration or sudiparous glands are numerous. On the back of the foot and of the toes, as in the case of the hand, some few hairs are found, which suggest a relationship to animals having abundance of such covering in corresponding positions.

A contrast, too, is seen between the skin under the arch, where, in a good foot, it does not touch the ground, and on those parts taking pressure. It is seen, too, between the under surfaces of the tips of the toes and the parts between the tips and the body of the foot. Here the skin is thin and soft, admitting of very free bending downwards, especially of the smaller toes.

This bending of the toes downwards is known as flexion, by it the toes are flexed. When straightened, the movement is known as extension, the toes are extended. If, however, this latter movement be continued, the foot is bent or flexed on the ankle, as it is drawn towards the extreme flexion shown in fig. 24, p. 10. By movement in the opposite direction the foot would be extended on the leg as it moved towards extreme extension. So that extension of the toes, continued, goes on to flexion of the foot, and *vice versâ*.

This movement of the foot on the leg, or, when the foot is on the ground, of the leg on the foot, is a hinge movement only. The upper part of the astragalus passes between two flanges, formed by extension of the tibia downwards on the inner side and, on the outer side, by an expansion of the fibula continued bodily downwards. These two projections, which are well shown in fig. 16, pl. 5, are known as the *malleoli*, from the fancied resemblance to little hammers, and, respectively, as the inner and outer *malleolus*.

A detailed description of the ankle joint would here be out of place, and is unnecessary. A curious provision against dislocation must, however, be noticed. It is obvious that when the foot is fully extended, in going down hill, the leg must have a disposition to ride over the rounded top of the astragalus and slip forwards. To assist the ligaments in preventing this the flange of the tibia is continued partly round behind towards the fibula. No such arrangement exists in front, where it is not only unnecessary but it would be an obstruction, because it would prevent the head of the astragalus from coming up in front against the end of the tibia, and so it would be the means of limiting flexion. It is unnecessary, because when the foot is flexed, as in going up hill, and so a disposition to dislocate the leg backwards ensues, the tendons going down behind either malleolus (fig. 8, pl. 3, and fig. 15, pl. 5,) are so tightened that such displacement is well-nigh impossible.

The upper part of the astragalus, fitting in between the malleoli, is wider in front than behind, so that when the foot is fully flexed the two bones are driven apart, and the ligament holding them together is stretched. The reason for this has been much discussed. My own view is that it is so simply because if it were otherwise the ligament would always be in the same degree of tension, which would speedily impair its efficiency. We have seen that in the Position of Rest the foot tends towards extension, the position in which the ligament in question is most relaxed. If it were always strained it would lose capacity for resistance.

The opening between these two flanges is not directed exactly forwards. With the body standing erect and the two feet together each opening is directed slightly outwards. Moreover the articular surface on the outer border of the astragulus is more extended than on the inner side, so that the joint in moving describes a curve. The effect is that as the feet are fully extended they incline towards each other; as they are flexed they tend to separate. The curve is not exactly a segment of a circle; the sweep of the foot inwards is more marked as it approaches extreme extension.

The same configuration of the ankle joint which causes the front part of the foot, when free, to incline inwards as it extends towards a straight line, necessarily causes the ankles to incline outwards when the foot is fixed on the ground. Thus if we stand with the feet flat on the ground, the inner margins together, and then spring to tiptoe, we shall find that the two ankles separate from each other. On the other hand if we sit with the heels resting on the ground, the feet a little distance apart, and extend the foot fully, the great toes come towards each other. If we fully flex the feet the toes will diverge.

Very closely associated with movement in the ankle joint under almost any circumstances is the movement taking place in the body of the foot. This may, for all practical purposes, be considered as in two places only.—

(1.) When the foot is moved from side to side, when, that is to say, it rotates on a horizontal plane, the principal movement occurs between the astragalus above and the os calcis below. The joints, as seen in the dry bone, are shown in fig. 11, pl. 4, where the former bone is lifted up so as to reveal the irregular bed in which it lies.

(2.) When the inner margin is uplifted and the outer depressed (or the reverse), when, that is to say, the foot is rotated on a longitudinal axis, the principal movement is at the joints laid open in the division shown in fig. 9, pl. 3.

These two movements are not simple, they are associated with each other and both with movement at the ankle. When the foot is held at the same angle with the leg no motion takes place in the ankle joint in horizontal or in longitudinal rotation of the foot, but, when the foot is free, these movements, if carried far, are almost inseparably associated with movement there.

With extension of the foot the toes incline inwards, and the inner margin is uplifted; with flexion of the foot the toes incline outwards, and the outer margin is slightly uplifted.

When the foot, with the sole flat on the ground, is everted (the toes turned out) the scaphoid bone is rotated downwards, and the ligament uniting it to the os calcis is relaxed. This (the calcaneo scaphoid ligament) is the support of the head of the astragalus, which, therefore, is the less supported, and has, in this position, the greater tendency to sink. If, however, the foot be inverted (the toes turned inwards) the scaphoid bone is rotated upwards, and the ligament in question tightened. This gives the head of the astragalus a firmer support. Thus, for the arch of the foot, the latter is the strong and the former the weak position. This is an important point in the question—How should we stand ?

Operation of the agency by which movements of the foot are effected does not, paradox though it seem, necessarily involve motion at all. The principal function of the toes is to give good foot-hold by active pressure against the ground, so as to supplement the passive pressure of the body's weight. This is effected by the same means as that which, when the toes are free to move, moves them.

Here let it be said that the toes play a far more important part in the ordinary functions of the foot than is generally admitted. One sees statements, (where better things might be expected) to the effect that their services could be dispensed with. Even in walking, as usually done, they are used much more than is generally supposed. If they were not used the muscles moving them would be found to be wasted. They should, however, be used much more than is, in the conventional style of walking, possible.

But, before considering more fully the movements of the foot, it will be important to realise fully what the agency is by which they are effected. That movements are made by muscles may be supposed to be sufficiently known, and yet indications are not wanting that writers on the mechanism of the foot—I am not, of course, speaking of surgeons—do not clearly understand what they mean by muscles. Terms are used with regard to them : such for instance, as "finely articulated," as to which it would be difficult to guess what the writer had in view.

Muscles are masses, varying in size and shape, of that substance known as muscle, or, with reference to the flesh of animals, as lean meat. They are the agents by which the different movements of the body are effected, the structure being composed of fibres which are endued with the property of contraction. It is by this contraction that the ends attached to different parts are drawn towards each other, movements of those parts resulting. The attachment of the end of a muscle, usually to a bone, may be direct, by its own proper tissue ; or it may be connected indirectly, with a more or less distant part by means of a cord of fibrous tissue, in popular language, a leader, or, in anatomical language, a tendon. This has no contractile property, it is simply a connecting cord. The fleshy, that is, the muscular, attachment is commonly spoken of as the *origin*, the attachment of the tendon (when it exists) being called the *insertion*. In the absence of the tendon, the latter term is applied to that end of the muscle which is supposed to move most frequently or most freely, while the origin remains stationary. The distinction is, as I regard it, very unfortunate, because it tends to encourage the idea that the muscle always or principally acts *from* the origin as the fixed point, *on* the insertion as a movable one.

The marked difference in result as one or the other end of the muscle is the fixed or the movable point will be shown hereafter as being highly important. An instance may, however, be given now. Powerful, and therefore large, muscles are attached to the leg and to the toes ; the effect of action of these muscles as they move the toes when the leg is fixed, or as they move the leg, and with it the body, when the toes are fixed on the ground, is altogether different. Yet, the action, the act of contraction, which takes place in the muscles, is exactly the same in either case.

Here the fleshy masses of muscular tissue are placed in the leg for the obvious reason that the necessary bulk, a matter of no consequence there, would cause serious inconvenience if placed in the foot. The tendons, which take up but little room, pass along éither surface of the foot, and cause no inconvenience whatever. The question, which portion of the length of combined muscle and tendon shall be muscular, and which tendinous, is entirely one of convenience. Just as a cord, elastic at one end, and rigid at the other, exercises the same degree of traction on each of its attachments, so the two insertions of a combined muscle and tendon are drawn towards each other in just the same degree at whichever end the muscle or motor power be placed. My preference is to call both ends insertions or attachments, muscular or tendinous, as the case may be, and to drop the term *origin* altogether.

Muscles of the leg, acting on the toes illustrate another principle. Those behind turn a corner beneath the ankle, and so divert the line of traction. The tendons run in smooth grooves in the ends of the leg bones, and in the os calcis and cuboid bone below, as cords run round pulleys. It is the position of the pulley which determines the effect of traction on the cord, so it is the position of these grooves, as fixed points, that determines the effect of action of these muscles. The position of the moving force is in either case immaterial. On the upper side of the foot a similar result is effected by strong bands (a, fig. 8, pl. 3) which bind the tendons against the ankle.

For effective action of muscles it is necessary that they shall be free from pressure, and especially from such pressure as any hard substance would occasion. The bony arch of the foot is a necessary provision against this.

Where variety and precision of movement rather than strength is desired then the muscles are small and numerous, and generally act either directly or with the interposition of short tendons only. This is exemplified in the number of small muscles which lie in the sole, that is to say under, and under the protection of the arch of the foot. If the muscles acting on the foot were all situated in the leg, and connected with the toes by tendons, (even supposing they could then fulfil their functions) it would involve a manifest increase of complexity.

Few movements of the body are effected by a single muscle, none certainly in the foot. They are the joint effect or resultant of two or more. It is obvious that for movements in opposite directions muscles or groups of muscles are required, which, if they act at the same time, will be antagonistic to each other. The purpose which would be served by the action of one only would be, in that case, more or less completely defeated. It may be, however, that a third purpose would be served by the joint action of both. In riding a horse the effect of pulling the left hand rein would be neutralized, as far as direction is concerned, by pulling the rein on the opposite side with equal force. But this would not be all ; the horse would be pulled in or restrained as the result of pulling both. So also the effect resulting from the action of any particular muscle must be considered both as to what it would be if acting alone and what it would be if acting jointly with others. These points are insisted on because, as it has seemed to me, they are not sufficiently recognized in books on Anatomy, and especially so in descriptions of the mechanism of the foot.

An important law relating to muscle must be noticed. Action promotes growth and strength. Total inactivity leads to rapid wasting. When, however, muscles have been fully developed in youth, a very slight amount of exercise will suffice to keep them fairly strong.

Still more important, in the case of the foot, is another law. Muscles developed by action remain, when not in action, passively contracted, not strained, but, as sailors say, taut. Now the effect of this is to keep the bones on which they act firmly pressed against each other in the joints on which they move. Here comes in the operation of the other law that *constant* pressure causes wasting. If, however, the always-taut muscle maintain even pressure, it will keep the articular surfaces of the joint adapted to the movements which action of the muscle occasions. Let this fail and the joints will sink into whatever position the weight of the body may determine, and the articular surfaces will assume whatever form the pressure so caused may determine. All this, of course, applies in a much greater degree to the young and growing body than to that of the adult. It applies to the latter, however, much more than might be supposed.

The leading principles which underlie physical education depend on these laws. It is, therefore, as it seems to me, of the highest importance that they should be understood, and the more because the salutary effect of suitable exercise has its counterpart in the production of deformity when wrongly applied. The prevention of deformity, caused by want of exercise on the one hand and by injurious labour on the other, offers a large field for physical education. The importance of muscular action in relation to the foot from this point of view will be seen presently.

The names and the positions of the different muscles acting in and on the foot are shown on the plates and set forth in the explanations. The special feature to be noted is that they form two well marked divisions, those of the foot and those of the leg acting on the foot. The bony heel pushes through the line, completely dividing even the fibrous expansion or fascia which covers the sole from the muscle, which is supposed to tighten it. The *plantaris* muscle, in shape like one of the *lumbricales* seen in fig. 10, pl. 4, and in size little more, sends down from behind the knee a little ribbon-like tendon all down the leg to the heel, where it merges in the large tendon (No. 8, in fig. 8, pl. 3). The corresponding muscle in monkeys tightens the fascia of the hinder-hand, a function which a corresponding muscle in the arm does for the human hand. Here, in the heel, it serves only as a connecting link to keep up evidence of uniformity of type.

One of the most interesting and important movements which the muscles acting on the foot are designed to effect is to raise it to the tip-toe position, or, in other words, to change it from the plantigrade to the digitigrade form. The whole of the weight then falls on the anterior pillar of the arch alone. How this is done, not only without damage but rather with increased strength to that structure, must be fully comprehended if the mechanism of the foot is to be understood.

The action is sometimes described as that of a lever of the first order, where the power of the muscles of the calf acts on the heel, and, through the fulcrum formed by the leg, on the weight supplied by the resistance of the ground against the toes. Another and a better way of putting it is that the lever is of the second order, the weight being that of the body, while the fulcrum is supplied by the toes. This is shown in fig. 6, pl. 2. In either view there is an essential difference from ordinary levers: the power is attached to the leg, *i.e.*, to the fulcrum or to the weight, according as the action is regarded as that of a lever of the first or of the second order.

Both views are, however, liable to mislead. It is usual to give the combined muscle acting on the heel as *the* power by which the body is raised to tip-toe as if it were the *only* power. One who writes with the highest authority says, in a book intended for general readers, "The muscle which acts upon the heel is one of the largest and most powerful in the body, and well it may be, for in raising the heel it has to raise the whole weight of the body." This is misleading and inaccurate. If the foot be taken when at rest, no tendons can be felt behind the ankles; when the body rises to tip-toe they start out on either side. The most prominent on the inner side is the *flexor longus pollicis*, on the outer the *peroneus longus*. Those tendons which are deeper are also tightened; the *flexor longus digitorum* and the *tibialis posticus* on the one side, and the *peroneus brevis* on the other. Now all these muscles are strong—their combined strength is enormous—and although they do not act at the same advantage as the calf muscle, which acts on the projecting or lever-like heel, they do exercise a very great influence in bringing the leg and foot towards a continuous straight line, which is the essence of the tip-toe movement. Take the first-named only; the *flexor longus pollicis* is so strong that it may be trained to bear the weight of the body itself, as in the stage dancer, who will support himself, or more generally *her*self, literally on the great toe. Though incapable in most persons of anything like such a feat as this, the muscle in question is, in all good feet, very strong.

Of my long-entertained view that the influence of the calf muscle in walking has been over-rated, and that of the other muscles under-rated, I have recently had a striking illustration. A young gentleman, able to take his share in rough games at a public school, and to do a long day's shooting with his father, an excellent walker, has, on one side, no calf muscle at all. It had been paralyzed in infancy, and neither it nor the tendo Achillis has developed; the latter is, in fact, a mere attenuated ligament, contrasting strongly with the specially developed tendon on the other side. Here an extra development of the remaining muscles of the same side and of those of the opposite foot and leg have almost completely compensated for the deficiency, so that the subject and his friends are hardly conscious of any defect. Had the deficiency existed in both legs it would have been serious indeed.

Fig. 27

The mechanism of rising to tip-toe consists in an elevation of the heel by the great calf muscle acting upon it, (fig. 8, pl. 3,) assisted by the concurrent action of the groups of muscles whose tendons pass down behind either ankle. These latter, which move the foot or the toes, when those parts are free to move, move the body on the foot when the foot is fixed. To say that the body is raised by the calf muscle acting on the heel, (a statement often made,) is an incomplete and misleading description. The same action continued and effected with sufficient vigour propels the body forwards, whether for purpose of walking, running, hopping or jumping.

But so that the heel be raised does it very much matter how it is done? The answer to this will appear from the following considerations :—Fig. 27 shows the tendons of one muscle only crossing the sole from end to end, all else being, for the sake of clearness, removed. This, the tendon of the

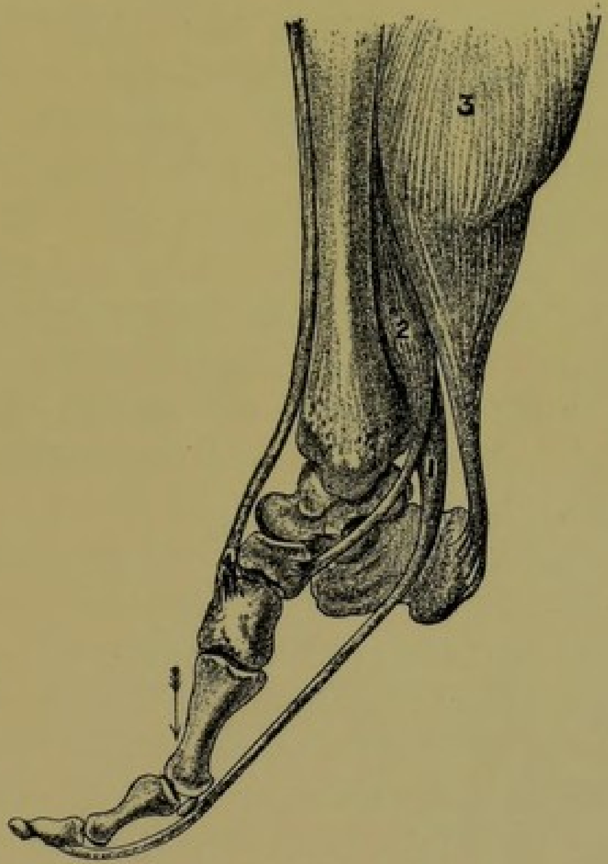


Fig. 28

Shows the effect of muscular action in throwing up the arch, and is to Fig. 27 as Fig. 26 is to Fig. 25. 1 is the *flexor longus pollicis*, 2 the *tibialis posticis*, and 3 the combined calf muscle. The *tibialis anticus* is seen in front.

flexor longus pollicis, has, to the arch of the foot which it subtends, the relation of a chord to an arc, of a bow-string to a bow. Now this arch, or arc, or bow, is made of flexible material. The bones are bound together by ligaments, as shown in fig. 5, pl. 2; still they are not so firmly bound together but that the bracings which they form admit of a considerable extent of yielding. If, then, the arch be yielding, and the muscle acting on this tendon be strong, both of which facts are indisputable, the action of the muscle must brace up the arch as certainly as tightening a bow-string increases the convexity of the bow in diminishing the distance between the ends of it. Some shortening of the sole ought, therefore, to take place in the act of rising to tip-toe.

Let a piece of tape be laid on the floor and trodden on in a line with the sole of the naked foot, the end at the heel being carried round and held at a point on the skin in the middle line behind the ankle. Now stand on tip-toe, bearing the whole weight of the body on the foot. It will be seen that the tape (assuming the foot to be in healthy working order) will be visibly slackened ; which, as it seems to me, proves beyond all doubt that the anticipated shortening does take place. This, however, is not generally accepted as a fact. The bow-string action of the tendons of the leg muscles and consequent shortening of the sole in rising to tip-toe had never, so far as diligent search can discover, been recognised at all until pointed out by myself in a communication to a local medical association, in 1874, expanded into a pamphlet in 1877. Figs. 27 and 28 are intended to show the changes in the condition of the arch shown in fig. 25 to that in fig. 26 as a result of the muscular action attendant on raising the heel. Of the figures, 28 is to 27 as 26 is to 25. The long flexor of the great toe (1) braces up the arch at the same time that the *tibialis posticus* (2) turns up the inner margin of the foot, and the calf muscle (3) lifts up the heel.

It will be seen that the effect of tightening, of shortening the tendon of the long flexor muscle is to diminish the distance between the great toe and the point where the tendon passes round the bone of the heel below the ankle. The result of this is to brace up the arch and increase its convexity. But, it should also be understood, the effect of tightening this tendon or cord is to draw it towards a straight line between the point of attachment to the great toe and the point where it passes below the heel. By this agency the joint at the root of the great toe is uplifted, and if the tightness be sufficient to bear the weight of the body, the anterior pillar of the arch literally dances on the tight rope. If, however, the weight of the body, as indicated by the arrow in fig. 28, be sufficient to bear it down, the anterior pillar is, at least, let down lightly. Thus the same agency that assists in raising the body braces up the arch of the foot, and, in lifting the joint at the root of the great toe, relieves it from the pressure against the ground which the weight of the body suddenly thrown upon it would occasion.

The tip-toe position which is attained by vigorous action will be seen to pretty closely accord with that shown in the frontispiece as the position of complete rest. The apparent contradiction is apparent only. The beauty of the arrangement is—it is one of the many pretty things in the domain of physiology—that the tip-toe position, where the muscles have been thrown into vigorous action, is one in which they do the work of sustaining the arch, in their action as bow-strings or as tie-rods. Thus the ligaments which bear the strain when the foot is flat on the ground are completely relieved. For this complete relaxation of the ligaments it is necessary that the foot be as nearly as possible in the position of complete rest. So far as there is any strain at all on ligaments it is on those which bind together the bones on the upper surface. The two agencies for supporting the arch do not do the same duty at the same time; one or other is in repose.

It is not suggested that figs. 27 and 28 are anything more than diagrams. It would be impossible to effect so much change without very much displacing the bones on each other. For a flat foot to become arched involves changes in the bones which can only be effected in time. That some such change as that indicated (p. 11) does really take place is shown by the experiment with the tape, and by the photographs reproduced in figs. 25 and 26, ps. 12 and 13.

As compared with the long flexor muscle, which is common to all the smaller toes, that acting on the great toe alone plays, in supporting the arch, the much more important part. In animals, as in man, the flexor muscle is generally divided into two.—The horse has, in his divided flexor muscle acting on a single tendon, a relic of remote ancestors having two toes and two flexors—But, where all the digits exist, the division of duty is, however varied in arrangement, more evenly distributed than in the case of man, where one division forms the *flexor longus pollicis*, acting on a single toe. This is a special characteristic. This is one more evidence of the special importance of the great toe in the human foot.

The long flexor of the smaller toes acting on the outer and less marked portion of the arch has less influence upon it than the other muscle. It serves, however, an important purpose : the tendon which divides to go to each of them comes into the sole on a higher level, farther from the extremity of the arch, but in passing outwards to the smaller toes, it does not pass above the other tendon, as with greater apparent convenience it might do : it passes underneath, dipping downward and picking up, so to speak, the lower one. The course of the muscles is shown in fig. 8, pl. 3, and in figs. 10, 11, and 12, pl. 4. Otherwise, however much tension of the long flexors increased the height of the arch it would do nothing to increase the hollow beneath. In fig. 28 the space beneath the tight tendon, between it and a line drawn from heel to toe is no greater than it is beneath the relaxed one in fig. 27.—In these figures, for the sake of clearness, only one tendon is shown.—Thus it is that the action of the long flexor tendons on the arch of the foot may with greater propriety be compared to a tie-rod than to a bow-string. The chord of the arc becomes itself an arc as it is drawn upwards by the tendon crossing it. This arrangement of the tendons in the sole is shown in fig. 13, pl. 4.

Special prominence has been given to the *flexor longus pollicis* muscle in bracing up the arch, because its bow-string or tie-rod influence (figs. 27 and 28) is most manifest as well as of first importance. The *tibialis posticus* which has been mentioned serves a very useful purpose : it draws the scaphoid bone towards the bony prominence on the os calcis (sustentaculum tali) round which the tendon runs, and so throws up the head of the astragalus, which rests on the ligament between those bones. Then, the *peroneus longus* which draws the inner margin of the front part of the arch and the outer ankle towards each other, has a most potent influence in bracing up and increasing the concavity.

An important question here arises. We have seen that the muscles concerned in holding down the toes, especially the great toe, are the agents for giving good foot-hold, and that these muscles are also concerned in raising the body to tip-toe, and in propelling it onwards in walking. In what position of the foot do they most effectively act ?

It is easy to test this question practically by means of pieces of tape or slips of paper placed one under the middle joint of each great toe. Stand with the bare feet, first in the military position, the inner margins inclined from each other at an angle of 45 degrees. Judge now of the degree of firmness with which the tapes are held in opposition to an attempt by another person to draw them away. Now do the same thing with the feet slightly inclined towards each other, and note the difference.

It will probably be found that the tape or paper will be held down most firmly in the latter position. The explanation seems to be this: Turning the feet outwards, with the soles flat on the ground, has the effect of relaxing the tendon of the *peroneus longus* muscle, which crosses the sole from the outer ankle to be inserted into the base of the first meta-tarsal bone (fig. 14, pl. 5). This muscle is a most important agent in holding down the front part of the inner margin of the foot, and with it the great toe. But all muscles act best when the tendons are already taut, when there is no loose line to gather up before commencing to pull. This condition is present when the toes are inclined inwards, and thus good foothold is best maintained, and springing to tip-toe most readily and effectively done when the toes are so directed.

The law relating to the effect of constant pressure and of constant tension on the tissues of the body has been stated on page 23, as also the one that muscles developed by use remain taut and firm when not in use, (p. 33). They thus exert constant pressure on the joint surfaces, constant tension on any ligament stretched, and tend so to modify them that permanent modification of form is the result. As already stated, the whole principle of physical education hangs, to a very large extent, on these laws. If we apply them to the arch of the foot it is apparent that such exercise as involves springing on tip-toe must influence the contour of the arch, and that, in the process of physical training, movements which involve it should play a large part, if only as a means of counteracting the influence, in a direction directly opposite, of prolonged standing.*

The arch of the foot is, in fact, formed by exercise; in infancy it hardly exists. As youth advances, it becomes, or

* Mentioning this view to Sir James Paget on one occasion, he replied that many years before he had known a dancing-master at Windsor who always told his pupils to stand on tip-toe whenever possible, assuring them that if they did so they would never be flat-footed.

ought to become, more and more marked. To what degree full development may take it, depends partly on inheritance, still more on the freedom with which the foot is habitually used, and the avoidance of prolonged standing, or of standing in a bad position. It is a question of physical education, designed or unconsciously effected, or, on the other hand, of neglect and misuse.

But if it be true that the arch is formed by exercise, the question naturally arises, why is it not over-formed, and the arch made excessive by too constant or too powerful straining of the tie-rods, of which the *flexor longus pollicis* muscle is the type ?

An excessive form of arch may exist as a deformity, but it is due to a morbid contraction of the fibrous plantar fuscia not to healthy muscular action, which, as it seems to me, could not cause it. This is partly explained by the influence of the *tibialis posticus* muscle. Compare its attachment as seen in fig. 14, pl. 5, and the bony construction of the arch (fig. 11, pl. 4) with the diagrams 27, 28, ps. 36 and 37. It will be seen that the tendon passes under the *sustentaculum tali*, and stretches across the space unoccupied by bone on which the head of the astragalus falls, as seen in pl. 1, fig. 2. Thus it is clear that action of this muscle relieves from strain the ligament crossing the space. Now, the astragalus cannot be driven upwards too much, as shown in the sketch, fig. 28, where the bones were simply set in clay for the purposes of the drawing. The weight of the body will in any case keep it down to its proper level. But let us suppose that the scaphoid bone has been thrown up too high, above the level of the *sustentaculum tali*, then the muscle in question, whose line of traction is always determined by that bony point, draws the scaphoid bone downwards, and corrects any excessive convexity so far as that bone is concerned. Any undue springing upwards at the base of the first metatarsal bone is prevented by the *peroneus longus* muscle, which tends to bring that point and the outer ankle towards each other by means of the tendon passing obliquely across the sole, fig. 14, pl. 5. Although this is one of the agencies for bracing up the arch, it also keeps the inner side of the foot down, and prevents undue uprising. Dr. Duchenne (of Boulogne) has spoken of the *peroneus longus* as the agent which forms the arch *(le formateur).* This is too much to say: it assists in forming and assists in limiting the formation. The same may be said of the *tibialis posticus.*

Thus, the rising to tip-toe, which is the principal movement of the foot, develops the principal feature it has; while provision exists against over-development.

The influence of exercise in developing the calf muscle acting on the heel is well known. So long as a weak calf muscle exists, a long lever, in the form of the heel, is supposed to be necessary; and this arrangement, so long as only slow movement is required, suffices. If, however, quick, vigorous movement of the heel is necessary, then a shorter lever and a stronger power is required. It has, therefore, been commonly supposed that as races have developed larger calves they have acquired also shorter heels. Professor Flower has investigated this subject, and he finds that the heels of the higher races are not shorter than those of savages. I have no doubt of this—Professor Flower is not likely to be wrong—but I also have no doubt that the heel of the highly developed foot is practically, though not actually, shorter. There is less projection backwards because more projection downwards. As the foot changes from the position shown in fig. 25 to that in fig. 26 (p. 13), and explained by figs. 27 and 28, (ps. 36 and 37), the heel does not shorten, but it does project more downwards, less backwards. And so it is as one watches, from month to month, a flat foot become permanently more arched.

Under the influence of vigorous and rapidly executed movements, the muscles of the calf and lower part of the leg are modified in form, as well as increased in size. The fleshy (muscular) fibres of the deeper muscles (fig. 8, pl. 3) are extended very much lower than those of the calf muscles, where the tendon extends high up into the leg. Thus an enlargement takes place just above the ankle, gently increasing to the calf. This is seen in the dancer; but in the labourer, accustomed only to lift heavy weights, but not to rapid movements, these deeper muscles, although partaking of the development, share it in a less degree. In such cases one sees an enormous calf abruptly projecting from the leg, not gracefully narrowing down to the ankle, as in the dancer.

Thus, development depends not only on the amount but on the manner of the exercise. Excellence of form depends on exercise of function, and on the manner in which function is fulfilled. This is true of the foot as regards strength as well as beauty, and if it be admitted, then will be recognised the importance of properly performing the most ordinary functions. Foremost among these are standing and walking; but, as we are discussing movements, the latter will be taken first.

The act of walking is, essentially, a series of alternate risings to tip-toe of either foot, so as to take the weight of the body alternately on each, and in that position propel the body onwards in the direction of the other foot (brought forward ready to go through the same movement), towards which the body is also drawn. Where properly performed it may be briefly described as follows :—

Let us take it at a time when the right foot has been put forward and has reached the ground. The body will have been propelled onwards from the left by the agency of the muscles which raise the heel, and those which bear down the front part of the foot and the toes. Now, the group of extensor muscles on the front of the leg, acting from their attachments to the back of the foot and to the toes, as fixed points, draw the leg, with the body, forwards. Thus, principally by propulsion, but partly by traction, the body is brought over the spot where the right foot is placed ready to bear it. The muscles acting as tractors are the *tibialis anticus*, *peroneus tertius*, *extensor longus pollicis*, and *extensor longus digitorum*. While they are so acting, the flexors are holding the toes to the ground, ready to be, in turn, a basis from which to spring upwards and onwards.

At the time when the weight of the body is for the moment borne on the right foot, the left has risen from the ground, and is swinging forward. In this position the left foot is ready to be again placed on the ground, for the purpose of receiving, in turn, the weight of the body passing over it. The toes should be directed forwards, the line of the inner margin of the foot slightly inwards. The foot should be in extension, the toes pointed downwards, so that they, and not the heel, should first touch the ground. These two points are in opposition to the generally accepted view, and to the teaching of authority ; but, they are, to my mind, so important—the whole question of what constitutes good walking turns on their acceptance or rejection—that each will be separately discussed hereafter.

By the time that the weight has fallen on the tread of the right foot, the heel has sunk to the ground, and is immediately lifted, raising the foot into the tip-toe position. The effect of this movement in bracing up the arch has been already pointed out (p. 38). Now, as the weight comes to be fully borne on the anterior pillar, a bending or hinge movement takes place. How tension of the flexor tendons acting on the great toe limits this bending, and relieves the pressure which would otherwise be thrown on the anterior pillar, has also been explained (p. 39.) Such bending as takes place at this stage is at the joints formed by the bend at the heads of the *three inner* metatarsal bones. On reference to the skeleton, it will be seen that these three ends are not in line (E.F., fig. 1, pl. 1) : it is not desirable that they should be. If they were so, the bending would be on too narrow a line, the comparison to a hinge would be too exact. The arrangement of the head of the middle metatarsal bone of the three in advance, and that of the two outer, opposite each other, increases the base on which the weight of the body is, for the moment borne, and from which it is propelled onwards. But as the foot is brought to extreme tip-toe, after the weight of the body has passed over it, the tendency of the ankle is to go more and more outwards. For this, an oblique hinge is necessary, and it is supplied at the heads of the three outer metatarsal bones. These are nearly in line C D, and so do form a narrow, though not an absolutely straight, hinge. It will be recognised that a broad base is not now necessary, the weight of the body having passed over. The propulsion onward in the last part of the act being done mainly from the great toe, little weight is thrown on the line of the outer hinge.

Thus, for weight bearing, we have a broad hinge, on the line E F, and the limiting influence on the bending of it supplied by the flexor tendons. When a free but simple bending only is required, we have the narrow oblique hinge, C D. This, in my view, is the explanation of the irregular line across the foot described by the heads of the metatarsal bones.

But this is not all. When the foot is fully raised to tiptoe, and the body thrust onward, the joint at the root of the great toe is uplifted, dancing on a tight-rope, as shown in fig. 28. It has ceased to act as a hinge to the foot, the final joint of the great toe must take part in the bending on which the foot is finally up-lifted from the ground. It will be seen that it forms part of a line, C D, in fig. 1, pl. 1, which coincides with the rest of the hinge concerned in this movement.

Why should the ankle be so constructed that it is projected outwards as the foot comes to full extension in moving forwards? There are two distinct advantages. One is that the ankle of the moving foot is thrown out of the way of the other as the former is brought past the latter. Thus brushing of the up-lifted foot against the ankle on the opposite side is avoided. The other advantage is that the excessive extension of the foot, which conveying it directly over the tip of the great toe would involve, is unnecessary, because the foot is, in fact, carried over the outer or shorter toes.

In order that all these movements, involved in a single step, should be done well, they must not be done too rapidly. Fast walking, as done in foot-races, cannot possibly be done well; it ought not to be done at all. When an increased speed is necessary, running is the natural course. In this both feet are for a period entirely removed from the ground—the heel never touches it—the digitigrade position being maintained throughout.

It is important also that, whatever the speed, the length of stride should not be too great. If so, the ground can only be reached with the heel; there is no good foot-hold to which the body can be drawn by the muscles acting from the back of the foot on the front of the leg. The bearing of the hinder foot is also diminished to the smallest point, and the propulsion onwards is more likely to be attended with a sliding backwards. These difficulties cause greater muscular effort, as well as greater friction on the sole.

There should be good firm pressure of the toes on the ground, and especially of the great toe at the beginning, continued up to the end of every step.

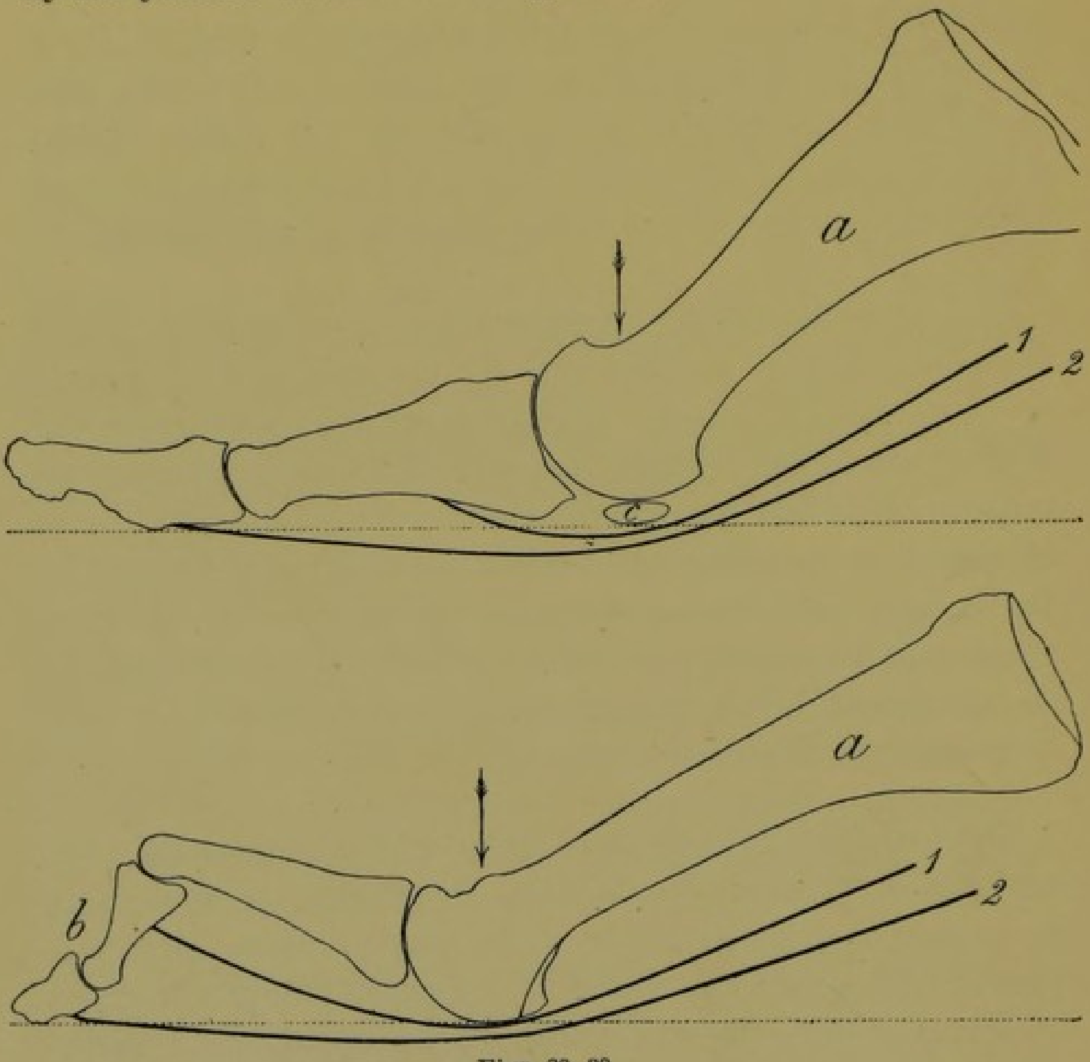
Dancing is a much more complex proceeding. The principal movement, however, even here, is to and from the tip-toe position. Its influence, as a means of promoting the development and in maintaining the strength of the foot can hardly be over-rated. Of this exercise, looked at from another point of view, let another speak. "The true idea of dancing entitles it to favour. Its end is to realize perfect grace in motion. And who does not know that a sense of the graceful is one of the higher faculties of our nature ?"*

It is, however, with the mechanism of movement, rather than the poetry of motion, that we are here concerned, and we now come to another highly interesting feature in the mechanism of the human foot, one which very largely contributes to its efficiency, and at the same time stamps it as altogether different from any other foot—the difference in the behaviour of the great and of the little toes as they are all pressed against the ground, whether for the purpose of securing good foot-hold in standing, for rising to tip-toe, or for propelling the body onwards.

The division of the great toe into two phalanges only, with two flexor muscles, one to each, is effective to hold both down and keep it straight in all its length. Here the advantage of this construction and of the special development to remarkably large size of the first digit is apparent. It forms a firm solid base, much more so than if, like the other toes, it became flexed. Figs. 29 and 30 mark the contrast. In the one case, representing the great toe, a metatarsal bone (a) is shown with two phalanges. Let it be remembered that there is not only a short flexor of the great toe but an abductor and an adductor, one pulling one way and one in the opposite direction, and, like the two reins of a bridle when both are pulled together, they have a joint or collective action. This is the same as that of the short flexor. The three may

* Channing.

therefore be regarded as one set of flexor muscles. Their effect, represented by the line 1, is to hold down the first phalanx, acting on it as on a lever, the fulcrum being formed by the joint at the base of the great toe.

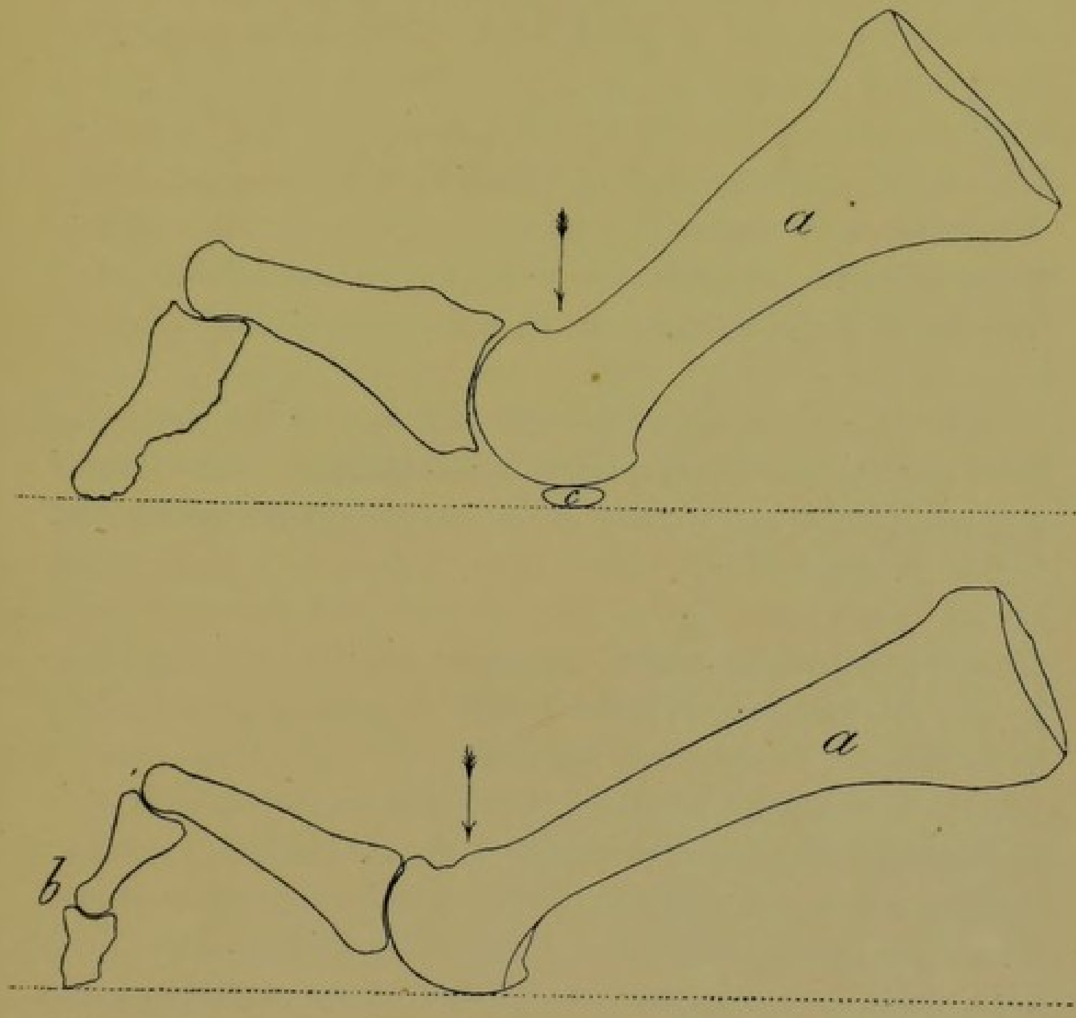


Figs. 29, 30

Figs. 29, 30 show, in the great toe and in the smaller toes, the heads of metatatural bones (*a*) borne down by the weight of the body, indicated by arrows, and the phalanges (two in the case of the great toe, three in the case of the smaller) acted on by the muscles shown by lines. *1* is the *flexor brevis*, *2* is the *flexor longus*. The great toe is held flat and not flexed as in fig. 31, and the smaller toes have a depression at *b*, not a prominence, as in fig. 32; *c* is a small bone (sesamoid) not usually found in the smaller toes.

This joint is held down by the weight of the body, as indicated by the arrow. Clearly, then, if the combined muscles be strong enough to hold down the first phalanx, the middle joint cannot rise. As a fact they are sufficiently strong, and in a good foot no up-rising is seen at that joint.

On the contrary, as it lies between the points operated on by the two forces indicated by the lines 1 and 2 in fig. 29, it is the point of greatest downward pressure. Thus, the first phalanx being held down, the powerful long flexor, (2) acting on the second, exerts all its influence on a straight great toe.



Figs. 31, 32

Fig. 30 shows a toe with three phalanges and a short flexor tendon (1) inserted into the second or middle phalanx. Here there is nothing to prevent the joint between the first and second rising up, and it does so as the toes are drawn firmly against the ground by the long flexor muscle (2.) This is desirable where the object is, as far as possible, to grip the ground, which is the function of the smaller toes.

Every one can try for himself how far this description of the difference in the behaviour of the great and of the smaller toes corresponds with observations on good feet in the living body. On the other hand, if a recently amputated foot be placed on a table in the standing position and traction made on the tendons of the long flexors, the great toe and smaller toes will all of them bend. In this experiment the short flexor muscles are as if they did not exist. The toes are then drawn into the position shown in figs. 31 and 32. We see the same thing in feet that have become flat, where the bony pressure has for the time destroyed the action of these muscles; it probably exists too in races always flat-footed. It certainly does not exist in feet of a high class.

Figs. 31 and 32 represent the position which the bones must occupy in toes as represented in sculpture. The Discobolus of Myron has already been mentioned as having this faulty position of the toes. Here either the athlete represented must have flexed his great toe and then pressed it against the ground, which he would not be likely to do, or he had no power in his short flexor muscles, also unlikely in an athlete, or the artist must have idealised from a faulty ideal. That artists in classic times did represent their own conceptions of what the human body in the highest perfection should be, adopting their own ideal rather than strictly following nature, there can, I think, be little doubt. It is difficult to look on the foot of the Venus di Medici and regard it as modelled from one in a living body.

The manner in which the smaller toes are represented in the Discobolus also calls for remark: they are properly shown as gripping the ground, as flexed, but they are also shown as a hand would be in grasping an object; all the joints are prominent, as seen in fig. 32. In fact, however, the two muscles, as seen in fig. 30, combine to depress the joint between the second and third phalanges, as we actually see in nature, and as shown at b. The joint is not prominent, as at b, fig. 32. This error, for so I cannot but regard it, is still more apparent in another Discobolus in the Hellenic room of the British Museum, a marble copy said to be made in Roman times from a Greek original, possibly of Alkamenes. Both artists, as it seems to me, must have idealised from a bad ideal.

The collection at South Kensington contains two striking figures expressive of action, by eminent modern artists: both are placed in the Chantrey Bequest room. One (in bronze) is Sir Frederick Leighton's *Athlete struggling with a Python*. Here the toes of the foot furthest back are seen to be all of them vigorously flexed, the middle joint of the great toe and the joint between the first and second phalanges of the smaller ones are all of them projecting upwards in one continuous straight line, as if they were all constructed on the same plan.

In Mr. Thornycroft's marble statue of *Teucer*, close by, the same features exist, but in a less marked degree.

Whoever the artists may be, whatever their authority, who portray the toes as if they were used as grasping organs, it cannot be right to do so. Man may be (in more senses than one) a grasping animal—his hand is admirably designed for such acts—but his foot is intended to press upon the ground, and good foot-hold is given in direct proportion as it can be so pressed. Such pressure can best be given by maintaining the great toe extended in all its length, as in fig. 29, not as in fig. 31. The smaller toes, it is true, are adapted to take advantage of any softness existing in the surface of the ground, but even they have their ends pressed downwards, as in fig. 30; there is no digging into the ground with the nails, as indicated in fig. 32. This, however, would actually happen in any attempt to hold soft ground with the hands.

The human foot does, in a very slight degree, retain the grasping power which characterises the Quadrumana, but this cannot be the "essential character" which the artist would wish to represent. The great glory of it is the adaptation for treading firmly on that solid earth which man is directed to subdue.

My apology for expressing, in a manner so decided, opinions on a subject which may seem to belong to the artist rather than to the surgeon or to the physiologist, is two-fold. First: If it be true that the function of the artist is to reproduce the essential characters of the foot, it is within the domain of physiology to point out what they are. Secondly: In the decision how the feet should be used, and how they should be clothed, artists will exercise an influence greater, perhaps, than physiologists, and it is highly important that these essential features should be known.

The difference between the great and smaller toes is interesting from another point of view. The curious arrangement common to the whole Mammalian kingdom, of two phalanges for the first, and three for the other digits, seems to have always existed through every geologic period since Mammals first appeared—it was seen in reptiles even before that.—And yet no Mammal or other animal, recent or fossil, has been found in which this arrangement has appeared to be of the slightest advantage, excepting only man. In him it is essential. One might imagine a human hand with a first digit or thumb in three segments. The whole scheme of the human foot would have to be changed, if such an arragement existed in it. How equal efficiency could be obtained I, at any rate, cannot imagine.

The finer movements, which can be made with the fingers, need hardly be considered in relation to the toes. The same machinery exists. The *lumbricales* muscles might, perhaps, under training, be made to hold down the first phalanx, while the extensors, by means of the expansion of the tendons onwards towards the tips, extended them—a movement similar to that of making the up-stroke in writing. No such faculty exists in ordinary feet.

Nor is there any similarity between the second toe and the index finger, which has its special indicator muscle. Still, the second toe has a special character. It supplies for the act of expanding the toes an imaginary middle line. In figs. 17 and 19, pl. 6, the action of the *interossei* muscles is explained. The four on the upper side (dorsal) move the four toes from an imaginary middle line in the second, which, therefore, has two muscles attached to it. The three muscles on the under side (plantar) move the three outer toes towards the second, which remains stationary. In the hand, the corresponding line is in the middle finger. There the balance of power is less disproportionate than it is in the foot where the great toe, on the one side, fully balances the three outer ones on the other.

Before leaving the consideration of the toes, and the manner in which they are acted upon by the muscles, it is desirable to notice that the words flexor and extensor, as applied to those muscles, express that which those corresponding to them do in the hand. They express that which the muscles acting on the toes *would do* towards them if the toes were used as grasping organs. The words do not express their action in the ordinary function of the feet, in walking.

In this act the flexors of the great toe do not flex it at all : they hold it against the ground at full length. The flexors of the smaller toes do not flex them in the ordinary sense of the word : they do not put them in the position shown in fig. 32, p. 51, but in that shown in fig. 30, where the final phalanx is actually *extended* on the second. The extensors do not extend the smaller toes : they pull the leg forward, acting on the first phalanges as fixed points, while the second and third are held down by the flexors. Nor does the long extensor special to the great toe, and the portion of the short extensor going to it, have any effect in extending the great toe ; they pull upon it while the flexors hold it straight on the ground.

Moreover, the flexors and extensors are, in the hand, antagonistic. The former relax in order that the latter may open and extend the fingers ; these, in turn, relax in order that the flexors may close the fingers and grasp the object. In the foot, on the contrary, the flexors hold the toes against the ground, while the extensors use the toes, so held, as fixed points on which to act as they assist in pulling the body forwards. Thus, instead of antagonising each other, the flexors and extensors, act, at the same time, in perfect harmony of action.

Yet one more contrast with the hand. The muscle acting on the fingers which corresponds with the *flexor brevis pollicis* is situated high up in the forearm. It is there free from pressure. Moreover, there is no room for it in the palm. The small muscles which act on the thumb and on the little finger, specially, can be pushed aside as the hand grasps an object ; and such pressure as they then get is of no consequence, because it is at a time when the finer functions of the thumb and of the separate finger in which they are concerned are not in operation. In the sole, thanks to the arch, there is room and protection for all, at all times. Moreover, in the foot, the sole is never used as a palm ; any grasping action is done by the toes only.

A point in connection with the movements of the foot in walking which must not pass unnoticed is this—To have suggested that neither classic nor modern artists have really understood the essential characters of the feet they have portrayed is hardly a greater heresy than to say that the human foot, in walking, does not lengthen. That it does do so, seems to be an article of faith in writers upon it; of faith, be it said, for they do not give any grounds for the assertion, nor do they point out how it can be demonstrated. One sees simply the statement, without explanation or reference, that it does lengthen "about an inch." Even the late Dr. E. A. Parkes, a name ever held in deservedly high honour, says, in his *Manual of Practical Hygiene; prepared especially for use in the Medical Service in the Army*, "In the action of walking, the foot expands in length and breadth; in length, about one-tenth"—that would be about an inch—"in breadth, even more. In choosing shoes this must be attended to." If this were really so, it would indeed be important. The fact that this assertion is repeated in the last edition (1887) edited by the late Dr. de Chaumont, and reproduced by those who exercise much influence, is sufficient reason to call for a careful examination of the point in question. It would be very interesting to see some demonstration of the grounds on which the assertion is based, if they exist, beyond that given a hundred years ago by Camper.

The statement that the foot in walking, lengthens about an inch, so far as I can discover, was first made by Petrus Camper, a Dutch anatomist and philosopher, who wrote on a variety of subjects: among others, on the lines of the face. Camper's facial lines are well known. He died in 1789. A posthumous treatise, "On the better form of shoe," written in Dutch, was quickly translated into German and French, but did not appear in an English form until retranslated from the French for the late Mr. Dowie, the bootmaker. It forms the first part of his work on Feet and Foot-Clothing. In order to be sure that the translator had derived no wrong impression, I procured the French edition, published in 1792.* There is no doubt as to Camper's meaning. Fig. 33 is an exact reproduction of his diagram, omitting only, for the sake of clearness, some of the letters which are not essential. He reasons thus—the line d b is equal to d c : therefore d B is longer by a quarter of an inch in the figure, and, consequently, we are told, an entire French inch (about the same as the English inch) in the body. Now, the extension in length cannot go backwards because of the solid heel, and of the stiffness of the leather in the

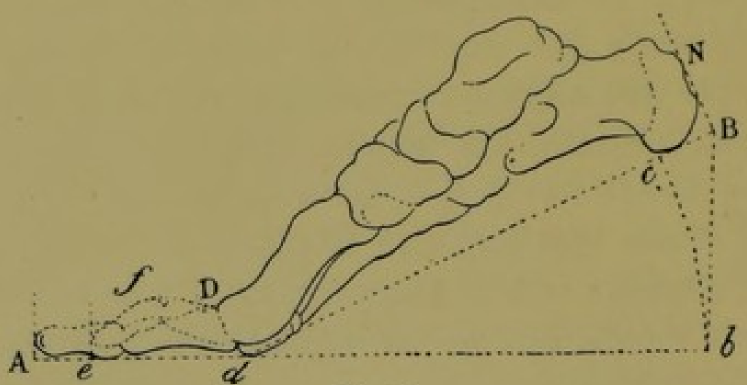


Fig. 33

Camper's diagram showing his view of the (supposed) lengthening of the foot in walking—explained in the text.

heel of the boot. It follows then that unless the point of the great toe be allowed to move forward a distance equivalent to c B, it must be forced back, in the form of the angle f, in order to give, in the distance A e an equivalent to c B. This is Camper's reasoning.

No doubt all would be as he puts it if the foot did lengthen to the extent of c B, but there are two fallacies. In the first place, d is not the centre of the segment of circle which the heel describes. The real centre is at a middle point in the joint between d and D. From this point to the extremity of the heel would be the radius of a circle, which radius would be the equal in length in whatever

* For this, I am indebted to the kindness of Messrs. Hachette & Cie.

position the heel might be. Secondly, Camper had not recognised that on which I have so strongly insisted—that, by one of the same agencies that raise the heel, the arch of the foot is braced up, and the distance between its extremities diminished. The very simple experiment with the tape, already described (p. 38), shows that there must have been some fallacy in Camper's reasoning. It is further demonstrated in figs. 25 and 26, and explained by figs. 27 and 28.

Everyone who wears slippers knows that if they be ever so little too long their heels fall down as the heel of the foot is raised ; but, if the foot lengthened in raising the heel, that part would be clipped more firmly.

It is due to the honoured memory of Dr. Parkes to point out that he was a physician and sanitarian, and, although a many-sided man, it is not likely that he ever investigated the point in question for himself. He accepted as fact that which, even now, is generally accepted. Really nothing but his high authority and the wide-spread influence of his work justifies further discussion of the matter. It is, however, remarkable that, so far as appears, neither to himself, nor to the distinguished editor of the last edition of his work, nor to the many readers he has had among those devoted to the personal welfare of soldiers, does this question seem to have occurred,—If the foot lengthened an inch in every step, what would become of it if subjected to the friction that a long march would involve? Camper rightly recognised that the heel cannot extend backwards ; the foot must come forwards if it move at all. Now calculating from data supplied in Dr. Parkes' book, a soldier takes more than 2000 steps in a mile, more than 1000 for each foot.* He marches say 20 miles in one day. 20,000

* The word *mile* indicates this—*mille passus*, or a thousand Roman paces as taken from the spot whence each foot rises, to that on which it falls.

times slipping forward of the front of the foot to the extent of an inch, and 20,000 times slipping back, the former movement with the weight of a heavy man on it! The result would be too terrible to contemplate.

The supposed expansion in breadth to the extent of one-tenth, or anything like it is equally imaginary. There is one condition under which actual lengthening of the foot may occur. When the weight is borne by one foot flat on the ground, the arch, if it be a weak one, falls, with a slight increase of length. It is, however, even then, very little; the falling of the arch being to some extent attended with a bulging of the inner margin, there is only a very slight extension of distance between toe and heel. What actually takes place may be seen by putting the foot between two objects on the floor, and watching the effect of changes in the position of the foot in separating those objects. The fact is, that no man, do what he will, can add one inch to the length of his foot, any more than he, "by taking thought, can add one cubit to his stature."

Exception must also be taken to the statement, common in descriptions of the act of walking, that the foot unrolls itself. It does not do, or ought not to do, anything of the kind. We have seen that the under side is shortened rather than lengthened: it is braced up by the action of muscles which assist in raising the foot to tip-toe. There is a stiffening with increase of the concavity on the under side of all the body of the foot, and a bending, with a consequent convexity, at the roots of the toes. This is something very different from unrolling. The existing roll, as represented by the concave arch, is actually increased. Again, the foot is frequently compared to a rocker. Unhappily, the prevalent habit of coming down on the heel, then falling forward on the ball of the great toe, with little, if any, pressure on the ground by the toes, is only too close an imitation of a rocker; but should it be called walking?

In good walking, the toes should reach the ground first : they are the organs of feeling ; it is for them to literally feel the ground. In discussing the question, which part of the foot should reach it first, it must be remembered that use of the shoes cannot be pre-supposed. Man must be considered as going barefooted if we are to discover the best mode of walking. In the savage state, the foot never has a hardness at all comparable to the hoofs of animals ; it is not to the savage a matter of indifference what he treads on. Now let it be supposed that he is walking where he is liable to encounter sharp objects hidden, it may be, by verdure. If such an object be felt by the toes in pointing the foot forwards, it is possible to avoid it by withdrawing or diverting the toes while still holding the ground with the other foot. If there be no impediment : if good foot-hold for the toes and front part of the foot be found, it will afford a bearing. On this bearing the walker can spring if any sharp object come in contact with the sole of the hinder part of the foot. Moreover, the heel, coming last, is the least sensitive part of the sole.

On the other hand, if the heel reach the ground first, it is a poor guide as to the nature of the foothold. Let us assume it to have come on a good surface, but that the point where the tread will fall is occupied by a sharp object, unsuspected. In that case, when the weight of the body falls on it, recovery is impossible : one can't spring backwards on to the heel as one can forwards on to the toes. Let anyone try to walk blind-fold about a room strewed with tin-tacks. It can be done if you feel the ground first with the toes, not otherwise. It is idle to meet this by saying that for walking among tin-tacks it would be better to walk on tip-toe altogether—this was the reply actually made, in print, by a critic.—The question is, what is the best means of walking where sharp objects are unexpected, but liable to be ?

Nor is it sufficient to say that pointing the toes downwards is an "affected" mode of walking. That is a matter of taste. It is the natural walk of at least some of the highest types of savages. We are at liberty to prefer seeing the toes first touch the ground, and held down to it by tendons of muscles, which allow the heel to descend smoothly and firmly. We may think that this is better than using the foot as if it were indeed a rocker, or as if it were the plantigrade foot of a bear. Let them call it "affected" who will; it is only using the foot as it ought to be used. But, in reality, there is nothing very remarkable in the former mode of walking if it be done well. It is possible to walk about a room with chalked, but otherwise bare feet, and yet the persistence of the chalk on the heels show that they have not touched the carpet; and, still, to an ordinary observer, nothing unusual be apparent. Where the muscles are vigorous, and under complete control, that which, in a person with weak feet, or in one wearing tight or ill-fitting boots, would appear extraordinary, passes unnoticed. An attempt to walk in a natural but unaccustomed manner, with unnatural impediments, is not likely to go smoothly.

This last described style of walking is only mentioned for the sake of illustration, and not as intended for imitation. It is, however, hardly too much to say that, so long as the heel does reach the ground at every step, the less weight borne upon it the better the walking.

But it may be asked what purpose is the heel intended to serve? It is fitted with a firm and at the same time soft pad covered with a thick skin, and is so adapted better than any other part of the foot for contact with the ground. Is not this a reason for believing that the weight of the body is intended to fall upon it in walking? We are told that to place the foot almost flat on the ground is a mistake, as the body loses in part the advantage of the "buffer-like mechanism" of the heel. This would be pertinent if the construction of the heel were not otherwise explained. As it is, there is nothing in it to outweigh reasons for believing that the heel is intended for a different purpose.

The heel is admirably adapted for sustaining the weight of the body, which, in the position of standing at ease, falls mainly upon it, and is by it transmitted to the ground. For this purpose a soft covering is very desirable, which consideration alone is sufficient to account for the cushion-like pad beneath the heel, hardly, however, to be compared to a buffer. But it would be in the act of walking down a hill side with bare feet that the *necessity* for such a structure as exists would be evident. In serving as a drag to prevent slipping down a rocky slope, strong hard tissues are more than desirable; in a bare foot they are necessary. In walking up a steep hill no one uses the heels; in level ground it involves no great effort to do without them; but it would be impossible or, at least, exceedingly difficult to do without them in descending a steep incline.

Among races going barefoot the practice seems to vary. The Arabs, who have finely developed feet, point the toes downward, while some of the flat-footed inhabitants of India are said to bring the heel first to the ground; but it is admitted even of them that, in going down hill, the toes first touch the ground.

If, then, pointing the toes downwards be a necessity in going up and in going down an incline, who will explain why it is better to bring the heel first to the ground when it is level? Who will tell us at what angle of slope approximating to a level it becomes desirable to change?

After all, however, the question whether the toes should first touch the ground must be decided by another—ought they to be turned out? To keep the sole of the foot parallel with the level of the ground and yet point the toes outwards and downwards is practicably impossible. As they are pointed downwards they are naturally pointed inwards; this has been shown to be due to the construction of the ankle joint. I have before me a book on Calisthenics, where the author, having prescribed an angle of 60 degrees, enjoins on the teacher to "see that, while marching, the pupils point their toes down." Without being actually impossible, this involves so much difficulty that it would never be continuously done, however much the teacher might *see* to it.

The two questions, whether the heel or the toes should first touch the ground and whether the toes should be inclined outwards or not, must be considered together; they must stand or fall together. The decision is of great practical importance, if only because it involves the question whether the present mode of marching in the army is best for a soldier's feet, and, therefore, for his efficiency?

As to turning out the toes Camper was very emphatic. He said that it was "incontestible," for the reason "that we then form with the two feet a kind of triangle, which, like the tripod, gives them firmness." The poet, on the contrary, tells us of

> "A tower that stood four square to every wind that blew."

And the expression *standing square to all four winds of heaven* is familiar, as indicative of the firmness of a structure. It will hardly be contended that the idea of strength would be better conveyed by saying that it stood three cornered, nor will anyone allege that a square table with four legs will not stand more firmly than one three cornered with three legs. Camper's reason, therefore, may be dismissed as untenable.

It is too hastily assumed that because, in standing, one instinctively inclines the feet at an angle in relation to each other, therefore it is natural, and consequently right. Prolonged standing still is itself unnatural, and the question how it can best be done so as to avoid ill consequence is not so readily decided.

The position of rest, in the attitude of standing upright, differs from that seen in the frontispiece, where the foot is hanging loosely and the front part turned inwards. In standing it comes to a right angle with the body—it becomes more flexed. For the reason that the more the foot is pointed downwards, or extended, the more it inclines inwards, so the more it is drawn up or flexed the more it is turned outwards. This is why, in standing at ease, the feet are diverted from each other. The feet, in walking, are instinctively directed forwards, with the inner margin inclined slightly inwards. Hanging loosely, the foot having left the ground, it is in an attitude very nearly that of the position of rest, and in that position falls on the ground. Then, as the heel is lowered, that which was the relaxed position of the arch with the foot extended, becomes the strong position when the foot is at right angles with the body. All this is instinctive. Education, therefore, is necessary to acquire the habit of turning out the toes in walking, according to the conventional notion of elegance. Camper recognized this ; he said that "the toes of a gentleman should always be turned out," but he adds "those of peasants, and particularly of boatmen, are always turned in." If there be any who will contend that the toes should be turned out, in standing because it is natural, and in walking because it is indicative of education, they are beyond argument.

Let us suppose that a man has been for a considerable time walking, and that he has done it well : the opportunity then comes for a pause. The probability is that he will straighten the right knee, over-extending it, so that it locks, so to speak, in that position requiring no muscular effort to hold the thigh and leg in a straight line. Over the pillar so formed the weight of the body will be thrown, the whole being steadied by the left leg, with the foot on that side inclined at an angle to the other. He will form a natural tripod and "stand at ease." It is argued that because a man does this naturally, therefore it is the position in which nature intended him to stand. So it may be as a means of resting from muscular exertion, and yet not be the position in which to stand for a long period : that, if it is to be done without injury, must be itself a state of muscular action, not a mere sinking into repose, letting the body squat down into what position it will, so long as it does not fall. We do not argue that because a weary man inclines his head forward on his chest, therefore stooping is the proper position.

When, as in the case supposed, a man has walked a long distance, his muscles are tired ; they have borne the burden ; the ligaments have been supported by their bracing action, and very little strain has fallen on them. On the ligaments, then, the weight falls, properly and fairly falls, in repose. But ligaments are not adapted for a prolonged strain ; whether it be in walking or in prolonged standing, they must be relieved. They are relieved in walking by the bow-string or tie-rod action of the muscles, and this agency must be utilized for standing, with the same object. Nothing relieves feet strained by long standing so much as springing to tiptoe, tightening the tie-rods.

If the feet be placed parallel to each other at such a distance apart that central points under the tread of each foot and under each heel shall all of them be at equal distance from each other, we have the four-square arrangement which is the most secure ; we have also the strong position in which the arch is the most firm, and in which the muscles, acting as tie-rods, are most effective.

This, shown in fig. 34, is, as it seems to me, the position in which, beyond all question, prolonged standing should be done. I propose to call it the four-square position, because central points in the heel and in the tread are equally distant. The front part of the foot being wider than the heel, it follows that the inner margin is inclined slightly inwards. It makes an angle of about 10 degrees with a line between the two feet. Meyer's line is indicated in dots. Fig. 35 is the military position, where the feet are inclined, at an angle of 45 degrees from each other.

Why is the former of these two positions the better for standing? First, because it is four-square, and no other figure, consisting of straight lines, gives so wide a basis of support in a limited area. 2ndly, it is the strong position of the arch, so prone to yield in prolonged standing. 3rdly, a turning out of the toes tends to uplift the great toe, and so prevent the muscles acting upon it from giving so firm a pressure against the ground, and, for the same reason, the long flexor is less effective in acting as a tie-rod when the heel is lifted, as should be frequently done in prolonged standing.

Under the heading *How to Stand* I have been at some pains to explain my reasons, for the benefit of those whose duties compel them to stand for many hours daily.* The advice may be summed up in this—

1.—Always stand in the four-square position.

2.—Frequently tighten the tie-rods by springing gently on tip-toe, and do this vigorously, when opportunity occurs, with bare feet.

3.—Take care that free movement is not impeded by boots nor by socks. The proper form of these will be described presently.

* "Nursing Notes," Sept., and "The Nursing Record," 29th Nov., 1888.

4.—Let your walking be well done. This we will now proceed to further discuss.

The four-square position should be maintained for walking. In fig. 36 each foot is in precisely the same relation to the line along which the body is supposed to be moving as, in fig. 34, it is to one between the two. The importance of Meyer's line, here indicated by dots, has already been mentioned. It is the line along which the body is drawn, principally by action of the *tibialis anticus*, acting from the inner margin of the foot, and the extensor muscles acting from the toes, as fixed points. It is the line along which

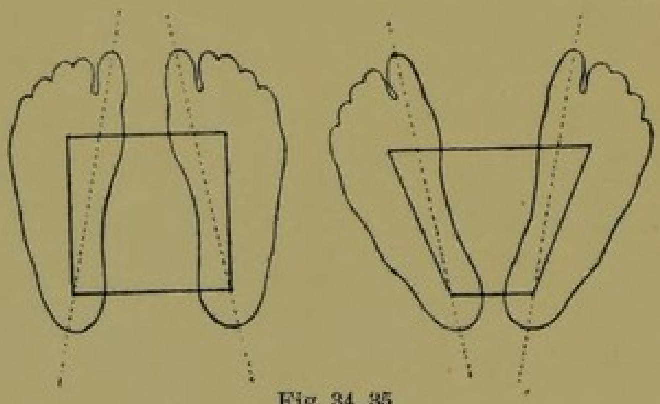


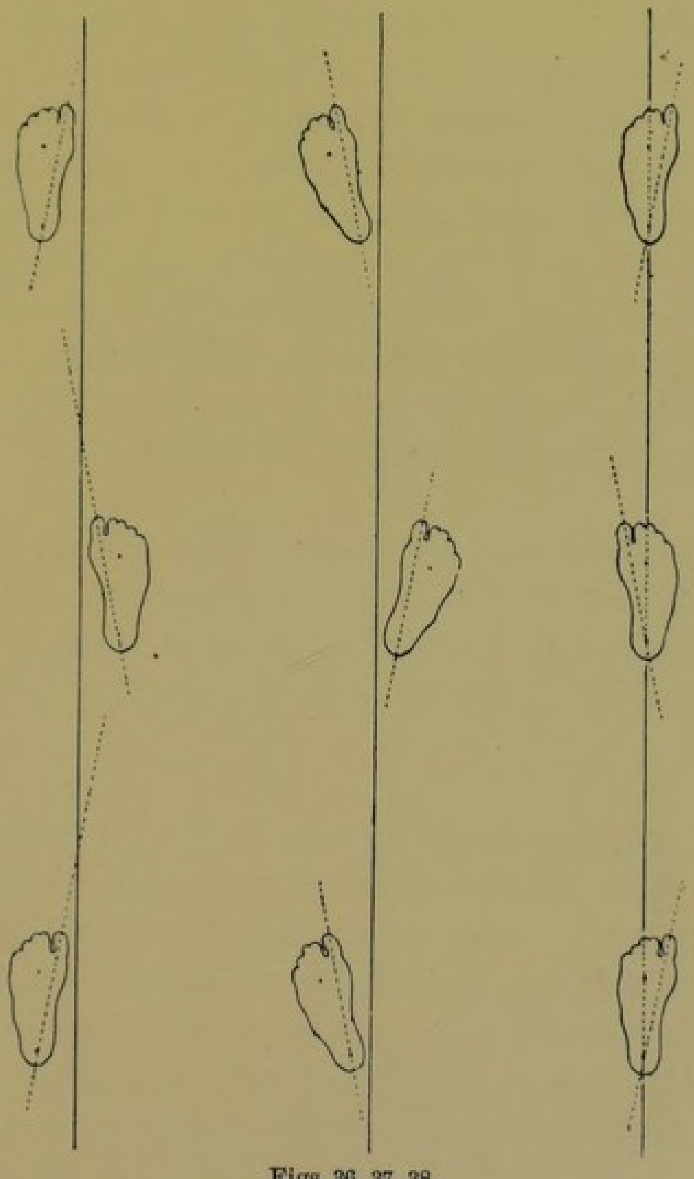
Fig. 34, 35

The four-square and the military position in standing.

the body is propelled by the powerful long flexor of the great toe, assisted by the *tibialis posticus* and long flexor of the smaller toes, which pass with it round the inner side of the ankle ; assisted also by the two *peronei* which pass round the outer side of that joint. It is, in fact, the line of traction forward when the body is behind the foot, of propulsion onward when the body has passed over it.

On looking at this diagram, it may be observed that this line does not accord with that in which the body is supposed to be moving. No, but it does point directly towards the spot on which the right foot is to fall, over which the centre of gravity must for a time be.

The right foot does literally *fall* on this spot, and in the position indicated by the diagram. The toes are inclined inwards because the ankle has been thrown outwards as the foot became extended in rising to tip-toe. The foot is now in the position of rest, and all the muscles concerned in propelling the body onwards having relaxed, the rest is complete.



Figs. 36, 37, 38

The two former correspond (in walking) to figs. 34, 35. Fig. 38 is the Red-Indian position.

Thus the most complete rest possible is given to the foot which has just borne the strain of having the body propelled onwards from it. The foot is also in the position adapted for *falling* into the proper place for the next step, without muscular effort in placing it. In this way, *foot-fall* is, as it should be, something more than a figure of speech.

Such rest as can be obtained in the intervals between steps may seem to be a small matter: the period during which the foot is uplifted from the ground seems so small as to be of no appreciable value for rest. This is not really so. The muscles concerned in respiration get no rest beyond that obtained between the inspirations: the heart, a muscular organ, only that between the beats. Yet, rest, for muscular action, is necessary, and is in each case sufficiently supplied. The slight interval of complete rest is important, too, for the ligaments, and it is highly desirable that it should be as complete as possible. The position which gives this must, therefore, be sought.

To me it seems that all these reasons tell most conclusively in favour of the four-square position, and that, in direct proportion as they do so, they tell against the conventional practice, which has the sanction of military authority.

It is, to me, impossible to believe that it can be right, for standing, to place the feet in a position in which the arch of the foot is weak rather than in one which renders it strong; (p 29) in a position for which the muscles which by action brace up the arch are much less able to act with effect (p 41), and in that which affords a less satisfactory area of support (p 67). For walking, too, the same reasons hold good against the military position, as shown in fig. 37. Moreover, muscles acting along Meyer's line draw the body forward and then propel it onwards, in a direction away from that in which it is to go; this, too, is a course for which the hinges are not adapted, while the backward thrust must be across the great toe, instead of along the line of it.

Let us see how far these hinges are adapted to the movements described. Fig. 39 is an enlargement of the bones of the left foot, as seen in fig, 1, pl. 1, the letters being the same.

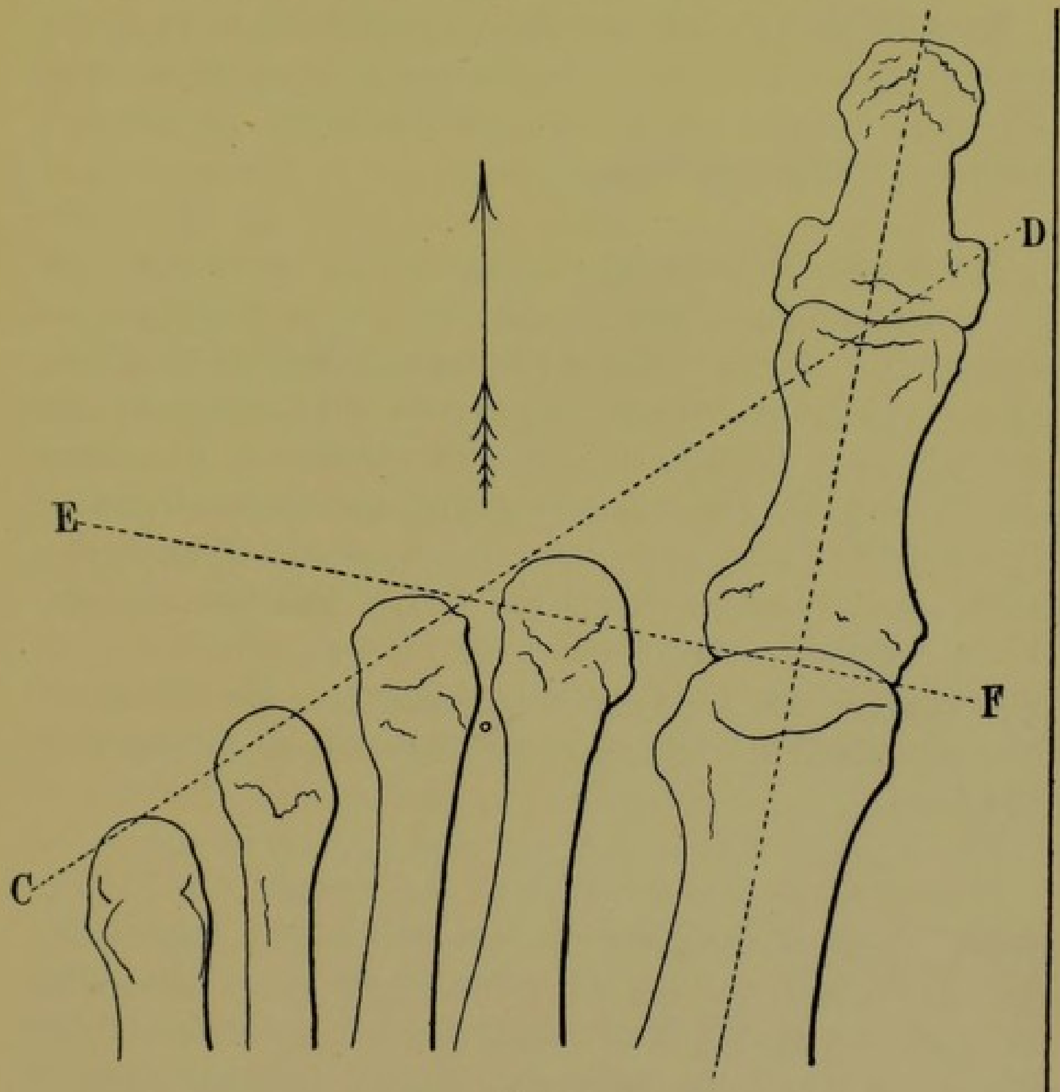


Fig. 39

The hinge line E F is seen to be at right angles to Meyer's line, which, passing through the great toe, points towards the spot where the *opposite* foot is to fall, (fig. 36). The hinge line C D is seen to pass through the *middle* joint of the great toe. The arrow points towards the spot where this foot will fall in the next step.

Meyer's line is seen passing along the great toe, which points towards the spot where the right foot is to fall, just as it does in fig. 36, making the same angle with a line between the two feet. The broad hinge E F is at right angles to this line, just as it should be. When the foot has risen to extreme tip-toe, and the body has been carried onward, then this foot has to be carried outwards so as to clear the right foot, which it has to pass; for this the hinge C D is well adapted.

These hinges, already mentioned at page 47, seem to me easy to understand, if the four-square position for walking be accepted as the natural one, but impossible to reconcile with the military position.

The reasons assigned for this position in walking do not bear examination. Here, for the sake of quoting from an authority, let us take those given in Dr. Parkes' book. First, as to the increased base of support; the gain in this respect must be in a forward and outward direction. But when the one foot is lifted from the ground the centre of gravity falls on the inner side of the other; where, then, is the advantage of having turned the toes of that foot outward where support is not wanted, away from the middle line of the body, where it is specially needed? The increased area of support is required on the same side as the uplifted foot.

Secondly "the feet can advance in a straight line." This seems to imply that there is less risk of the foot which swings forward striking the ankle of the other leg. The arrangement of the angle joint already described which throws outwards the ankle of the foot that has risen to tip-toe (the position it has assumed at the time when the other passes by), provides sufficiently against collision. Moreover, if the toes be turned out, the heel must be turned in, and be, consequently, directed towards the ankle of the other foot. Of two men walking in a dirty path, one turning out his toes, one putting them straight before him, the former will be found to have left more mud on the trouser legs, opposite the ankles, showing the greater rather than the less disposition to brush the uplifted foot against the opposite ankle.

Thirdly, it is only admitted to be "doubtful" whether, with the toes in front, there is any increased spring from the great toe, and it is alleged that the position involves a loss, in this respect, as regards the other toes. Now, taking the great toe as the base from which the body is to be propelled onward, it is, when directed slightly inwards, in line with the direction in which the body has to be carried, and in line with the tendon of the long flexor muscle which propels it. On the other hand, when turning out, it is oblique in relation to both. As to the smaller toes, they have little to do with the forward spring; their function has been explained to be that of gripping; but in direct proportion as they are turned out, the line of propulsion is oblique as regards them. This is evident from examination of fig. 39.

It is argued that military authorities may be trusted to have discovered the best way to march, and that unless it had been found by long experience that the manner followed was satisfactory it would have been changed.

But is military experience as to the mode of standing and of marching satisfactory? We are sometimes told, on reliable testimony, that, in actual service, the directions of the *red book* are ignored, and that the regulation angle of 45 degrees is not observed.

Dr. Parkes's book tells us regarding soldiers "in the attitude of attention" that the heels are close together, the toes turned out at an angle of 60°: he further states that "the position is not a secure one, as the basis of support is small," and that in the manual and platoon exercises, because of the "constant muscular action necessary to maintain the equilibrium," the men are "seldom kept long under attention." May we not ask why the men are not allowed to stand in a more secure position? Why should they not stand like the tower, "four square?" If work can be done well under such conditions as described, it could be done better with the feet further apart, and the muscles, as Dr. Parkes puts it, "less constrained."

Muscular action there must be; no one advocates that the work in question should be done in a stand-at-ease attitude. It should, however, be done in a position that is strong and secure, without being constrained.

Evidence that all is not quite satisfactory in marching is found in directions for military surgeons on field service. "At the end of the march inspect the foot-sore men." This condition has also been described as a "bane of marching armies." Why should there be so many cases of foot-sore, some men suffering, and some not at all? It is largely, if not mainly, a question of bad and of good marching, of *friction on* the ground, or of pressure against it.

We know that a file, as an instrument, is inoperative if it be merely pressed on an object; there must be sliding to cause friction. Now if the foot be pressed against the ground, and good foothold taken, especially with the great toe, at the beginning up to the end of every step, there is very little sliding and, consequently, very little friction on the sole. This foothold, for reasons already given, can be best secured when the foot is in line with the onward direction. If on the other hand, the toes are turned out, it is on the outer half of the sole that the pressure and the friction mainly comes—this is shown by the tendency of boots to wear out on that side; and it is against the outer side of the boot that the foot is thrust—this is shown by the tendency to tread over on that side. All this means sliding, friction, and consequent soreness. If the foot be hard enough to stand it, no such harm ensues, but those persons who have much horny cuticle on the sole are not the least liable to this trouble. It is possible, on the other hand, to have a very soft sole, and yet, with good walking, to go long distances, and not suffer at all. This is as it should be. A horny condition of sole, or any part of it, must be taken as indicating bad walking, and this ought to mean bad *marching* also.

Sir John Burgoyne, an eminently practical soldier, could not have been perfectly satisfied with the English mode of marching, or he would hardly have recommended that the tread of the Red Indian should be our model.* The excellence of this mode of walking has received strong testimony at the hands of travellers—notably by Catlin, and in later times by Lord Milton and Dr. Cheadle, in *The North-West Passage by Land.* Still, I should be sorry to see it adopted.

The Red-Indian walk is shown in fig. 38. The centre points of the tread and of the heel are both coincident with the line of movement. There is a manifest advantage in this, under some circumstances, because the feet can be kept in precisely the same tracks. Beyond this, I see no advantage over the four-square position, and, to me, a fatal objection is that the feet require to be *placed* in position. *Foot-falls* should be a literally exact expression. Moreover, the Red Indian, as I am informed, does not straighten his knee: this kind of step is not conducive to doing so. The step is stealthy rather than bold and springing, and, as an apparrent consequence of this, I am also informed that their feet are not finely arched.† The Arab mode of walking (a

* Transactions of the Royal Engineers—quoted by Dr Parkes.

† It was so stated in the Medical Papers of Deerfoot, a North American Indian, who was in London, a few years ago, engaged in running matches.

stately springing step) and the Arab ideal of a foot (one under which water will flow) are both far more deserving of admiration.

A very eminent military surgeon, at a meeting of the Medical Society of London, in January, 1884, enquired what could be done for flat-foot in soldiers? That such a condition could possibly arise in soldiers, unless it be from injury, disease or paralysis, is enough to condemn any manner of marching. They who walk properly are never flat-footed. All that has been said of the tie-rod effect of the long flexor muscles would, if this could be shown to be wrong, have to be unsaid, and the principles which this book is intended to teach, admitted to be unsound. It is bad enough that the army authorities should feel compelled to reject many otherwise suitable men on account of this deformity in slight or incipient form. Before me is a letter from a surgeon accustomed to examination of recruits, who says: "If it could be made clear to military medical officers that these cases rapidly get well under treatment, many a good man might be gained for her Majesty's service." There is no reason why the parade ground should not be made a school for the correction of any but very severe cases of acquired flat-foot as it is for the correction of round shoulders. A *school* is said advisedly. In each case it is a matter of Physical Education.

One good man, at least, who, as a boy, had this deformity in a most marked form, was "gained for her Majesty's service." Albert Organ, a farrier's apprentice, was under my care in the Gloucester Infirmary, with feet so flat and so painful that he could not walk across the ward, a condition acquired by standing in his occupation. He went out in a better condition, having begun exercises consisting of springing to tip-toe, which he was urged to continue. He left Gloucester, and I had forgotten his existence until more than ten years after: he then turned up as a farrier in the 2nd Life Guards, just returned from the Egyptian Campaign. His gratitude, very strongly expressed, was, however, tempered with a reproach. He said that I had advised him to take to dancing—it must have been to him, in the condition he then was, a bit of very grim humour. He took the advice to heart and carried it out so vigorously that he was, it appears, celebrated in the regiment for his proficiency. It had, however, so he said, made him much too fond of it, and led him into frivolities, which he seemed to lay at my door. Happily, be it added, the career has been too creditable to leave serious cause for remorse on my part.

This case has been published with an account of the accident which first directed my special attention to the mechanism of the foot. A horse falling on one of my own feet in going over a street crossing crushed it so severely that the strong ligaments which bind the os calcis and the scaphoid were torn through; thus nothing remained to prevent the head of the astragalus from sinking. One of the cuneiform bones was displaced upwards, and the cuboid downwards. This derangement of the chess-board, as it has been called, is evident to this day. Here was a flat foot indeed. It was held up by cleverly contrived mechanical arrangements, but, as a foot, it had ceased to be; it was a block on which I did walk, and was to me preferable to an artificial foot, but only from the hope of making it better, not because it was better. The pain of bringing a new apparatus as often as required into something like comfort was great, and, on the whole, it was difficult to imagine anything better calculated to stimulate a special study of the mechanism of the foot, in order to see if it were possible to find some means of permanent relief.

The following bit of reasoning saved me. In a horse, the hock corresponds to the heel, and the so-called leg is made of separate bones, corresponding to the human foot. In the uplifted foot (fig. 28) a likeness is apparent. Now when a horse rears, or springs over a fence, the backward thrust against the leg must be such as no ligaments could stand. But a powerful muscle which assists in raising the body has its tendon passing down behind the "leg," to be inserted into a final bone at the hoof. Thus, the same act which raises the body tightens the tendon, and has a tendency to throw these bones forward, and prevent the backward thrust. All these conditions seemed to be precisely comparable to the human foot, and my reasoning was that if in my case the tendons crossing the sole could be tightened the arch of the foot might be thrown up. Nothing would do this but action of the muscles, and any such action was painful because it moved the displaced bones. Little by little, however, the desired object was realized. In six months, a foot which for six years previously had never (without instrumental support) risen to tip-toe, was strong enough to allow of hopping over a footstool.

This was in reality a tightening of the bow-string or tie-rod (to which the tendons crossing the sole have already been compared) as a means for increasing the convexity of the bow, or throwing up the roof. The personal references must be pardoned : to make them is my only course in order to give emphatic testimony to the principle involved, a principle applicable to the prevention and cure of a common as well as distressing condition arising from the too prolonged standing incidental to many occupations.

Flat-foot is too commonly regarded as due to the weight of the body pressing down the arch. For myself I do not find that heavy well nourished children are those in which weak ankles and the more complete deformity are most common ; nor do I believe that the differences, in races, which travellers describe are due to weight of body so much as to manner of walking. Of two races, let one be heavy but haughty and imperious, accustomed to conquer and to command, let the other be light but submissive, a conquered and servile race; I venture to predict that the latter rather than the former will be flat-footed, difference of weight notwithstanding.

This deformity has received a great number and a great variety of explanations which need not be discussed. One, however, seems to call for protest. An English writer in a foreign journal, a copy of which he kindly sent me, has in the present year (1888) given his adhesion to the opinion of another authority that it is due to defective design. For myself I cannot accept as "the most rational" or as rational at all, the view "that in the normally constructed foot the lower end of the tibia is placed too much toward the inner border of the foot, so that the tendency of the tarsal arch is to give way under the pressure of the weight of the body, and has to be constantly combated by the efforts of the strong leg-muscles inserted into the foot. If we had to create a new foot and leg simply with the view of preventing flat-foot, we should plant the lower end of the tibia rather more toward the outer margin of the foot."

Of course the tendency of the tarsal arch is to give way. How otherwise could there be sufficient elasticity? Although the yielding element exists, as already stated, it is a necessity. Unless the arch were made, like a piece of masonry, unyielding, it must yield according as it braced *up* by the muscles, as in walking, or pressed *down* by the weight of the body, as in standing at ease or in falling suddenly on the feet. To say that this tendency "has to be constantly combated by the action of the strong leg-muscles," ignores the fact that they do this not as a special exertion for that purpose; they do it *in* the fulfilment of their proper functions, in moving the foot on the leg and the leg on the foot. They and their action would be just as necessary if no such extra need existed. It is one of the beauties of the animal mechanism, frequently manifest, that more than one purpose is effected by a single action, just as more than one effect generally results from the exercise of function in the different organs of the body.*

When, in walking, the heel is raised, the foot is thrown outwards, so as to escape contact in passing the other, and, at the same time, into the position of the most perfect rest and readiness for falling on the ground in the next step—all in one movement. The toes are pressed against the ground, and good foot-hold obtained, by muscles which also lift up the heads of the metatarsal bones, relieving them from undue pressure as the weight of the body falls on them. The arch, existing for the protection of muscles, is by the action of muscles formed and supported ; of these, some, in helping to form, limit the formation of it. And so, too, this arch is braced up, and all tendency to flat-foot prevented by muscles, which, in the act of raising the body, and propelling it onwards, relieve the ligaments from strain.

We must always bear in mind that the pillar formed by the upright body is a series of curves. In the spine they are directed alternately forwards and backwards ; in health there is no lateral deviation of the spinal column, which, if existing, destroys the symmetry of the body. At the hip there is an outward curve, changing to one inwards at the knee ; then the tibia has an outward curve, changing to one inwards at the ankle. The outward curves, it will be observed, are rigid ; those directed inwards are the ones which yield. Fig. 40 is a diagram of the curves at the hip, at the knee, at the ankle, where the curve is again changed to forwards and backwards at the same time. Knock-knee is an

* See motto on title page and dedication.

undue yielding at the knee (a), just as flat-foot is a yielding at the ankle (b). In each case there is, if anyone care to call it so, *a tendency to deformity* always existing, but it exists to supply a necessary purpose, and provision against

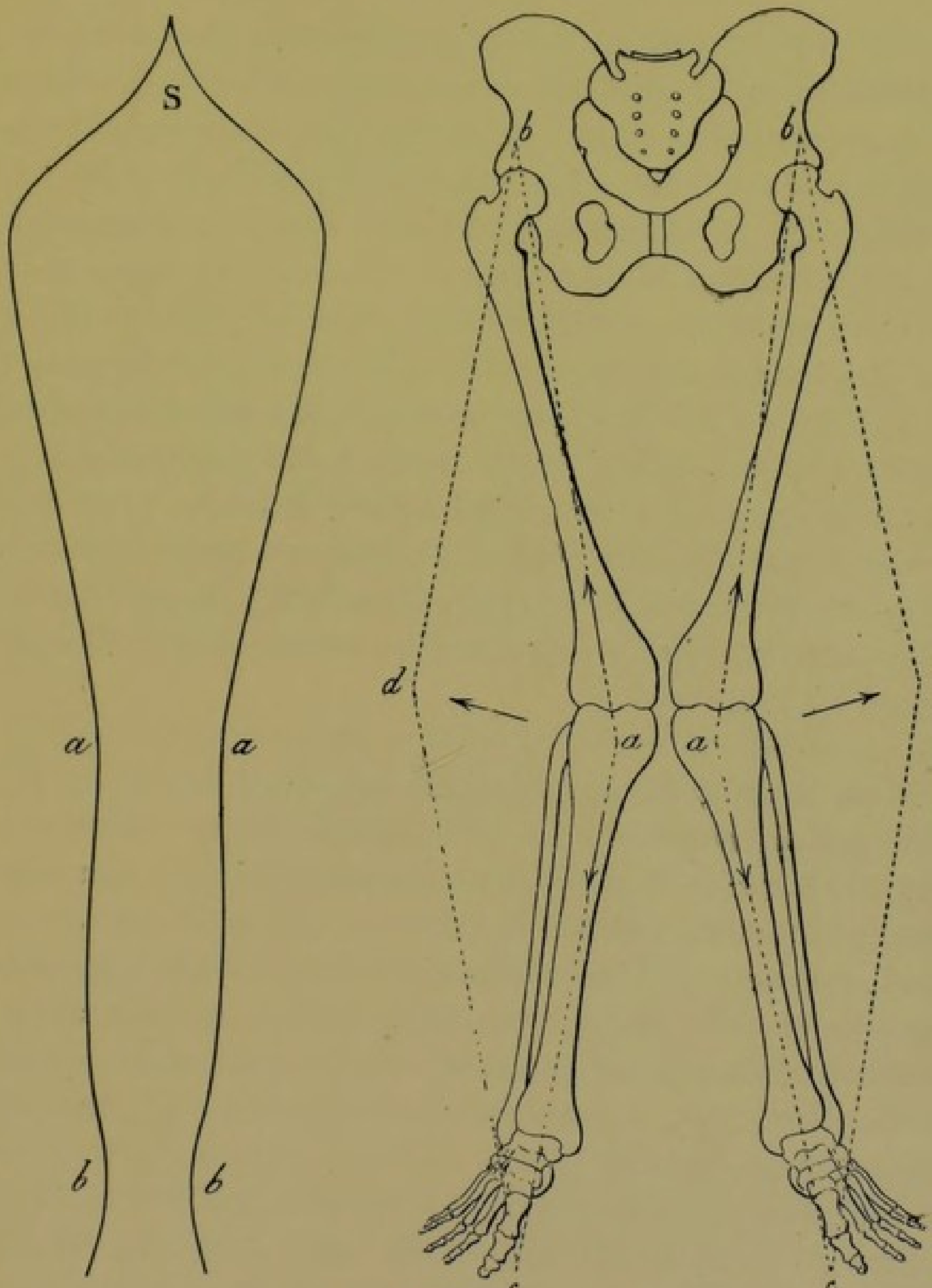


Fig. 40, 41

The former indicates the natural curves at the knee (*a*) and at the ankle (*b*), the lines uniting in the spine above S. In fig. 41 the arrows show the direction, (towards *d*), of the resultant of the two forces acting, from *a*, towards *b* and towards *c*, thus preventing knock-knee.

actual occurrence of deformity is supplied by the agency, muscular action, which, at the same time, effects another purpose, that of movement. The extent of the curve (b) is seen in the section through the ankle, fig. 16, pl. 5.

The two deformities are so closely allied that a diagram illustrating the mechanism of knock-knee is here introduced. In it two lines, the thigh and the leg, are inclined at an angle meeting at the knee. Let these be represented by a b and a c (fig. 41). We know that when two lines are inclined at an angle, traction on both ends has a tendency to draw them into one continuous straight line. The well known law of the parallelogram of forces is but an expression of this simple fact. By this law if a force acting in the line a b be counteracted by one acting in the line a c, the resultant will be in the diagonal of a completed parallelogram, or towards d, in the direction of the arrow. But this is towards a straight line between b and c. Clearly, then, if this could be done with sufficient force, the knock-knee, or the tendency thereto, would be prevented.

Now, beyond all question, the weight of the body is a force acting in the line a to c. It also acts in the line b to a, but this latter is more than counteracted by strong muscles acting in the line a to b. If these were insufficient to counteract the weight of the body, it could not be lifted from the kneeling to the upright position. These muscles are all attached, above, to the pelvis or bony ring forming the basis of the trunk and, beneath, to the bones of the leg below the knee. Some, uniting in the tendon in which the knee-cap is included, are inserted to the tibia in the middle line; others go to form the ham-strings on either side behind. The fact that these muscles are also attached to the thigh bone, along which they pass, does not affect the position. They are all collectively represented by the force acting in the line a b.

Here then we have all the conditions necessary for the operation of the law of the parallelogram of forces. Now let us suppose that a person with a tendency to knock-knee—he will probably have a tendency to flat-foot also—makes an effort to reach to the greatest possible height. He springs on tip-toe, and the foot is braced up by the bow-string or tie rod action of the muscles on the sole ; the muscles of the front of the thigh acting in the line a b (fig. 41) exert themselves to the utmost in straightening the knee, and drawing it towards a straight line between b and c. This, however, is not all. The *peroneus longus* muscle, acting from the foot as the fixed point, not only braces up the sole, but also draws the leg outwards. Moreover, the mass of muscle attached to the haunch bones, which swings the thigh and leg outwards, when they are free to move, can only act on the knee and draw it outwards when the foot is fixed on the ground. Thus we have a great array of forces all tending to prevent knock-knee and flat-foot as they draw towards a straight line between the toes of the uplifted foot and the hip.

Springing upwards, as done in reaching the bough of a tree, a strictly natural occupation, must, then, tend to prevent both of these deformities. Unfortunately, it is a movement seldom necessary in the ordinary life of most persons, and many sink downwards in consequence. Sir James Paget has well said that persistent effort to conceal deformity will often do much to correct it. This is specially true in these cases. *Reaching upwards* is a good thing to do, not only in a metaphorical sense.

Now let it be supposed that the body has reached the extreme height, and that the hands have taken hold of something to be drawn down in opposition to resistance from above, like the bough of a tree. This is done by muscles also acting in the line a b (fig. 41), but behind the thigh; they bend or flex the knee as they draw the body downwards. Still, even they tend to keep the thigh and the leg bones in a straight line from before backwards—they tend to prevent knock-knee. But the leg has to be drawn down, the knee towards the toes; this is done by the extensor muscles on the front of the leg, and, largely, by the *tibialis anticus*. This latter muscle is attached to the very crown of the arch of the foot, which, by its action, is drawn directly upwards. Here again we find the same muscular act (that of drawing down in opposition to resistance from above), good alike for the prevention of knock-knee and of flat-foot.

The influence of the *tibialis anticus* muscle is here seen to be of value in the prevention of flat-foot, but not at all commensurate with that of the bow-strings beneath. An eminent American authority, however, attributes flat-foot entirely to paralysis of this muscle, a view from which I emphatically dissent.

The arch of the foot is formed, is maintained, and, as ample experience has shown me, may be restored by the muscular action which free use of the limbs involves. But enough, I hope, has been said in justification of the view already put forth that it is not a weak point in the human body—that, given free play to the functions of the foot, the provision for maintaining the arch will be found to be as complete as for the maintenance in position of any other structure. It is almost enough to say, with respect to falling of the arch or flat-foot—for prevention promote, for restoration renew the functions of the great toe. If the short flexor muscle which holds down the first, and the long flexor muscle which holds down the final phalanx, be habitually in vigorous action, the other muscles which assist in holding up the arch (*tibialis posticus* and *peroneus longus* especially) will be pretty sure to be doing their part also. Not so the converse; the operation of the muscles acting on the foot may be continued although those acting on the great toe have become inactive. This may be instinctive, on account of pain or irritation in the large joint at the base of this toe.

It will readily be admitted, if the all-important part in the mechanism of the foot assigned to the great toe and to the muscles acting on it is to be efficiently performed, free play of all the joints concerned is a necessity. But the enormous amount of injury more or less directly traceable to interference with such free play cannot be realized unless the effects of it be carefully traced through a variety of phases.

In rest the great toe lies in contact with its fellows ; in action, when pressed against the ground, it comes away from them towards the middle of the body, moving not only downwards but sideways. This same movement takes place if it be simply pushed down with the finger and allowed to follow its own course independently of muscular action. Clearly, then, that is the line of movement for which the articular surfaces at the base are intended (fig. 1, pl. 1). Now let us suppose that it is held firmly against the others, or even over or under, as is done by a median-pointed boot. In direct proportion as this is done the joint in question grinds, so to speak, like a hinge pressed out of the proper line. Provided that this be done gently and constantly no manifest irritation is set up in the joint, and in time the new position becomes more or less permanent. The deformity, for such it is, has been successfully induced. If, however, the proceeding be violent or sudden, then evidence of serious injury to the joint will at once appear, or, as is much more likely, the full extent of injury will not be apparent, but the joint will in any case be a damaged one.

Sometimes this joint is remarkably tolerant, and will submit so quietly that the great toe will be found to have described nearly a quarter of a circle, and to have come to lie across the other toes. In such a case it is manifest that the powerful flexor muscles must have ceased to act. Thus the bow-string or tie-rod action of the long flexor must be lost. Flat-foot may therefore be expected, and is in fact often found to exist. The irritation set up may result in such spasmodic contraction of muscles as to hold the great toe rigid until it assumes a more or less permanent rigidity, or it may be found to be persistently flexed at either of the two joints ; it may assume the form seen in fig. 31, or the whole toe may point downwards. The latter form is due to causes not always clear ; the discussion of them would be out of place here. The former may be caused by direct pressure of the boot, or it may be due to loss of power in the short flexor muscles, (generally caused by temporary paralysis, due to pressure by a fallen arch) which fail to exercise the influence shown by the line 1 in fig. 29. Thus the condition portrayed by artists actually exists as a deformity, and, happily, ceases to exist so soon as the arch is restored and the muscles relieved from pressure.

The severe irritation set up in the joint, caused by the distortion and by the pressure of the boot causing it, leads to thickening at the angle formed by the base of the great toe. This thickening becomes itself a cause of increased pressure, in turn leading to still greater thickening. A fully formed bunion, as it is called, ultimately results. This very common deformity is very frequently supposed to have an hereditary origin, and the subjects of it flatter themselves that it is not due to boots at all. The tendency may be hereditary, but an exciting cause, such as distortion or pressure, must always exist.

A case in which the joint in question has never been injured by distorting the great toe from its natural position and preventing it from following its natural line of motion, is, I believe, very rare indeed. Consequently it is almost always a weak point, and liable to be the seat of disease.

This joint is well known to be a favourite seat of gout. Although it must be admitted that this familiar disease has curious preferences, not easy to explain ; it is certain that damaged parts are more favourable to it, as to all other diseases, and that the frequent occurrence of it at this spot is mainly due to the circumstance that it there finds a place which has long been the seat of more or less persistent irritation.

In-growing toe-nail is a frequent and painful result of pressure on the margins of the broad nail, developed, like everything else about the great toe, to large size. The edges curl under, and, in growing forward, throw out exceedingly sharp points, joined to the front edge of the nail by little crescents. This is a case in which removal of the cause is frequently insufficient for cure. The nail itself has to be removed, so as to make a new start.

The evils of distortion of the great toe are not confined to itself. A condition resulting therefrom known as hammer-toe is frequently found in the second. Fig. 30 shows the position in which all the smaller toes are naturally drawn by their flexors. When the upward-projecting joint cannot be straightened, and this position remains permanent, it constitutes hammer-toe. Let us see how distortion of the great toe is the cause.

The second toe in the position shown in fig. 30, that which it naturally assumes by the action of its flexor muscles, presents on its upper side, at b, a surface or bed on which the end of the great toe may lie. Now that toe, in its position of rest, is extended upwards and outwards, close to if not partially over the second. On to this surface, at b, it will probably be pressed when packed into a tight sock or median-pointed boot. When the unyielding sock or boot prevents the great toe from moving inwards it can only press downwards. Thus with every step its own flexors draw the second toe into the position which (when permanent) constitutes this deformity, while the great toe presses down the end and keeps it there. Any joint held in one position long enough tends to get fixed ; the ligaments become permanently contracted. It must also be recognized that very few persons will deliberately extend their toes when the clothing is removed, as a means of counteracting the contracted position in which they are held while it is worn. The Position of Rest, too, tends to promote contraction, as involving flexion rather than extension.

In a similar manner either of the smaller toes may become affected with hammer-toe, but the conditions favour it most in the second toe pressed down by the distorted great toe ; here it commonly appears.

Much mystery is made of hammer-toe, which has been supposed by authorities of eminence to be due to some obscure cause, seated somewhere in the nerve system. To my mind the explanation I have given is amply sufficient. But, it is argued, why should it occur almost always in this particular toe ? Because, as explained, it is the one which is over-ridden by the great toe. It is, however, distinctly shown to be hereditary: it is so manifestly hereditary in one distinguished family that the family name has been applied to the deformity.

Doubt is thrown on the probability that deformities, originally due to injury, may be transmitted and become hereditary. I see no reason for doubting this. I find in the feet of young infants, even in those newly born, the fourth toe turned in under the third, and the opposed surfaces flattened to fit each other, a condition exactly similar to that induced by pointed boots. Surely this must be a transmission of a deformity so acquired ; and there is no apparent reason why the same thing should not happen in the case of hammer-toe.

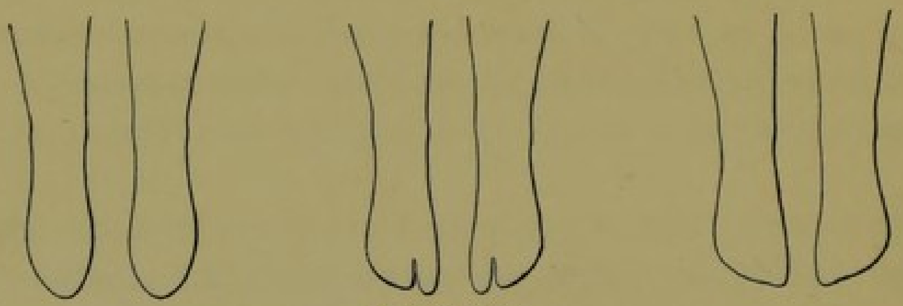
Let us take a broad view of the matter. These and other varieties of deformity of the toes are not found in races who walk barefooted ; while flat-foot, which is a consequence of bad walking, is common enough in people who go barefoot. This is noticed in India. A very reliable correspondent, writing from Sutherlandshire, states that among those who go barefooted or who, like game-keepers and shepherds, wear broad-toed boots, hammer-toe is unknown, but that it is found "amongst the younger members of the community, who, wishing to look neat, wear the narrow cramping boots which are sent from wholesale houses in the south." This is civilization extending northwards.

The relation between corns and too tight or badly fitting boots is too obvious for dispute. Corns are illustrations of the law that intermittent pressure and friction causes overgrowth. The cuticle becomes thickened at the pressure point until, in turn, it becomes itself a cause of pressure from its own hardness and large size. Here removal of the cause is speedily followed by disappearance of the effect.

That a long train of evils are more or less directly due to defective foot clothing is beyond all reasonable doubt. But while this may be recognized and admitted as regards boots, few persons at all realize the amount of injury traceable to socks and stockings. They are usually made with a middle point, and, being put on while the foot is in the Position of Rest, the toes readily accommodate themselves, and assume a pointed, crowded form, which friction against the sides of the boot, in putting it on, tends further to aggravate. Now it requires a vigorously acting great toe to overcome the impediment to side-way action, even if the sock be sufficiently elastic to allow it at all and there be room in the boot for it to take place.

If, when a great toe has been persistently distorted, the subject of it be convinced that a boot with a straight inside line is the proper thing, and has one made accordingly, it is found that the great toe will not occupy the space provided; the leather falls and hardens, the great toe, occupying its old place, crowded up with the others. This is pointed to, triumphantly, as conclusive evidence that room on the inner side was not wanted, and is of no use when supplied.

If, however, a sock with a separate stall for the great toe be worn, there is no longer any dragging on the smaller ones every time that it moves downwards and inwards; then, with good walking, the great toe will maintain its proper place. If distortion have had the effect of apparently fixing the great toe in an everted position, even then, if the great toe be persistently used, it will, as it recovers its functions, resume its proper place, unless the deformity have been so bad as to involve complete loss of function, when it can't be used at all.



Figs. 42, 43, 44
Ordinary and proper forms of sock.

The ordinary median-pointed or even-sided sock is productive, directly and indirectly, of much of the evil put down to the charge of boots, and should be discarded by all who wish to use their feet as feet. The separate stall for the great toe is always desirable, but for those who, happily, have no distortion and full use of the great toe, a sock with a straight inside line will suffice. The three forms are shown in figs. 42 '3 '4.

The separate stall for the great toe is an element of great importance, but, as regards function, there is no advantage in a separate stall for each of the smaller toes; they all move together and do very well in one casing. Under some conditions of unhealthy skin it is of decided benefit, but only then.

On the material of which the sock is composed the comfort and the healthiness of the skin much depends. It is important that it should be of wool, not of a character liable to mat together; that it should be porous, readily absorbing perspiration and readily allowing it to evaporate. Cotton does not readily absorb moisture at all, but once wet it remains clammy, and is a long time drying. As a material for clothing a foot pent up in a boot it is most unsuitable.

Free exposure of the feet, and of the socks, if they are to be worn again, to the air from which they have been secluded is highly important. For the unpleasant character which the perspiration sometimes assumes, readily amenable to judicious treatment, no remedy is efficacious unless there be free exposure to the air. To this end, cloth shoes are highly desirable.

It should be always borne in mind that the impurities in clothing consequent on personal wear are all of organic character, and capable of oxidation,—that is to say, literally burning up by free contact with air. So far as mineral matter, in the form of dust, gets in the material, that, on the removal of the organic matter holding it, readily shakes out. Thus, if only exposure to the air be sufficiently free, washing is unnecessary. What amount of exposure will be sufficient depends somewhat on the porousness of the material as well as on the freedom of the exposure.

Of a very eminent military commander I have heard Mr Villiers, the war correspondent of the *Graphic*, say—that he only takes three socks in his campaigning kit ; one always hanging on a line outside his tent, gives each a renovation in turn. In my view, that each should have a straight inner line, if not a separate stall for the great toe, two pairs would be necessary. If it be remembered that the organic matter is removed by oxidation, literally burnt out, and the inorganic matter, left as dust, is readily shaken out, then this substitution of fresh air for a laundress need cause no surprise.

Locke, in his "Essay on Education," advised for the "young gentleman" that his "shoes be made so thin as to leak and let in water whenever he comes near it." No one who advocated this would gain many adherents now. Still I have little doubt that if the feet were allowed to get freely wet, as they would through a porous material like cloth, and freely dry again, which that material would permit, the risk of injury would be less than in allowing them to get wet, or even damp, and retaining them in that condition encased in wet leather. This material is sufficiently impermeable to prevent drying, and is, especially when wet, such a good conductor of heat that the chilling of the feet is severe.

A material which would allow air to come to the skin and yet serve to keep the feet dry, both being desirable, involves an impossible combination ; and, whatever be the demerits of leather, and they are many, there is, literally, nothing like it for general acceptance, and it must be accepted as the material for clothing the foot. There is no doubt that the property of extensibility which leather possesses in a very marked degree, and which would seem to render it exceedingly easy to use for fitting an irregular object, has been the occasion of the great want of success in fitting the foot.

Of this general want of success there is no doubt. An American young lady is said to have paid her dress-maker the compliment of saying, with respect to her dress, "It fits as if I had been melted and poured in." When a boot which nearly fitted at first has been worn some time it does so fit that if liquid plaster were poured in a fairly accurate model of the foot might be obtained. But this is when the boot has been moulded to the foot by the foot itself. Few if any makers would care to submit to the same test as applied to a new boot. And yet the leather, unlike the material of the young lady's dress, is sufficiently stiff to stand up so as to receive the liquid plaster.

Why should not the moulding which the foot has to do for itself be done for it? That it is possible to cut material so unadaptable as that of which dresses are made, and with it cover shoulders accurately, but that it is not possible, with a material so adaptable as leather, to cover the foot with equal accuracy, is not a proposition which carries reasonable probability on the face of it. Moreover a wooden model, in the form of a last, on which to work, is available in the one case and not in the other. If a tailor could have an exact model in wood of the shoulders he is called on to fit, his task would surely be made more easy. I contend that no reason exists why a boot-maker should not have, in the form of a last, a model of the foot he has to fit as accurate as a sculptor's skill can make it.

No one will allege that the ordinary last is anything more than a gauge as to size. Nor can it be doubted that a boot sent home in a shape strictly conforming to the contour of a natural foot would afford no satisfaction to any but very few persons for whom they might be intended. A new boot must be elegant, as elegance is accounted. An old boot is supposed to be ugly. I think that the old boot should be the more elegant of the two. This, apparently, is not the accepted view.

The explanation is really due to a vain striving after a false ideal of beauty, for which boot-makers are not wholly responsible. They seek to supply foot clothing which accords with (to quote a trade prospectus) "that symmetry of form so desirable with persons of good taste." Whether, as appears to be the case, symmetry is here used in the strict sense of even-sidedness or not is immaterial; there is no doubt that this element is always held in view and attained as much as possible. Even those makers who make boots with straight inside lines think it necessary to make the other side to match, by giving it an angle too, as nearly as may be corresponding, although less pronounced. No one, so far as the work has come under my notice, has boldly accepted the fact that the two sides of the foot are altogether unlike, that there is no symmetry in the two sides, and has acted accordingly.

And yet if this even-sidedness be an element of beauty, it must be admitted that the pig and other animals have it in far greater perfection than, to the human foot, any boot can give.

"All facts of nature conform to utilitarian as well as to æsthetic principles, and symmetry is no doubt necessary to the mechanical balance of the body."* Yes, of the body, of the foot on either side of it, not to the two sides of one foot any more than to the two sides of one hand.

Sir Gilbert Scott, in his Lectures on Gothic Architecture, condemns any attempt "to avoid irregularity by making two essentially different parts look alike at the sacrifice of their practical demands." He had no sympathy with any "morbid striving after forced uniformity, torturing of the internal arrangements to fit a pre-conceived elevation." Is not an exactly corresponding course taken in the "morbid striving"

* Moody—Lectures on Art.

to make the boot look, if not symmetrical, as nearly so as possible? Verily there is a "torturing of the internal arrangements" of many a foot to fit a wrongly conceived idea of the form.

The two sides of the foot differ in form, in structure and in function. Instead of attempting to conceal the dissimilarity, ought we not (as Sir Gilbert puts it of a building where there is a difference in the requirements) to "rejoice in making the exterior in some degree expressive of the change of purpose in the internal arrangement?"

If the foot is to be clothed with due regard to good taste, as I understand it, all idea of symmetry must be abandoned, and real beauty seen in the absence of any such feature. The inner portion of the foot includes the strong arch on which the body is supported and the pillars thereof, from one of which the body is propelled onwards. The outer forms a buttress to give additional area of support where such support is not afforded by the foot on the other side, This difference should be expressed rather than effaced in the clothing.

It is clear that any beauty to be seen in the foot must be in the form. The texture and the colour are hidden, and, for the most part, any expression which movement can give, is hidden also. It has great beauty in form, and probably no beauty is more permanently satisfying than that of form, whether it be in a vase, as Mr Gladstone has recently pointed out, or in trees, as Lord Beaconsfield found. It would indeed be a cause for congratulation if this beauty in the foot could be expressed through clothing, fitting the foot and fully revealing the form.

Unhappily the existing state of things is only too forcibly illustrated by the writer of the official account of the

Clothing Section in the Handbook of the International Health Exhibition, who says—"Unfortunately the more hygienic the reputed qualities of the boot the less does its form commend itself to the artistic taste." Anyhow there must be something wrong here. They who worshipped the goddess Hygeia knew what beauty in form meant, and nothing should be called hygienic that is ugly or offensive to good taste.

It is by no means easy to see in what sense this much abused word "artistic" is given ; and the only clue we have is that, while the writer goes out of his way to object to the so-called hygienic boot, he finds no cause for disapproval—at any rate he expresses none—of the conventional type.

To ordinary persons fine art may be a sealed book, "for fine art is a deep well to draw from ; it covers a wide space, it penetrates far below the surface of things, it appeals to a wide range of sympathies, embracing subjects near akin to science and poetry, philosophy and religion."

These words were noted and preserved when first uttered long before they appeared in a printed book.* They may seem to discourage any utterance with respect to fine art by those who have no pretensions to be themselves artists, Not so their intention. Spoken by one who spoke with the highest authority, one who ever taught that fine art must, before everything, be true, and must accept truth from whatever source it may come, they encourage comment rather than forbid it.

* "The Ministry of Fine Art to the Happiness of Human Life," by T. Gambier Parry. The death of Mr Gambier Parry occurred just as these pages are written, at his residence, Highnam Court, near Gloucester; an irreparable loss to the neighbourhood where for fifty years he had lived and worked to promote the happiness of those around him, not only by means of the fine arts which he understood and loved so well.

Science tells us that the human foot is something very different from that which the modern boot makes it appear to be. There can be little *akin to Poetry* in that which limits the poetry of graceful motion and associates it with pain. *Philosophy* cannot accord with that which degrades to the similitude of the lower animals essentially human characters. *Religion* cannot fail to condemn that which distorts a portion of God's noblest work.

But can the boot-maker be an artist? While these pages have been in preparation one who claimed to pronounce dogmatically on *art*, said in my hearing, that a boot-maker, however skilful as an artizan, cannot be an artist. From this I did and do emphatically dissent. He may be so as really as any of the monk-masons of old, who delighted to express in stone the sense they felt of what their work was. Surely one may conclude that Mr Murray, who told us that the artist *re-produces the essential character of the object*, would allow that the boot-maker, in so far—only in so far—as he expresses in the clothing the *essential characters* of the object he clothes, may claim to be, in the highest sense of the word, an artist.

Of those who make up for want of knowledge of those essential characters by expressing a middle line which does not exist, and by putting on ornament, which expresses nothing but the designers idea of elegance, nothing need be here said.

If without presumption I may offer advice from the artistic point of view, it would be summed up in this:—Look on the feet as two halves of a harmonious whole, each the complement as well as the counterpart of the other. Bear in mind that the principal characteristic of the human foot is the great development of the inner side; that the main line of action along which the body is drawn forward and propelled onward is that which I have called the leading line, corresponding to Meyer's line in the sole. The leading line is appropriately marked in the foot by the circumstance that it is the highest part, it is, in fact, the crest of the ridge. Express this in the clothing, and let it be marked out by some feature, by the line of the laces or in the line of a seam. Let the outside of the foot appear as it is, a sort of buttress to the inner portion, and abandon all attempts to make the two sides *symmetrical.* Rather, as Sir Gilbert Scott put it, rejoice in the opportunity of making the clothing expressive of the difference of purpose in the two sides of the object you clothe.

If you must put ornamental stitching, or, as often seen in toe-caps, perforated work, avoid all appearance of attempting to express a middle line, which exists only in imagination. Accentuate, if you will, that which is an essential character, and mark out the leading line or any other feature which exists, but, at any rate, abstain from expressing that which has no existence.

The principle involved in the maxim "let the shoe-maker stick to his last," *ne sutor ultra crepidam*, if applied to the Surgeon, may forbid him to meddle with it. Surgeons have said hard things of boot-makers, without doing much to show what, from their point of view, is wanted. On the other hand one reads how that eminent medical men have "recommended shapes for the soles of boots as unfit for the human foot as a Queen Elizabeth frill for a giraffe." This was the statement of a contributor to the *Boot and Shoe Trades Journal*, but the editor of that paper once said that there were questions in which "we think that the functions of the Surgeon and the military boot-maker might be judiciously blended." In the hope that they will be accepted in the same spirit as that which dictated the above sentence any suggestions herein made as to boot making in civil life are offered, and certainly with no pretensions to any ability to teach that of which I have very little practical knowledge.

For material there is little choice ; leather is a foregone conclusion. Still I fully believe that if boots could be made to really fit the foot—fit it as a coat or lady's dress fits the shoulders—the advantages of cloth for summer wear would ensure an extensive adoption. The objection to cloth boots is generally expressed in the word clumsy.

Boots are not fitted to the foot while in process of making, as tailors or dress-makers *try on* their unfinished work : they are fitted once for all on a last, supposed to supply the purpose of a gauge rather than a model on which the work is done. My own feeling is that this *last* should be indeed a model throughout, of the same form as the foot, and including a portion of the leg above the ankle. That there is no valid reason why this should not be will be shown further on.

First, as to the outline of the sole. I distrust the pencil tracing run round the foot with no guarantee that the pencil will always be held upright or inclined at the same angle. I much prefer a tracing made by measurement *from* two parallel lines *along* other parallel lines, as indicated in fig. 45. By holding an ordinary flat rule on edge it is easy to measure from these lines to the edge of the foot, and note the distances from the heel of every measurement taken.

But a ground plan of the sole and a series of girths is not sufficient ; the contour should be taken. If the differences in the two sides of the foot should ever come to be fully realized, it may be that this in every case would not be necessary ; the sole-outline and dimensions would be sufficient direction for filling in the contour. I have never yet seen, except so far as I myself have had them made, lasts which had any pretensions to following the contour of the foot. But, surely, the highest part of the foot should have, as far as possible, its exact counterpart in the last which is to serve as a model for its clothing.

From this the necessity has followed for having some means of taking measures, not of length and girth only, but also supplying contour lines. It is also obviously necessary that these should be capable of expression in such form that the last or model-maker can understand them, and that means should exist for verifying the accuracy with which the directions given have been fulfilled.

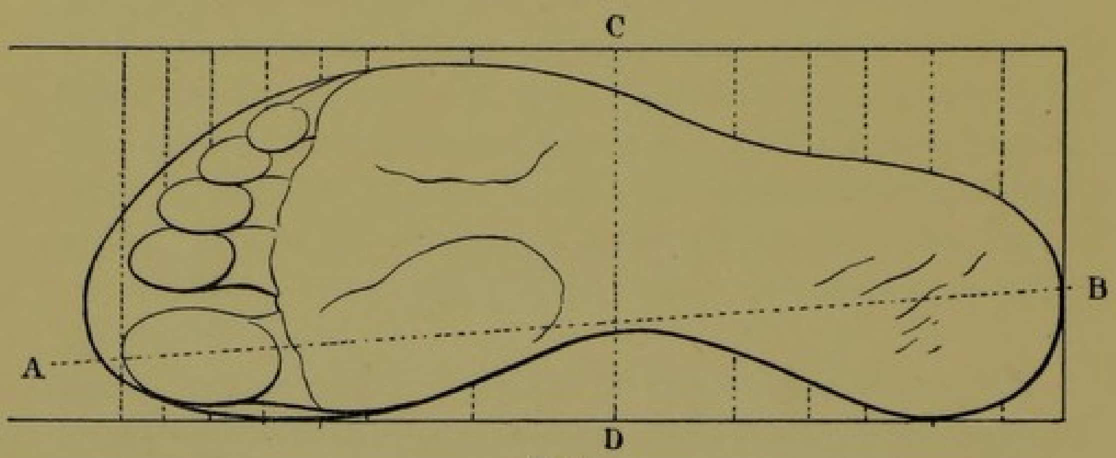


Fig. 45

Outline of sole measured *from* the continuous lines *along* the dotted lines. A B section through Meyer's line. C D section across the foot at the *creasing point*.

To fulfil these conditions I devised a form of foot-stand, which, for the sake of a distinguishing name, I propose to call the *pedistat*, fig. 46. It consists of wood, and has a middle platform twelve inches long and four wide. At one end of this is a block, against which the heel is placed. Outside the two borders of the platform are sunken grooves, along which slide two upright brass pillars ; the inner edges of these also maintain a distance of four inches apart. The margins outside the grooves are graduated in one-eighths of an inch, dating from the heel block. The pillars are similarly graduated, dating from the platform level. These pillars slide by means of a running screw, moved by a round milled head, seen in front.

A six-inch brass rule is provided, marked in the middle, but the inches not numbered ; this so as to measure either from the end of the rule or, when sliding in the grooves of

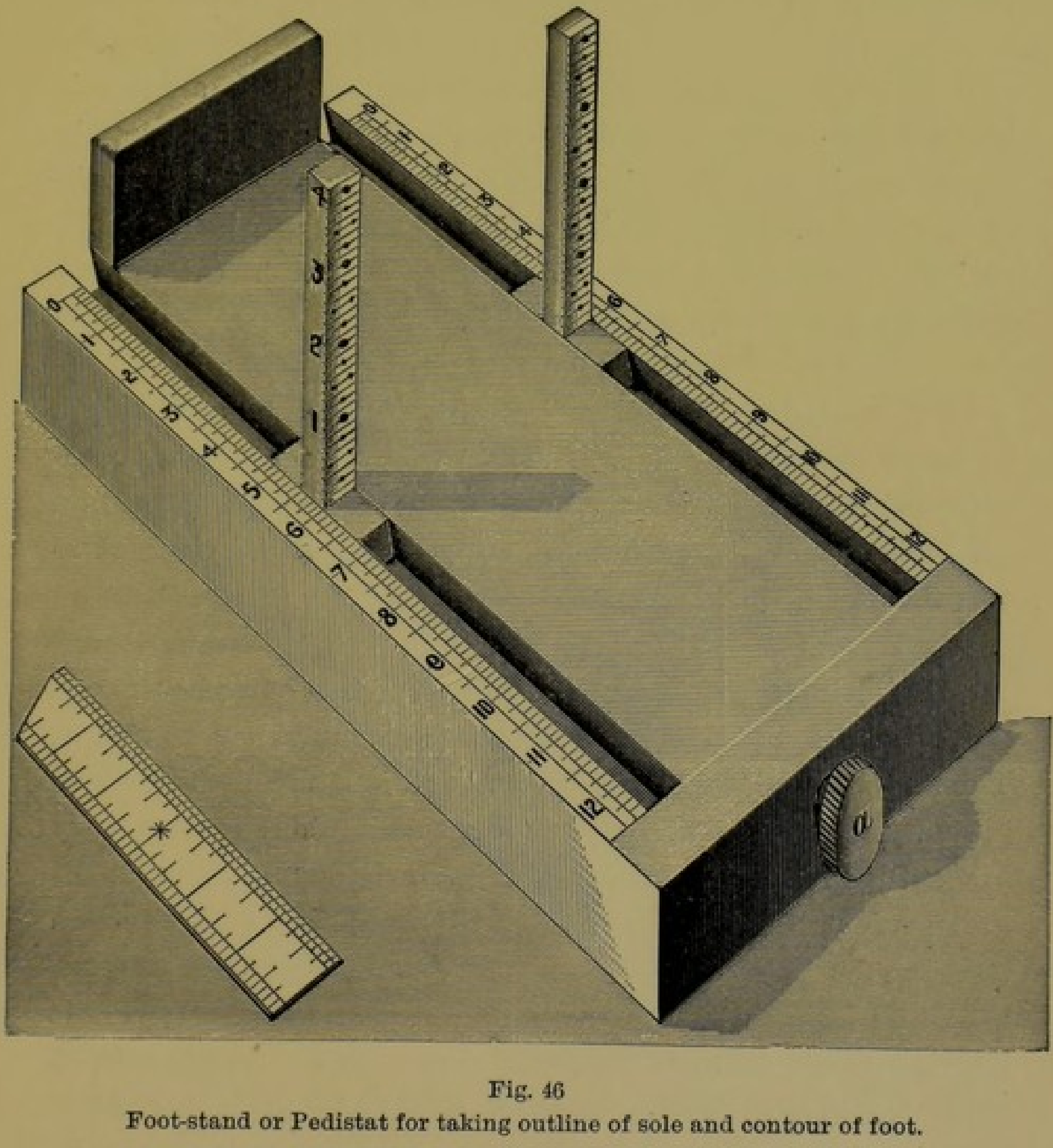


Fig. 46
Foot-stand or Pedistat for taking outline of sole and contour of foot.

the two pillars, from the first inch. The corner is cut off at one end and not at the other, so as to afford a pointed or a square ending, as desired. Both sides are graduated alike, the longer edge being bevelled, so as to run in the grooves of the pillars. When these are set at any place in the length of the foot, the brass rule bridging across from pillar to pillar will fix the exact position of the highest point of a section across that line. L. H. D. will indicate its length from the heel block, its height from the platform level, and the distance from the inner or outer border of the four-inch platform.

It is obviously easy to see whether a last with a flat sole has any point, corresponding to one in a given foot, accurately placed, as in the directions. Nor is there any difficulty in giving a ground plan which shall express the distances (D) and the lines, along or across the foot, at which sections are made by means of measurements recorded.

In fact, the making of any number of sections is only a question of time and care. If, however, the outlines common to all feet be known, very few are necessary. A section made, if cut out in cardboard, supplies a gauge by which to test the last in making it.

Fig. 45 shows a sole outline so taken, the extreme length being found by stretching the rule from pillar to pillar. The additional length has been added and the desired curve given. What this additional length should be must vary according to the thickness of material. Some must be given ; for although the supposed lengthening of the foot in walking is fallacious, room must be given, for various reasons. The foot does expand a little in standing. It is liable to slide forward in going down hill. Turning room must be given to the leather, especially if it be thick. Finally, the unpleasant appearance caused by too sharp, too abrupt, a turning, is thus prevented.

Now suppose that the contour, following the leading line, coincident with Meyer's line, be desired. If the length from the heel block (L), the height as shown by the pillars (H), and the distance from the inner margin (D), be all noted at a succession of points, a section is easily obtained. So also, if the pillars be fixed opposite the creasing point, data are easily obtained for a section across the foot. These are the two sections, indicated by the lines A B and C D in fig. 45, which were actually supplied with the ground plan shown in that figure.

The ordinary last is shown in fig. 47. The part corresponding to the ankle has no pretension to be at all like the ankle itself. The curved upper surface is shaped as seen in plan at *a*. The upper part of the hinder portion projects backwards, (even more than is shown in the figure) although the tendon above the heel lies further forward than the heel itself. This is for the obvious purpose that the last shall *draw*, that is to say, be drawn from the boot, which, if it were larger below than above, could not be done. It will be seen that the last is divided in such a way that, although the upper part can be moved, the sole-line is continuous. At *b* a section of an ordinary last would be, as shown, highest in the middle, whereas the great toe, and still more the joint at the root of it, is manifestly thicker than the little toe on the outer side.

The ordinary last is always raised at the toe, so that the tread of the foot shall rest in a hollow of the boot-sole. Thus it is only when the heel is raised that the toes can be brought to the ground.* To this I object. For ordinary walking boots, such as I use myself, I am sure that it is not necessary. These, however, have no heels : I would not on any account return to the use of them.

In my judgment no last is satisfactory that does not conform to the shape of the foot throughout, *as it stands on a*

* According to the degree, the last is said to have *spring*.

level surface. It should even include a small portion of the leg above the ankle. The difficulty of *drawing* the last is got over by a little device of my own, represented in fig. 48.

Here the last has no longitudinal division, as in fig. 47; the necessary division is made from *c* to *e*. Before this is done a hole is drilled from above the heel through to the sole at the part corresponding to the tread. The ends are counter-sunk, so as to receive a screw-head above and a nut below, where the broken surface is filled in with leather, so as to render the sole smooth. The cut, *c d*, is made at right

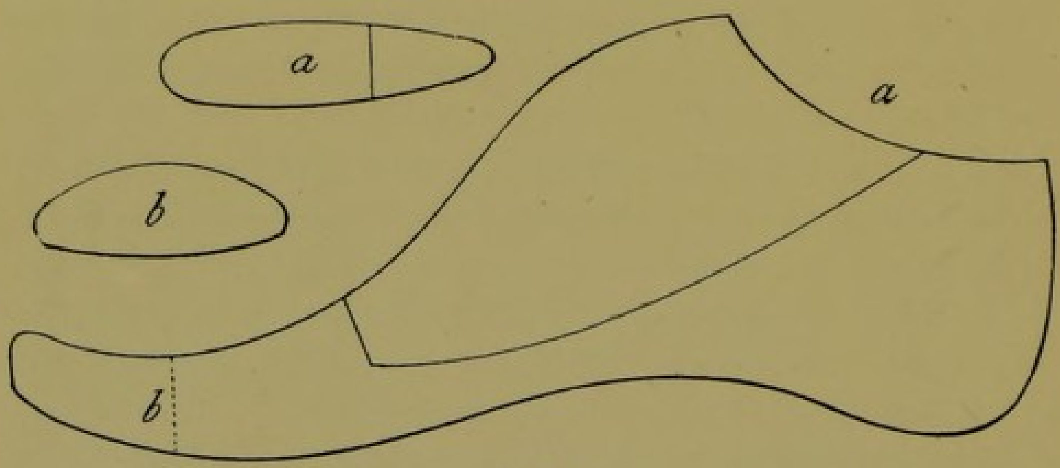


Fig. 47
Ordinary form of last. Compare fig. 48.

angles to the drill hole, so that when the pin, for which the hole is intended, is screwed into the nut, it shall pull quite straight on the opposed surfaces and not obliquely. When the cut is made as far as *d*, it is met by one made from and at right angles to the sole. The two lines thus meet and form a slight shoulder at *d*. This locks the two pieces together and prevents rotation, as well as any tendency of the hinder piece to slip up the inclined plane presented by the piece in front.

When, on the boots being finished, it is desired to withdraw the lasts, the heel part is turned back, so as to expose the screw-head and allow the pin to be unscrewed. The pin being withdrawn, the sole is bent upwards, so as to dislodge the hinder part, by raising the sole line and bringing it above *d*, when it moves up the inclined plane. The hinder part now moves forwards as it moves upwards, and so allows the projecting heel to be withdrawn. The front part is then pushed back from the toe, when it is easily removed.

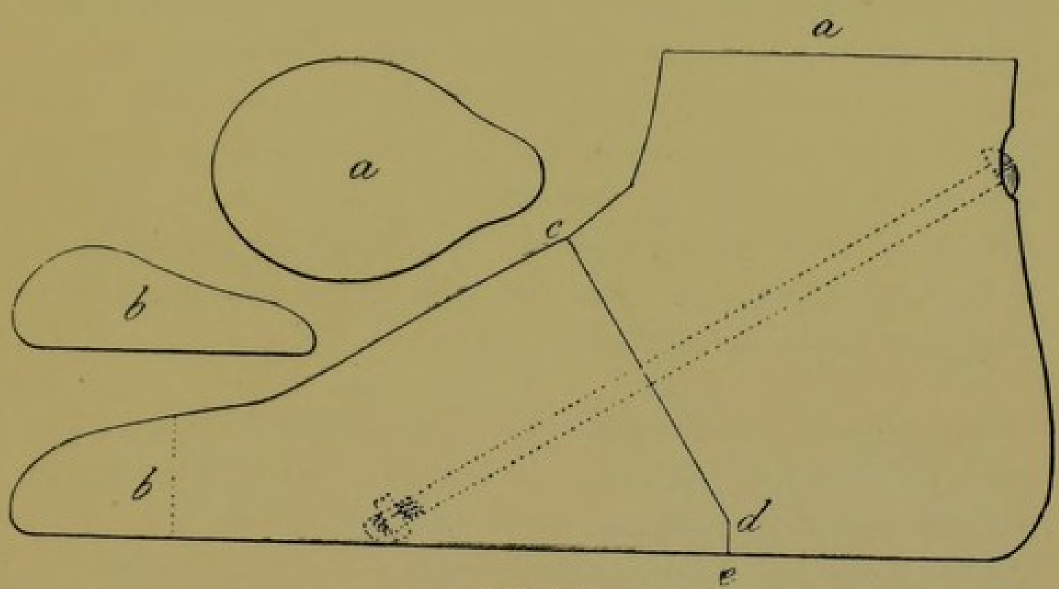


Fig 48

Author's form of last; *a* being a horizontal section across the ankle; *b* a vertical section through the front part. The dotted lines show the pin uniting the two parts divided along the line *c d e*.

It is, moreover, eminently desirable that the last should admit of being replaced in the boot. By this means alone can the question be tested whether the boot-maker has cut his patterns so as to *fit* the last, or whether he has stretched the leather so as to *make it lie smooth.* With this form of last, replacement within the boot is easy, if the boot really fit the last.

These lasts (fig. 48) are seen to be not only without spring at the toe but with a continuous line in front of the heel, and, apparently, without any waist, as it is called. The fact is that the great majority of feet do touch the ground along the whole line, so far as the outer margin is concerned, and where this is the case it is better that the lasts should do so. If, however, the pair of lasts be put together, they have the same dome-like form as the pair of feet whose sole prints are given in fig. 20. There is, in fact, a waist, although it does not extend to the sole line on the outer side.

Here I would point out that a strongly-marked waist to a boot, as a means of supporting the arch or of making a foot appear more arched than it really is, leads to disappointment. True, it gives some sense of support, at least when the boot is first worn, but the weight of the body soon bears it down and the whole boot is distorted.* The means by which, and by which alone the arch can be properly supported have been fully explained. The last should have as much and only as much waist as the foot has.

One sees it stated by last makers that "by having lasts made to your feet you not only ensure a perfect fitting boot but are always certain that each succeeding pair will be of the same shape." Would that it were so. Such, however, is not the fact. If the vamp be cut, as in fig. 49, the same for each boot, as is usually done, it is obvious that, if the last be highest on the inner side, following the contour of the foot, then the leather must be more stretched on the inner than on the outer side. When the support of the solid last is removed the leather will sink on the inner side, giving insufficient room for the ball of the great toe. The whole foot is thus driven against the other side of the boot, and it is erroneously assumed that more room is wanted on that side.

If, on the other hand, the vamps be cut so as to fit each foot, the two will have somewhat the outlines as in fig. 50;

* Pads or springs, for the purpose of supporting the arch, should be avoided. In proportion as they press it upwards, they press upon and paralyse the muscles of the sole.

one, turned over, is a pattern by which to cut the other. Then, the last being removed, the leather should stand up on the inner side, and not have the least tendency to fall. This will be so if the pattern really fit the last.

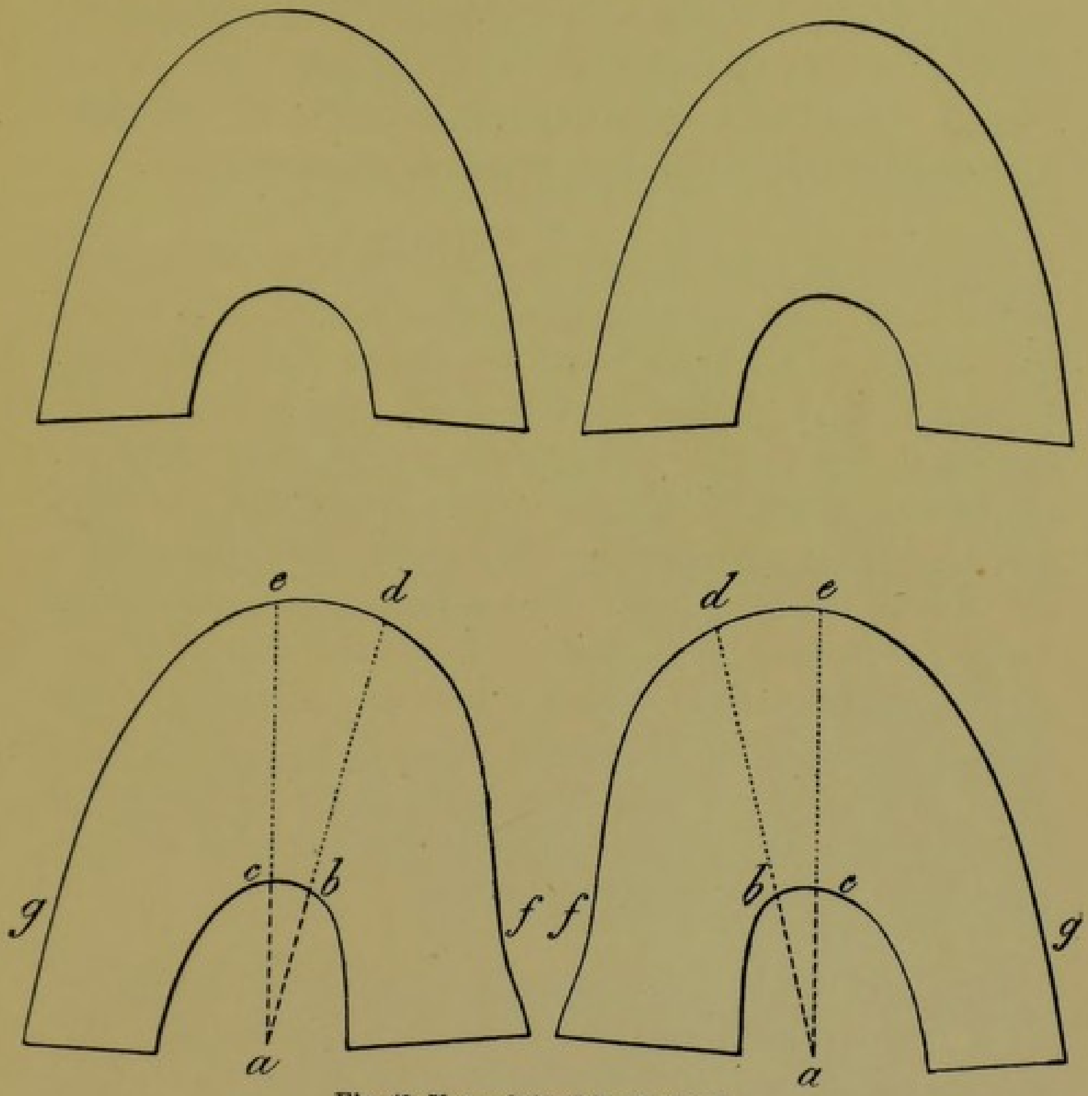


Fig. 49, 50, explained in the text.

When the pattern has been cut in this manner, and really fits the foot, it becomes absolutely necessary to discard all idea of symmetry. Let us suppose that the line of the laces in a Balmoral boot, or a prominent seam in the upper leather in one of another kind, come down from the front of the ankle through *a* to *c*, fig. 50. The upper part of the boot will then seem to point in that direction, towards *e*, while the front part will point in the direction of the great toe, towards *d*. A very awkward appearance is the result.

The line of the laces or of a seam should follow that which has been called the *leading line* of the foot. It then follows the crest of the ridge and points towards the great toe, and thus accords with and expresses a line which exists, and a far more pleasing appearance is afforded. The two sides of the boot are in that case not symmetrical. Nor should they be. The line *a b* pointing towards *d* (fig. 50) indicates the direction that the laces or visible seam should take.

But, it may be asked, how is a pattern to be cut so as to fit the last? How can an accurate fit be ensured? A skilful boot maker might find a better or simpler plan than mine. I mark or have marked on the last a line indicating the margin of the vamp. I then lay a narrow strip of paper, say half-an-inch wide, along a portion of this line, let it run quite smoothly wherever it will go, and attach the ends to the sole by drawing pins. I then keep on laying similar strips overlapping each other, and gum them together as it is done until the whole surface is covered. The gum having dried, the whole sheet is spread out, and a single piece of paper of the shape which these many pieces have assumed is cut to form the pattern. The proceeding does not take long, there is really no difficulty in it.

Still, even if the last conform to the foot and the pattern of the vamp to the last, the result may yet be bad. The leather which projects over the margin of the last will lie smoothly along the inner and outer edges as it is turned over to be attached to the sole. But at the angle corresponding to the great toe, and, in a less degree, at a point opposite the little one, the leather will fall into folds crowded together, involving much difficulty in getting it to lie smoothly as it is turned over the margin of the last. The boot maker will save himself trouble if, instead of carefully arranging these folds where they are, he should slide some of the leather backwards from *d* towards *f*, and from *e* towards *g* (fig. 50).

If he do so, bye and bye when the boot has been worn, the leather will fall into grooves having those directions.

Thus while a good last affords the means for obtaining a "perfect fitting boot," it does not ensure that it will always be "of the same shape." It ought to do so, and, in careful hands, it will.

A difficulty may be found in getting lasts of the new pattern made. It is out of the ordinary way, and last makers do not like it. There is, however, no real difficulty in making them. In fig. 48 every measurement can be referred to a straight line on the sole below and to another across the ankle above. In fig. 47 there is no straight line anywhere. A last maker accustomed to that form may make them more easily, but, in point of fact, anyone accustomed to wood carving could easily learn to shape out those having two straight lines, above and below, as in fig. 48.

As already stated I object to a last which has any *spring* or elevation at the toes. For good foot-hold pressure on the ground by the great toe before the heel rises is necessary, and this, as it seems to me, is impossible if the toe be uplifted. How far *spring* in the last would be necessary in boots with very thick soles I can't say. Of this, however, I have no doubt—that boots are often made with soles unnecessarily thick. The best provision against rapidly wearing out of the boot and against foot-soreness, is in letting the foot *fall* on the ground, with the sole level, and in firmly pressing it on the ground without friction.

It may be too that for boots having heels some *spring* would be required, which obviously must vary according to the height of the heel intended.

Here the question arises—Why is a raised heel necessary at all? I do not admit that it is necessary, or even advisable.

The presumption is that in a structure so perfect as the foot no change of level in the sole at any part is desirable. The onus of proof, then, that heels are required rests with those who advocate them ; it is not necessary to prove the negative. I may however point out that if, as I contend, the movement incidental to change of position is the agency by which the arch of the foot is maintained, then that movement should be free. If the heel is to be vigorously raised, it must be allowed to go *down* as a preliminary to springing *up*. And in direct proportion as the heel is high this going down is prevented.

The raising of the heel does not necessarily tend to destruction of the arch of the foot. We see sensational pictures of a bridge with one of its abutments uplifted and the stones falling out of place as indicative of the injury done by high heels. This is not true to nature : the arch is not only just as strong when the heel is raised as when the foot is flat, but, when raised by the action of muscles, it is even stronger.

The evils really due to high heels in boots are these—First, the heel of the foot is prevented from going down, the necessary preliminary to springing up, which is the most important movement from a functional point of view. Secondly, the foot rests on an inclined plane, and there is a constant tendency to slide forwards, driving the toes like a wedge into the front part of the boot. In this position the toes cannot move comfortably, and the tendency is for them to remain quiescent, and all the weight of the body to fall plump on the joint at the root of the great toe, to its damage, with all the train of evils, therefrom resulting, which have been detailed.

High heels are supposed to be an elegance derived from the French, who are credited with a taste superior to our own. It is not however generally recognized that the French idea of a high heel is a thing to rest on, not to walk on. The observant Max O'Rell, who has contrasted the manners and customs of the two countries, says that an English lady walks with her arms hanging down, supporting herself on her heels, the French lady walks with her arms bent, supporting herself on the toes.* I have seen it stated, in print and in all gravity, that French ladies actually practice this manner of walking with a slipper fitted with an India-rubber ball beneath the heel. This ball squeaks when subjected to pressure, and the object in the practice is to move freely and yet not sound this squeak.

We read in the *Drama of 1793*, by Alexandre Dumas, that Marie Antoinette entered the hall, on her trial, with that step of which Virgil speaks, and which reveals the queen or the goddess.† It is very difficult to imagine the possibility of this being done in high-heeled boots. Anyway we may be quite sure that there was no pounding on the heels such as strikes the ears of anyone living in an English town and sitting in a room next the street.

The reason most readily assigned for heels as being necessary is for the purpose of keeping the wearer "out of the dirt." Why there should be any greater need for protecting the heel than the front part of the foot does not appear. The latter is by far the more sensitive. Moreover, when one walks in a specially dirty place, it is on the toes rather than on the heel that it is done, a raised heel to the boot notwithstanding. In the matter of cleanliness there is a distinct advantage in a boot without a raised heel ; the sole

* L'Anglaise marche les bras pendants, en appuyant sur les talons ; la Française marche les bras pliés, en appuyant sur la pointe de pieds.

† Elle entra dans la salle de ce pas dont parle Virgile, et que révèle la reine ou la déesse.—The reference is to the Æneid, Book I, line 405—et vera incessu patuit dea.

can be passed backwards and forwards along the scraper or door mat without hindrance from the projecting heel. Gentlemen may object that the hinder edge of the trouser at the heel will rub up and down at the heel. It is simply a question of shape: trousers for boots without heels should be shaped somewhat differently from those intended to be worn with them.

That trousers are, as an element of dress, essentially bad, at least when activity is desired, there can be no doubt. Pedestrians and horsemen and cyclists all recognize this, and the workman imitates the breeches and gaiters, which he, of all others, ought not to have abandoned, by fastening a strap beneath his knee around the up-drawn trouser leg. When men have learned to use and to clothe their feet as they should do, then the same freedom which develops fine feet will develop fine legs, and a demand may arise for a dress that will display them.

For the freedom necessary to anything approaching perfect function one element in the boot is absolutely necessary,— it must have a straight inside edge. A good foot has the great toe coming up to and even beyond a straight line with the heel and the inner margin of the foot—this is seen in fig. 20 pl. 7—and the boot must permit it to assume that position when the toes are pressed against the ground.

This point is mentioned with the more emphatic insistance because the view has, on high authority, been recently put forward that Professor Meyer was wrong when he said that this form of boot is the right one. It is argued that because mocassins, as worn by the North American Indians, and slippers, as worn by ourselves, always turn up at the toes; and that because, when the toes are turned up, the great toe is not in line with the inner margin of the foot; therefore the boot need not be made with the inner margin straight.

To me it is perfectly clear that, in good walking, the toes must, *at one period in the step*, be pressed against the ground when the great toe is in line with the inner margin of the foot ; and that the boot must allow this to take place just as if the toes remained in that position throughout.

I differ from Professor Meyer only in this. I do not see the need for leaving unoccupied space opposite the smaller toes merely to make the outer match the inner side of the boot, which it ought not to do.

The evils wrought by the absurd desire to make the boot as even-sided as possible and as pointed as the wearers can bear them, are terrible in amount and more or less universal in extent. The severer forms are, it may be, little known to those who, wearing only boots of soft material, and making only moderate use of their feet, are conscious in themselves of little if of any such trouble. And yet the adult foot of perfect development, which would serve as a model for an artist, is, I believe, in either sex not easy to find. Of minor troubles and of very imperfect development are not examples everywhere abundant ?

The ugliness which arises from weakness or from distortion is so common that the belief has arisen in the minds of those who deplore it that the glory of the human foot has departed ; that finely made feet, beautiful in their manifest strength, can never again be the rule unless boots and shoes be discarded. Some enthusiastic mothers adopt this plan for their children, but find few to imitate them.

The practice of going bare-footed, even for children, will not become general, whoever may recommend it. This is so far certain that little good can come from discussion of the advantages of such practice. That it has advantages there can be no doubt. We may regard a street Arab, running on pavement, as an object of pity because he has no boots. He, probably, whatever else may be his needs, would prefer not to wear them, even if given to him.

On the other hand it must be remembered that, speaking generally, races and persons going bare-footed do not have fine feet.

If the object be to fully develop the form or the faculties of the foot, it is best done without impediment by clothing of any kind ; but then the surface on which they are to move must be selected. If, however, the foot be properly clothed and properly used, I believe that no serious impediment to its functions need exist. On the other hand it may be that, under ordinary circumstances, complete confidence of protection against injury may do more to promote freedom of movement than good foot-clothing will do to impair it.

My endeavour has been to show that the *form* of the human foot is developed and the *structure* supported *in* and *by* the free exercise of its *functions*, and that to this the *clothing* ought to conform. I see no reason why this may not be.

Let freedom of function be relied on to give full support. Let the unnatural custom of turning out the toes be abandoned. Let it be understood that if standing is to be prolonged it must be not merely a sinking into position. Let it be realized that the two sides of each foot are not symmetrical, and ought not to be made to appear so. Let the form of boot-lasts correspond in shape to that of feet in action. Let boots be made to fit the lasts as carefully as if always made of unyielding material. Then, as I believe, the foot may be clothed with every reasonable regard for comfort and elegance, and yet, attaining its highest development, be preserved in the fulness of strength and of beauty.

INDEX

A

B

C

London, 11, *New Burlington Street*
November, 1888

SELECTION

FROM

J. & A. CHURCHILL'S GENERAL CATALOGUE

COMPRISING

ALL RECENT WORKS PUBLISHED BY THEM

ON THE

ART AND SCIENCE OF MEDICINE

N.B.—As far as possible, this List is arranged in the order in which medical study is usually pursued.

A SELECTION

FROM

J. & A. CHURCHILL'S GENERAL CATALOGUE,

COMPRISING

ALL RECENT WORKS PUBLISHED BY THEM ON THE ART AND SCIENCE OF MEDICINE.

N.B.—*J. & A. Churchill's Descriptive List of Works on Chemistry, Materia Medica, Pharmacy, Botany, Photography, Zoology, the Microscope, and other Branches of Science, can be had on application.*

Practical Anatomy:
A Manual of Dissections. By CHRISTOPHER HEATH, Surgeon to University College Hospital. Seventh Edition. Revised by RICKMAN J. GODLEE, M.S. Lond., F.R.C.S., Teacher of Operative Surgery, late Demonstrator of Anatomy in University College, and Surgeon to the Hospital. Crown 8vo, with 24 Coloured Plates and 278 Engravings, 15s.

Wilson's Anatomist's Vade-Mecum. Tenth Edition. By GEORGE BUCHANAN, Professor of Clinical Surgery in the University of Glasgow; and HENRY E. CLARK, M.R.C.S., Lecturer on Anatomy at the Glasgow Royal Infirmary School of Medicine. Crown 8vo, with 450 Engravings (including 26 Coloured Plates), 18s.

Braune's Atlas of Topographical Anatomy, after Plane Sections of Frozen Bodies. Translated by EDWARD BELLAMY, Surgeon to, and Lecturer on Anatomy, &c., at, Charing Cross Hospital. Large Imp. 8vo, with 34 Photo-lithographic Plates and 46 Woodcuts, 40s.

An Atlas of Human Anatomy.
By RICKMAN J. GODLEE, M.S., F.R.C.S., Assistant Surgeon and Senior Demonstrator of Anatomy, University College Hospital. With 48 Imp. 4to Plates (112 figures), and a volume of Explanatory Text, 8vo, £4 14s. 6d.

Harvey's (Wm.) Manuscript Lectures. Prelectiones Anatomiæ Universalis. Edited, with an Autotype reproduction of the Original, by a Committee of the Royal College of Physicians of London. Crown 4to, half bound in Persian, 52s. 6d.

Anatomy of the Joints of Man.
By HENRY MORRIS, Surgeon to, and Lecturer on Anatomy and Practical Surgery at, the Middlesex Hospital. 8vo, with 44 Lithographic Plates (several being coloured) and 13 Wood Engravings, 16s.

Manual of the Dissection of the Human Body. By LUTHER HOLDEN, Consulting Surgeon to St. Bartholomew's Hospital. Edited by JOHN LANGTON, F.R.C.S., Surgeon to, and Lecturer on Anatomy at, St. Bartholomew's Hospital. Fifth Edition. 8vo, with 208 Engravings. 20s.

By the same Author.

Human Osteology.
Seventh Edition, edited by CHARLES STEWART, Conservator of the Museum R.C.S., and R. W. REID, M.D., F.R.C.S., Lecturer on Anatomy at St. Thomas's Hospital. 8vo, with 59 Lithographic Plates and 75 Engravings. 16s.

Also.

Landmarks, Medical and Surgical. Fourth Edition. 8vo, 3s. 6d.

The Student's Guide to Surgical Anatomy. By EDWARD BELLAMY, F.R.C.S. and Member of the Board of Examiners. Third Edition. Fcap. 8vo, with 81 Engravings. 7s. 6d.

Diagrams of the Nerves of the Human Body, exhibiting their Origin, Divisions, and Connections, with their Distribution to the Various Regions of the Cutaneous Surface, and to all the Muscles. By W. H. FLOWER, C.B., F.R.S., F.R.C.S. Third Edition, with 6 Plates. Royal 4to, 12s.

General Pathology:
An Introduction to. By JOHN BLAND SUTTON, F.R.C.S., Sir E. Wilson Lecturer on Pathology, R.C.S.; Assistant Surgeon to, and Lecturer on Anatomy at, Middlesex Hospital. 8vo, with 149 Engravings, 14s.

Atlas of Pathological Anatomy.
By Dr. LANCEREAUX. Translated by W. S. GREENFIELD, M.D., Professor of Pathology in the University of Edinburgh. Imp. 8vo, with 70 Coloured Plates, £5 5s.

A Manual of Pathological Anatomy. By C. HANDFIELD JONES, M.B., F.R.S., and E. H. SIEVEKING, M.D., F.R.C.P. Edited by J. F. PAYNE, M.D., F.R.C.P., Lecturer on General Pathology at St. Thomas's Hospital. Second Edition. Crown 8vo, with 195 Engravings, 16s.

Post-mortem Examinations:
A Description and Explanation of the Method of Performing them, with especial reference to Medico-Legal Practice. By Prof. VIRCHOW. Translated by Dr. T. P. SMITH. Second Edition. Fcap. 8vo, with 4 Plates, 3s. 6d.

The Human Brain:
Histological and Coarse Methods of Research. A Manual for Students and Asylum Medical Officers. By W. BEVAN LEWIS, L.R.C.P. Lond., Medical Super intendent, West Riding Lunatic Asylum. 8vo, with Wood Engravings and Photographs, 8s.

Manual of Physiology:
For the use of Junior Students of Medicine. By GERALD F. YEO, M.D., F.R.C.S., Professor of Physiology in King's College, London. Second Edition. Crown 8vo, with 318 Engravings, 14s.

Principles of Human Physiology. By W. B. CARPENTER, C.B., M.D., F.R.S. Ninth Edition. By HENRY POWER, M.B., F.R.C.S. 8vo, with 3 Steel Plates and 377 Wood Engravings, 31s. 6d.

Elementary Practical Biology:
Vegetable. By THOMAS W. SHORE, M.D., B.Sc. Lond., Lecturer on Comparative Anatomy at St. Bartholomew's Hospital. 8vo, 6s.

A Text-Book of Medical Physics, for Students and Practitioners. By J. C. DRAPER, M.D., LL.D., Professor of Physics in the University of New York. With 377 Engravings. 8vo, 18s.

Medical Jurisprudence:
Its Principles and Practice. By ALFRED S. TAYLOR, M.D., F.R.C.P., F.R.S. Third Edition, by THOMAS STEVENSON, M.D., F.R.C.P., Lecturer on Medica Jurisprudence at Guy's Hospital. 2 vols. 8vo, with 188 Engravings, 31s. 6d.

By the same Authors.

A Manual of Medical Jurisprudence. Eleventh Edition. Crown 8vo, with 56 Engravings, 14s.

Also.

Poisons,
In Relation to Medical Jurisprudence and Medicine. Third Edition. Crown 8vo, with 104 Engravings, 16s.

Lectures on Medical Jurisprudence. By FRANCIS OGSTON, M.D., late Professor in the University of Aberdeen. Edited by FRANCIS OGSTON, Jun., M.D. 8vo, with 12 Copper Plates, 18s.

The Student's Guide to Medical Jurisprudence. By JOHN ABERCROMBIE, M.D., F.R.C.P., Lecturer on Forensic Medicine to Charing Cross Hospital. Fcap. 8vo, 7s. 6d.

Microscopical Examination of Drinking Water and of Air. By J. D. MACDONALD, M.D., F.R.S., Ex Professor of Naval Hygiene in the Army Medical School. Second Edition. 8vo, with 25 Plates, 7s. 6d.

Pay Hospitals and Paying Wards throughout the World. By HENRY C. BURDETT. 8vo, 7s.

By the same Author.

Cottage Hospitals — General, Fever, and Convalescent: Their Progress, Management, and Work. Second Edition, with many Plans and Illustrations. Crown 8vo, 14s.

Hospitals, Infirmaries, and Dispensaries: Their Construction, Interior Arrangement, and Management; with Descriptions of existing Institutions, and 74 Illustrations. By F. OPPERT, M.D., M.R.C.P.L. Second Edition. Royal 8vo, 12s.

Hospital Construction and Management. By F. J. MOUAT, M.D., Local Government Board Inspector, and H. SAXON SNELL, Fell. Roy. Inst. Brit. Architects. In 2 Parts, 4to, 15s. each; or, the whole work bound in half calf, with large Map, 54 Lithographic Plates, and 27 Woodcuts, 35s.

Public Health Reports.
By Sir JOHN SIMON, C.B., F.R.S. Edited by EDWARD SEATON, M.D., F.R.C.P. 2 vols. 8vo, with Portrait, 36s.

A Manual of Practical Hygiene. By E. A. PARKES, M.D., F.R.S. Seventh Edition, by F. DE CHAUMONT, M.D., F.R.S., Professor of Military Hygiene in the Army Medical School. 8vo, with 9 Plates and 101 Engravings, 18s.

A Handbook of Hygiene and Sanitary Science. By GEO. WILSON, M.A., M.D., F.R.S.E., Medical Officer of Health for Mid-Warwickshire. Sixth Edition. Crown 8vo, with Engravings. 10s. 6d.

By the same Author.

Healthy Life and Healthy Dwellings: A Guide to Personal and Domestic Hygiene. Fcap. 8vo, 5s.

Sanitary Examinations Of Water, Air, and Food. A Vade-Mecum for the Medical Officer of Health. By CORNELIUS B. FOX, M.D., F.R.C.P. Second Edition. Crown 8vo, with 110 Engravings, 12s. 6d.

Epidemic Influences: Epidemiological Aspects of Yellow Fever and of Cholera. The Milroy Lectures. By ROBERT LAWSON, LL.D., Inspector-General of Hospitals. 8vo, with Maps, Diagrams, &c., 6s.

Detection of Colour-Blindness and Imperfect Eyesight. By CHARLES ROBERTS, F.R.C.S. Second Edition. 8vo, with a Table of Coloured Wools, and Sheet of Test-types, 5s.

Illustrations of the Influence of the Mind upon the Body in Health and Disease: Designed to elucidate the Action of the Imagination. By D. H. TUKE, M.D., F.R.C.P., LL.D. Second Edition. 2 vols. crown 8vo, 15s.

By the same Author.

Sleep-Walking and Hypnotism. 8vo, 5s.

A Manual of Psychological Medicine. With an Appendix of Cases. By JOHN C. BUCKNILL, M.D., F.R.S., and D. HACK TUKE, M.D., F.R.C.P. Fourth Edition. 8vo, with 12 Plates (30 Figures) and Engravings, 25s.

Mental Affections of Childhood and Youth (Lettsomian Lectures for 1887, &c.). By J. LANGDON DOWN, M.D., F.R.C.P., Senior Physician to the London Hospital. 8vo, 6s.

Mental Diseases: Clinical Lectures. By T. S. CLOUSTON, M.D., F.R.C.P. Edin., Lecturer on Mental Diseases in the University of Edinburgh. Second Edition. Crown 8vo, with 8 Plates (6 Coloured), 12s. 6d.

Private Treatment of the Insane as Single Patients. By EDWARD EAST, M.R.C.S., L.S.A. Crown 8vo, 2s. 6d.

Manual of Midwifery. By ALFRED L. GALABIN, M.A., M.D., F.R.C.P., Obstetric Physician to, and Lecturer on Midwifery, &c. at, Guy's Hospital. Crown 8vo, with 227 Engravings, 15s.

The Student's Guide to the Practice of Midwifery. By D. LLOYD ROBERTS, M.D., F.R.C.P., Lecturer on Clinical Midwifery and Diseases of Women at the Owens College; Obstetric Physician to the Manchester Royal Infirmary. Third Edition. Fcap. 8vo, with 2 Coloured Plates and 127 Wood Engravings, 7s. 6d.

Lectures on Obstetric Operations: Including the Treatment of Hæmorrhage, and forming a Guide to the Management of Difficult Labour. By ROBERT BARNES, M.D., F.R.C.P., Consulting Obstetric Physician to St. George's Hospital. Fourth Edition. 8vo, with 121 Engravings, 12s. 6d.

By the same Author.

A Clinical History of Medical and Surgical Diseases of Women. Second Edition. 8vo, with 181 Engravings, 28s.

Clinical Lectures on Diseases of Women: Delivered in St. Bartholomew's Hospital, by J. MATTHEWS DUNCAN, M.D., LL.D., F.R.S. Third Edition. 8vo, 16s.

Notes on Diseases of Women: Specially designed to assist the Student in preparing for Examination. By J. J. REYNOLDS, L.R.C.P., M.R.C.S. Third Edition. Fcap. 8vo, 2s. 6d.

By the same Author.

Notes on Midwifery: Specially designed for Students preparing for Examination. Second Edition. Fcap. 8vo, with 15 Engravings, 4s.

A Manual of Obstetrics. By A. F. A. KING, A.M., M.D., Professor of Obstetrics, &c., in the Columbian University, Washington, and the University of Vermont. Third Edition. Crown 8vo, with 102 Engravings, 8s.

Intra-Uterine Death: (Pathology of). Being the Lumleian Lectures, 1887. By WILLIAM O. PRIESTLEY, M.D., F.R.C.P., LL.D., Consulting Physician to King's College Hospital. 8vo, with 3 Coloured Plates and 17 Engravings, 7s. 6d.

The Student's Guide to the Diseases of Women. By ALFRED L. GALABIN, M.D., F.R.C.P., Obstetric Physician to Guy's Hospital. Fourth Edition. Fcap. 8vo, with 94 Engravings, 7s. 6d.

West on the Diseases of Women. Fourth Edition, revised by the Author, with numerous Additions by J. MATTHEWS DUNCAN, M.D., F.R.C.P., F.R.S.E., Obstetric Physician to St. Bartholomew's Hospital. 8vo, 16s.

Obstetric Aphorisms: For the Use of Students commencing Midwifery Practice. By JOSEPH G. SWAYNE, M.D. Eighth Edition. Fcap. 8vo, with Engravings, 3s. 6d.

Handbook of Midwifery for Midwives: By J. E. BURTON, L.R.C.P. Lond., Surgeon to the Hospital for Women, Liverpool. Second Edition. With Engravings. Fcap. 8vo, 6s.

A Handbook of Uterine Therapeutics, and of Diseases of Women. By E. J. TILT, M.D., M.R.C.P. Fourth Edition. Post 8vo, 10s.

By the same Author.

The Change of Life In Health and Disease: A Clinical Treatise on the Diseases of the Nervous System incidental to Women at the Decline of Life. Fourth Edition. 8vo, 10s. 6d.

Diseases of the Uterus, Ovaries, and Fallopian Tubes: A Practical Treatise by A. COURTY, Professor of Clinical Surgery, Montpellier. Translated from Third Edition by his Pupil, AGNES MCLAREN, M.D., M.K.Q.C.P.I., with Preface by J. MATTHEWS DUNCAN, M.D., F.R.C.P. 8vo, with 424 Engravings, 24s.

Gynæcological Operations: (Handbook of). By ALBAN H. G. DORAN, F.R.C.S., Surgeon to the Samaritan Hospital. 8vo, with 167 Engravings, 15s.

The Female Pelvic Organs: Their Surgery, Surgical Pathology, and Surgical Anatomy. In a Series of Coloured Plates taken from Nature; with Commentaries, Notes, and Cases. By HENRY SAVAGE, M.D., F.R.C.S., Consulting Officer of the Samaritan Free Hospital. Fifth Edition. Roy. 4to, with 17 Lithographic Plates (15 coloured) and 52 Woodcuts, £1 15s.

A Practical Treatise on the Diseases of Women. By T. GAILLARD THOMAS, M.D., Professor of Diseases of Women in the College of Physicians and Surgeons, New York. Fifth Edition. Roy. 8vo, with 266 Engravings, 25s.

Diseases and Accidents Incident to Women, and the Practice of Medicine and Surgery applied to them. By W. H. BYFORD, A.M., M.D., Professor of Gynæcology in Rush Medical College, and HENRY T. BYFORD, M.D., Surgeon to the Woman's Hospital, Chicago. Fourth Edition. 8vo, with 306 Engravings, 25s.

Abdominal Surgery. By J. GREIG SMITH, M.A., F.R.S.E., Surgeon to the Bristol Royal Infirmary and Lecturer on Surgery in the Bristol Medical School. Second Edition. 8vo, with 79 Engravings, 21s.

The Student's Guide to Diseases of Children. By JAS. F. GOODHART, M.D., F.R.C.P., Physician to Guy's Hospital, and to the Evelina Hospital for Sick Children. Third Edition. Fcap. 8vo, 10s. 6d.

Diseases of Children. For Practitioners and Students. By W. H. DAY, M.D., Physician to the Samaritan Hospital. Second Edition. Crown 8vo, 12s. 6d.

A Practical Treatise on Disease in Children. By EUSTACE SMITH, M.D., Physician to the King of the Belgians, Physician to the East London Hospital for Children. 8vo, 22s.

By the same Author.

Clinical Studies of Disease in Children. Second Edition. Post 8vo, 7s. 6d. *Also.*

The Wasting Diseases of Infants and Children. Fifth Edition. Post 8vo, 8s. 6d.

A Practical Manual of the Diseases of Children. With a Formulary. By EDWARD ELLIS, M.D. Fifth Edition. Crown 8vo, 10s.

A Manual for Hospital Nurses and others engaged in Attending on the Sick, and a Glossary. By EDWARD J. DOMVILLE, Surgeon to the Exeter Lying-in Charity. Sixth Edition. Cr. 8vo, 2s. 6d.

A Manual of Nursing, Medical and Surgical. By CHARLES J. CULLINGWORTH, M.D., Obstetric Physician to St. Thomas's Hospital. Second Edition. Fcap. 8vo, with Engravings, 3s. 6d.

By the same Author.

A Short Manual for Monthly Nurses. Second Edition. Fcap. 8vo, 1s. 6d.

Hospital Sisters and their Duties. By EVA C. E. LÜCKES, Matron to the London Hospital. Second Edition. Crown 8vo, 2s. 6d.

Diseases and their Commencement. Lectures to Trained Nurses. By DONALD W. C. HOOD, M.D., M.R.C.P., Physician to the West London Hospital. Crown 8vo, 2s. 6d.

Outlines of Infectious Diseases: For the use of Clinical Students. By J. W. ALLAN, M.B., Physician Superintendent Glasgow Fever Hospital. Fcap. 8vo., 3s.

Infant Feeding and its Influence on Life; By C. H. F. ROUTH, M.D., Physician to the Samaritan Hospital. Fourth Edition. Fcap. 8vo. [*Preparing.*

Manual of Botany: Including the Structure, Classification, Properties, Uses, and Functions of Plants. By ROBERT BENTLEY, Professor of Botany in King's College and to the Pharmaceutical Society. Fifth Edition. Crown 8vo, with 1,178 Engravings, 15s.

By the same Author.

The Student's Guide to Structural, Morphological, and Physiological Botany. With 660 Engravings. Fcap. 8vo, 7s. 6d.

Also.

The Student's Guide to Systematic Botany, including the Classification of Plants and Descriptive Botany. Fcap. 8vo, with 350 Engravings, 3s. 6d.

Medicinal Plants: Being descriptions, with original figures, of the Principal Plants employed in Medicine, and an account of their Properties and Uses. By Prof. BENTLEY and Dr. H. TRIMEN, F.R.S. In 4 vols., large 8vo, with 306 Coloured Plates, bound in Half Morocco, Gilt Edges, £11 11s.

Materia Medica. A Manual for the use of Students. By ISAMBARD OWEN, M.D., F.R.C.P., Lecturer on Materia Medica, &c., to St. George's Hospital. Second Edition. Crown 8vo, 6s. 6d.

Royle's Manual of Materia Medica and Therapeutics. Sixth Edition, including additions and alterations in the B.P. 1885. By JOHN HARLEY, M.D., Physician to St. Thomas's Hospital. Crown 8vo, with 139 Engravings, 15s.

Materia Medica and Therapeutics: Vegetable Kingdom — Organic Compounds — Animal Kingdom. By CHARLES D. F. PHILLIPS, M.D., F.R.S. Edin., late Lecturer on Materia Medica and Therapeutics at the Westminster Hospital Medical School. 8vo, 25s.

The Student's Guide to Materia Medica and Therapeutics. By JOHN C. THOROWGOOD, M.D., F.R.C.P. Second Edition. Fcap. 8vo, 7s.

A Companion to the British Pharmacopœia. By PETER SQUIRE, Revised by his Sons, P. W. and A. H. SQUIRE. 14th Edition. 8vo, 10s. 6d.

By the same Authors.

The Pharmacopœias of the London Hospitals, arranged in Groups for Easy Reference and Comparison. Fifth Edition. 18mo, 6s.

The Prescriber's Pharmacopœia: The Medicines arranged in Classes according to their Action, with their Composition and Doses. By NESTOR J. C. TIRARD, M.D., F.R.C.P., Professor of Materia Medica and Therapeutics in King's College, London. Sixth Edition. 32mo, bound in leather, 3s.

A Treatise on the Principles and Practice of Medicine. Sixth Edition. By AUSTIN FLINT, M.D., W. H. WELCH, M.D., and AUSTIN FLINT, jun., M.D. 8vo, with Engravings, 26s.

Climate and Fevers of India, with a series of Cases (Croonian Lectures, 1882). By Sir JOSEPH FAYRER, K.C.S.I., M.D. 8vo, with 17 Temperature Charts, 12s.

By the same Author.

The Natural History and Epidemiology of Cholera; Being the Annual Oration of the Medical Society of London, 1888. 8vo, 3s. 6d.

Family Medicine for India. A Manual. By WILLIAM J. MOORE, M.D., C.I.E., Honorary Surgeon to the Viceroy of India. Published under the Authority of the Government of India. Fifth Edition. Post 8vo, with Engravings. [*In the Press.*

By the same Author.

A Manual of the Diseases of India: With a Compendium of Diseases generally. Second Edition. Post 8vo, 10s.

The Prevention of Disease in Tropical and Sub-Tropical Campaigns. (Parkes Memorial Prize for 1886.) By ANDREW DUNCAN, M.D., B.S. Lond., F.R.C.S., Surgeon, Bengal Army. 8vo, 12s. 6d.

Practical Therapeutics: A Manual. By EDWARD J. WARING, C.I.E., M.D., F.R.C.P., and DUDLEY W. BUXTON, M.D., B.S. Lond. Fourth Edition. Crown 8vo, 14s.

By the same Author.

Bazaar Medicines of India, And Common Medical Plants: With Full Index of Diseases, indicating their Treatment by these and other Agents procurable throughout India, &c. Fourth Edition Fcap. 8vo, 5s.

Diseases of the Heart and Aorta: Clinical Lectures. By G. W. BALFOUR, M.D., F.R.C.P., F.R.S. Edin., late Senior Physician and Lecturer on Clinical Medicine, Royal Infirmary, Edinburgh. Second Edition. 8vo, with Chromo-lithograph and Wood Engravings, 12s. 6d.

Medical Ophthalmoscopy: A Manual and Atlas. By W. R. GOWERS, M.D., F.R.C.P., F.R.S., Professor of Clinical Medicine in University College, Physician to University College Hospital and to the National Hospital for the Paralyzed and Epileptic. Second Edition, with Coloured Plates and Woodcuts. 8vo, 18s.

By the same Author.

Diagnosis of Diseases of the Brain. Second Edition. 8vo, with Engravings, 7s. 6d.

Also.

Diagnosis of Diseases of the Spinal Cord. Third Edition. 8vo, with Engravings, 4s. 6d.

Also.

A Manual of Diseases of the Nervous System.

Vol. I. Diseases of the Spinal Cord and Nerves. Roy. 8vo, with 171 Engravings (many figures), 12s. 6d.

Vol. II. Diseases of the Brain and Cranial Nerves: General and Functional Diseases of the Nervous System. 8vo, with 170 Engravings, 17s. 6d.

Diseases of the Nervous System. Lectures delivered at Guy's Hospital. By SAMUEL WILKS, M.D., F.R.S. Second Edition. 8vo, 18s.

Nerve Vibration and Excitation, as Agents in the Treatment of Functional Disorder and Organic Disease. By J. MORTIMER GRANVILLE, M.D. 8vo, 5s.

By the same Author.

Gout in its Clinical Aspects. Crown 8vo, 6s.

Regimen to be adopted in Cases of Gout. By WILHELM EBSTEIN, M.D., Professor of Clinical Medicine in Göttingen. Translated by JOHN SCOTT, M.A., M.B. 8vo, 2s. 6d.

Diseases of the Nervous System. Clinical Lectures. By THOMAS BUZZARD, M.D., F.R.C.P., Physician to the National Hospital for the Paralysed and Epileptic. With Engravings, 8vo. 15s.

By the same Author.

Some Forms of Paralysis from Peripheral Neuritis: of Gouty, Alcoholic, Diphtheritic, and other origin. Crown 8vo, 5s.

Diseases of the Liver: With and without Jaundice. By GEORGE HARLEY, M.D., F.R.C.P., F.R.S. 8vo, with 2 Plates and 36 Engravings, 21s.

By the same Author.

Inflammations of the Liver, and their Sequelæ. Crown 8vo, with Engravings, 5s.

Gout, Rheumatism, And the Allied Affections; with Chapters on Longevity and Sleep. By PETER HOOD, M.D. Third Edition. Crown 8vo, 7s. 6d.

Diseases of the Stomach: The Varieties of Dyspepsia, their Diagnosis and Treatment. By S. O. HABERSHON, M.D., F.R.C.P. Third Edition. Crown 8vo, 5s.

By the same Author.

Pathology of the Pneumogastric Nerve: Lumleian Lectures for 1876. Second Edition. Post 8vo, 4s.

Also.

Diseases of the Abdomen, Comprising those of the Stomach and other parts of the Alimentary Canal, Œsophagus, Cæcum, Intestines, and Peritoneum. Fourth Edition. 8vo, with 5 Plates, 21s.

Also.

Diseases of the Liver, Their Pathology and Treatment. Lettsomian Lectures. Second Edition. Post 8vo, 4s.

On the Relief of Excessive and Dangerous Tympanites by Puncture of the Abdomen. By JOHN W. OGLE, M.A., M.D., F.R.C.P., Consulting Physician to St. George's Hospital. 8vo, 5s. 6d.

Acute Intestinal Strangulation, And Chronic Intestinal Obstruction (Mode of Death from). By THOMAS BRYANT, F.R.C.S., Senior Surgeon to Guy's Hospital. 8vo, 3s.

A Treatise on the Diseases of the Nervous System. By JAMES ROSS, M.D., F.R.C.P., Assistant Physician to the Manchester Royal Infirmary. Second Edition. 2 vols. 8vo, with Lithographs, Photographs, and 332 Woodcuts, 52s. 6d.

By the same Author.

Handbook of the Diseases of the Nervous System. Roy. 8vo, with 184 Engravings, 18s.

Also.

Aphasia: Being a Contribution to the Subject of the Dissolution of Speech from Cerebral Disease. 8vo, with Engravings, 4s. 6d.

Spasm in Chronic Nerve Disease. (Gulstonian Lectures.) By SEYMOUR J. SHARKEY, M.A., M.B., F.R.C.P., Assistant Physician to, and Joint Lecturer on Pathology at, St. Thomas's Hospital. 8vo, with Engravings, 5s.

Food and Dietetics, Physiologically and Therapeutically Considered. By F. W. PAVY, M.D., F.R.S., Physician to Guy's Hospital. Second Edition. 8vo, 15s.

By the same Author.

Croonian Lectures on Certain Points connected with Diabetes. 8vo, 4s. 6d.

Headaches: Their Nature, Causes, and Treatment. By W. H. DAY, M.D., Physician to the Samaritan Hospital. Fourth Edition. Crown 8vo, with Engravings, 7s. 6d.

Health Resorts at Home and Abroad. By M. CHARTERIS, M.D., Professor of Therapeutics and Materia Medica in the University of Glasgow. Second Edition. Crown 8vo, with Map, 5s. 6d.

Winter and Spring On the Shores of the Mediterranean. By HENRY BENNET, M.D. Fifth Edition. Post 8vo, with numerous Plates, Maps, and Engravings, 12s. 6d.

Medical Guide to the Mineral Waters of France and its Wintering Stations. With a Special Map. By A. VINTRAS, M.D., Physician to the French Embassy, and to the French Hospital, London. Crown 8vo, 8s.

The Ocean as a Health-Resort: A Practical Handbook of the Sea, for the use of Tourists and Health-Seekers. By WILLIAM S. WILSON, L.R.C.P. Second Edition, with Chart of Ocean Routes, &c. Crown 8vo, 7s. 6d.

Ambulance Handbook for Volunteers and Others. By J. ARDAVON RAYE, L.K. & Q.C.P.I., L.R.C.S.I., late Surgeon to H.B.M. Transport No. 14, Zulu Campaign, and Surgeon E.I.R. Rifles. 8vo, with 16 Plates (50 figures), 3s. 6d.

Ambulance Lectures: To which is added a NURSING LECTURE. By JOHN M. H. MARTIN, Honorary Surgeon to the Blackburn Infirmary. Second Edition. Crown 8vo, with 59 Engravings, 2s.

Commoner Diseases and Accidents to Life and Limb: their Prevention and Immediate Treatment. By M. M. BASIL, M.A., M.B., C.M. Crown 8vo, 2s. 6d.

How to Use a Galvanic Battery in Medicine and Surgery. By HERBERT TIBBITS, M.D., F.R.C.P.E., Senior Physician to the West London Hospital for Paralysis and Epilepsy. Third Edition. 8vo, with Engravings, 4s.

By the same Author.

A Map of Ziemssen's Motor Points of the Human Body: A Guide to Localised Electrisation. Mounted on Rollers, 35 × 21. With 20 Illustrations, 5s.

Also.

Electrical and Anatomical Demonstrations. A Handbook for Trained Nurses and Masseuses. Crown 8vo, with 44 Illustrations, 5s.

Also

Massage and Allied Modes of Treatment. With 46 Engravings. 8vo, 4s. 6d.

Surgical Emergencies: Together with the Emergencies attendant on Parturition and the Treatment of Poisoning. By W. PAUL SWAIN, F.R.C.S., Surgeon to the South Devon and East Cornwall Hospital. Fourth Edition. Crown 8vo, with 120 Engravings, 5s.

Operative Surgery in the Calcutta Medical College Hospital. Statistics, Cases, and Comments. By KENNETH McLEOD, A.M., M.D., F.R.C.S.E., Surgeon-Major, Indian Medical Service, Professor of Surgery in Calcutta Medical College. 8vo, with Illustrations, 12s. 6d.

A Course of Operative Surgery. By CHRISTOPHER HEATH, Surgeon to University College Hospital. Second Edition. With 20 coloured Plates (180 figures) from Nature, by M. LÉVEILLÉ, and several Woodcuts. Large 8vo, 30s.

By the same Author.

The Student's Guide to Surgical Diagnosis. Second Edition. Fcap. 8vo, 6s. 6d.

Also.

Manual of Minor Surgery and Bandaging. For the use of House-Surgeons, Dressers, and Junior Practitioners. Eighth Edition. Fcap. 8vo, with 142 Engravings, 6s.

Also.

Injuries and Diseases of the Jaws. Third Edition. 8vo, with Plate and 206 Wood Engravings, 14s.

Also,

Lectures on Certain Diseases of the Jaws. Delivered at the R.C.S., Eng., 1887. 8vo, with 64 Engravings, 2s. 6d.

The Practice of Surgery: A Manual. By THOMAS BRYANT, Consulting Surgeon to Guy's Hospital. Fourth Edition. 2 vols. crown 8vo, with 750 Engravings (many being coloured), and including 6 chromo plates, 32s.

By the same Author.

On Tension: Inflammation of Bone, and Head Injuries. Hunterian Lectures, 1888. 8vo, 6s.

Surgery: its Theory and Practice (Student's Guide). By WILLIAM J. WALSHAM, F.R.C.S., Assistant Surgeon to St. Bartholomew's Hospital. Fcap. 8vo, with 236 Engravings, 10s. 6d.

The Surgeon's Vade-Mecum: A Manual of Modern Surgery. By R. DRUITT, F.R.C.S. Twelfth Edition. By STANLEY BOYD, M.B., F.R.C.S. Assistant Surgeon and Pathologist to Charing Cross Hospital. Crown 8vo, with 373 Engravings 16s.

Surgical Pathology and Morbid Anatomy (Student's Guide). By ANTHONY A. BOWLBY, F.R.C.S., Surgical Registrar and Demonstrator of Surgical Pathology to St. Bartholomew's Hospital. Fcap. 8vo, with 135 Engravings, 9s.

Regional Surgery: Including Surgical Diagnosis. A Manual for the use of Students. By F. A. SOUTHAM, M.A., M.B., F.R.C.S., Assistant Surgeon to the Manchester Royal Infirmary. Part I. The Head and Neck. Crown 8vo, 6s. 6d. — Part II. The Upper Extremity and Thorax. Crown 8vo, 7s. 6d. Part III. The Abdomen and Lower Extremity. Crown 8vo, 7s.

A Treatise on Dislocations. By LEWIS A. STIMSON, M.D., Professor of Clinical Surgery in the University of the City of New York. Roy. 8vo, with 163 Engravings, 15s.

By the same Author.

A Treatise on Fractures. Roy. 8vo, with 360 Engravings, 21s.

Lectures on Orthopædic Surgery. By BERNARD E. BRODHURST, F.R.C.S., Surgeon to the Royal Orthopædic Hospital. Second Edition. 8vo, with Engravings, 12s. 6d.

By the same Author.

On Anchylosis, and the Treatment for the Removal of Deformity and the Restoration of Mobility in Various Joints. Fourth Edition. 8vo, with Engravings, 5s.

Also.

Curvatures and Disease of the Spine. Fourth Edition. 8vo, with Engravings, 7s. 6d.

Illustrations of Clinical Surgery. By JONATHAN HUTCHINSON, F.R.S., Senior Surgeon to the London Hospital. In fasciculi. 6s. 6d each. Fasc. I. to X. bound, with Appendix and Index, £3 10s. Fasc. XI. to XXIII. bound, with Index, £4 10s.

Diseases of Bones and Joints. BY CHARLES MACNAMARA, F.R.C.S., Surgeon to, and Lecturer on Surgery at, the Westminster Hospital. 8vo, with Plates and Engravings, 12s.

Injuries of the Spine and Spinal Cord, and NERVOUS SHOCK, in their Surgical and Medico-Legal Aspects. By HERBERT W. PAGE, M.C. Cantab., F.R.C.S., Surgeon to St. Mary's Hospital. Second Edition, post 8vo, 10s.

Spina Bifida: Its Treatment by a New Method. By JAS. MORTON, M.D., L.R.C.S.E., Professor of Materia Medica in Anderson's College, Glasgow. 8vo, with Plates, 7s. 6d.

Face and Foot Deformities. By FREDERICK CHURCHILL, C.M., Surgeon to the Victoria Hospital for Children. 8vo, with Plates and Illustrations, 10s. 6d.

Clubfoot: Its Causes, Pathology, and Treatment. By WM. ADAMS, F.R.C.S., Surgeon to the Great Northern Hospital. Second Edition. 8vo, with 106 Engravings and 6 Lithographic Plates, 15s.

By the same Author.

On Contraction of the Fingers, and its Treatment by Subcutaneous Operation; and on Obliteration of Depressed Cicatrices, by the same Method. 8vo, with 30 Engravings, 4s. 6d.

Also.

Lateral and other Forms of Curvature of the Spine: Their Pathology and Treatment. Second Edition. 8vo, with 5 Lithographic Plates and 72 Wood Engravings, 10s. 6d.

Electricity and its Manner of Working in the Treatment of Disease. By WM. E. STEAVENSON, M.D., Physician and Electrician to St. Bartholomew's Hospital. 8vo, 4s. 6d.

On Diseases and Injuries of the Eye: A Course of Systematic and Clinical Lectures to Students and Medical Practitioners. By J. R. WOLFE, M.D., F.R.C.S.E., Lecturer on Ophthalmic Medicine and Surgery in Anderson's College, Glasgow. With 10 Coloured Plates and 157 Wood Engravings. 8vo, £1 1s.

Hints on Ophthalmic Out-Patient Practice. By CHARLES HIGGENS, Ophthalmic Surgeon to Guy's Hospital. Third Edition. Fcap. 8vo, 3s.

The Student's Guide to Diseases of the Eye. By EDWARD NETTLESHIP, F.R.C.S., Ophthalmic Surgeon to St. Thomas's Hospital. Fourth Edition. Fcap. 8vo, with 164 Engravings and a Set of Coloured Papers illustrating Colour-Blindness, 7s. 6d.

Manual of the Diseases of the Eye. By CHARLES MACNAMARA, F.R.C.S., Surgeon to Westminster Hospital. Fourth Edition. Crown 8vo, with 4 Coloured Plates and 66 Engravings, 10s. 6d.

Normal and Pathological Histology of the Human Eye and Eyelids. By C. FRED. POLLOCK, M.D., F.R.C.S. and F.R.S.E., Surgeon for Diseases of the Eye to Anderson's College Dispensary, Glasgow. Crown 8vo, with 100 Plates (230 drawings), 15s.

Atlas of Ophthalmoscopy. Composed of 12 Chromo-lithographic Plates (59 Figures drawn from nature) and Explanatory Text. By RICHARD LIEBREICH, M.R.C.S. Translated by H. ROSBOROUGH SWANZY, M.B. Third edition, 4to, 40s.

Refraction of the Eye: A Manual for Students. By GUSTAVUS HARTRIDGE, F.R.C.S., Assistant Surgeon to the Royal Westminster Ophthalmic Hospital. Third Edition. Crown 8vo, with 96 Illustrations, Test-types, &c., 5s. 6d.

Squint: (Clinical Investigations on). By C. SCHWEIGGER, M.D., Professor of Ophthalmology in the University of Berlin. Edited by GUSTAVUS HARTRIDGE, F.R.C.S. 8vo, 5s.

Practitioner's Handbook of Diseases of the Ear and Naso-Pharynx. By H. MACNAUGHTON JONES, M.D., late Professor of the Queen's University in Ireland, Surgeon to the Cork Ophthalmic and Aural Hospital. Third Edition of "Aural Surgery." Roy. 8vo, with 128 Engravings, 6s.

By the same Author.

Atlas of Diseases of the Membrana Tympani. In Coloured Plates, containing 62 Figures, with Text. Crown 4to, 21s.

Endemic Goitre or Thyreocele: Its Etiology, Clinical Characters, Pathology, Distribution, Relations to Cretinism, Myxœdema, &c., and Treatment. By WILLIAM ROBINSON, M.D. 8vo, 5s.

Diseases and Injuries of the Ear. By Sir WILLIAM B. DALBY, Aural Surgeon to St. George's Hospital. Third Edition. Crown 8vo, with Engravings, 7s. 6d.

By the Same Author.

Short Contributions to Aural Surgery, between 1875 and 1886. 8vo, with Engravings, 3s. 6d.

Diseases of the Throat and Nose: A Manual. By Sir MORELL MACKENZIE, M.D., Senior Physician to the Hospital for Diseases of the Throat.

Vol. II. Diseases of the Nose and Naso-Pharynx; with a Section on Diseases of the Œsophagus. Post 8vo, with 93 Engravings, 12s. 6d.

By the same Author.

Diphtheria: Its Nature and Treatment, Varieties, and Local Expressions. 8vo, 5s.

Sore Throat: Its Nature, Varieties, and Treatment. By PROSSER JAMES, M.D., Physician to the Hospital for Diseases of the Throat. Fifth Edition. Post 8vo, with Coloured Plates and Engravings, 6s. 6d.

Studies in Pathological Anatomy, Especially in Relation to Laryngeal Neoplasms. By R. NORRIS WOLFENDEN, M.D., Senior Physician to the Throat Hospital, and SIDNEY MARTIN, M.D., Pathologist to the City of London Hospital, Victoria Park. I. Papilloma. Roy. 8vo, with Coloured Plates, 2s. 6d.

A System of Dental Surgery. By Sir JOHN TOMES, F.R.S., and C. S. TOMES, M.A., F.R.S. Third Edition. Crown 8vo, with 292 Engravings, 15s.

Dental Anatomy, Human and Comparative: A Manual. By CHARLES S. TOMES, M.A., F.R.S. Second Edition. Crown 8vo, with 191 Engravings, 12s. 6d.

The Student's Guide to Dental Anatomy and Surgery. By HENRY SEWILL, M.R.C.S., L.D.S. Second Edition. Fcap. 8vo, with 78 Engravings, 5s. 6d.

A Manual of Nitrous Oxide Anæsthesia, for the use of Students and General Practitioners. By J. FREDERICK W. SILK, M.D. Lond., M.R.C.S., Anæsthetist to the Great Northern Central Hospital, and to the National Dental Hospital. 8vo, with 26 Engravings, 5s.

Mechanical Dentistry in Gold and Vulcanite. By F. H. BALKWILL, L.D.S.R.C.S. 8vo, with 2 Lithographic Plates and 57 Engravings, 10s.

Principles and Practice of Dentistry: including Anatomy, Physiology, Pathology, Therapeutics, Dental Surgery, and Mechanism. By C. A. HARRIS, M.D., D.D.S. Edited by F. J. S. GORGAS, A.M., M.D., D.D.S., Professor in the Dental Department of Maryland University. Eleventh Edition. 8vo, with 750 Illustrations, 31s. 6d.

A Practical Treatise on Mechanical Dentistry. By JOSEPH RICHARDSON, M.D., D.D.S., late Emeritus Professor of Prosthetic Dentistry in the Indiana Medical College. Fourth Edition. Roy. 8vo, with 458 Engravings, 21s.

Elements of Dental Materia Medica and Therapeutics, with Pharmacopœia. By JAMES STOCKEN, L.D.S.R.C.S., Pereira Prizeman for Materia Medica, and THOMAS GADDES, L.D.S. Eng. and Edin. Third Edition. Fcap. 8vo, 7s. 6d.

Atlas of Skin Diseases.
By TILBURY FOX, M.D., F.R.C.P. With 72 Coloured Plates. Royal 4to, half morocco, £6 6s.

Diseases of the Skin:
With an Analysis of 8,000 Consecutive Cases and a Formulary. By L. D. BULKLEY, M.D., Physician for Skin Diseases at the New York Hospital. Crown 8vo, 6s. 6d.

By the same Author.

Acne: its Etiology, Pathology, and Treatment: Based upon a Study of 1,500 Cases. 8vo, with Engravings, 10s.

On Certain Rare Diseases of the Skin. BY JONATHAN HUTCHINSON, F.R.S., Senior Surgeon to the London Hospital, and to the Hospital for Diseases of the Skin. 8vo, 10s. 6d.

Diseases of the Skin:
A Practical Treatise for the Use of Students and Practitioners. By J. N. HYDE, A.M., M.D., Professor of Skin and Venereal Diseases, Rush Medical College, Chicago. Second Edition. 8vo, with 2 Coloured Plates and 96 Engravings, 20s.

Parasites:
A Treatise on the Entozoa of Man and Animals, including some Account of the Ectozoa. By T. SPENCER COBBOLD, M.D., F.R.S. 8vo, with 85 Engravings, 15s.

Manual of Animal Vaccination, preceded by Considerations on Vaccination in general. By E. WARLOMONT, M.D., Founder of the State Vaccine Institute of Belgium. Translated and edited by ARTHUR J. HARRIES, M.D. Crown 8vo, 4s. 6d.

Leprosy in British Guiana.
By JOHN D. HILLIS, F.R.C.S., M.R.I.A., Medical Superintendent of the Leper Asylum, British Guiana. Imp. 8vo, with 22 Lithographic Coloured Plates and Wood Engravings, £1 11s. 6d.

Cancer of the Breast.
By THOMAS W. NUNN, F.R.C.S., Consulting Surgeon to the Middlesex Hospital. 4to, with 21 Coloured Plates, £2 2s.

On Cancer:
Its Allies, and other Tumours; their Medical and Surgical Treatment. By F. A. PURCELL, M.D., M.C., Surgeon to the Cancer Hospital, Brompton. 8vo, with 21 Engravings, 10s. 6d.

Sarcoma and Carcinoma:
Their Pathology, Diagnosis, and Treatment. By HENRY T. BUTLIN, F.R.C.S., Assistant Surgeon to St. Bartholomew's Hospital. 8vo, with 4 Plates, 8s.

By the same Author.

Malignant Disease of the Larynx (Sarcoma and Carcinoma). 8vo, with 5 Engravings, 5s.

Also.

Operative Surgery of Malignant Disease. 8vo, 14s.

Cancerous Affections of the Skin.
(Epithelioma and Rodent Ulcer.) By GEORGE THIN, M.D. Post 8vo, with 8 Engravings, 5s.

By the same Author.

Pathology and Treatment of Ringworm. 8vo, with 21 Engravings, 5s.

Cancer of the Mouth, Tongue, and Alimentary Tract: their Pathology, Symptoms, Diagnosis, and Treatment. By FREDERIC B. JESSETT, F.R.C.S., Surgeon to the Cancer Hospital, Brompton. 8vo, 10s.

Lectures on the Surgical Disorders of the Urinary Organs. By REGINALD HARRISON, F.R.C.S., Surgeon to the Liverpool Royal Infirmary. Third Edition, with 117 Engravings. 8vo, 12s. 6d.

Hydrocele:
Its several Varieties and their Treatment. By SAMUEL OSBORN, late Surgical Registrar to St. Thomas's Hospital. Fcap. 8vo, with Engravings, 3s.

By the same Author.

Diseases of the Testis.
Fcap. 8vo, with Engravings, 3s. 6d.

Diseases of the Urinary Organs. Clinical Lectures. By Sir HENRY THOMPSON, F.R.C.S., Emeritus Professor of Clinical Surgery and Consulting Surgeon to University College Hospital. Eighth Edition. 8vo, with 121 Engravings, 10s. 6d.

By the same Author.

Diseases of the Prostate: Their Pathology and Treatment. Sixth Edition. 8vo, with 39 Engravings, 6s.

Also.

Surgery of the Urinary Organs. Some Important Points connected therewith. Lectures delivered in the R.C.S. 8vo, with 44 Engravings. Students' Edition, 2s. 6d.

Also.

Practical Lithotomy and Lithotrity; or, An Inquiry into the Best Modes of Removing Stone from the Bladder. Third Edition. 8vo, with 87 Engravings, 10s.

Also.

The Preventive Treatment of Calculous Disease, and the Use of Solvent Remedies. Third Edition. Crown 8vo, 2s. 6d.

Also.

Tumours of the Bladder: Their Nature, Symptoms, and Surgical Treatment. 8vo, with numerous Illustrations, 5s.

Also.

Stricture of the Urethra, and Urinary Fistulæ: their Pathology and Treatment. Fourth Edition. With 74 Engravings. 8vo, 6s.

Also.

The Suprapubic Operation of Opening the Bladder for the Stone and for Tumours. 8vo, with 14 Engravings, 3s. 6d.

Electric Illumination of the Male Bladder and Urethra, as a Means of Diagnosis of Obscure Vesico-Urethral Diseases. By E. HURRY FENWICK, F.R.C.S., Assistant Surgeon to the London Hospital and Surgeon to St. Peter's Hospital for Stone. 8vo, with 30 Engravings, 4s. 6d.

Modern Treatment of Stone in the Bladder by Litholopaxy. By P. J. FREYER, M.A., M.D., M.Ch., Bengal Medical Service. 8vo, with Engravings, 5s.

The Surgical Diseases of the Genito-Urinary Organs, including Syphilis. By E. L. KEYES, M.D., Professor of Genito-Urinary Surgery, Syphiology, and Dermatology in Bellevue Hospital Medical College, New York (a revision of VAN BUREN and KEYES' Text-book). Roy. 8vo, with 114 Engravings, 21s.

The Surgery of the Rectum. By HENRY SMITH, Emeritus Professor of Surgery in King's College, Consulting Surgeon to the Hospital. Fifth Edition. 8vo, 6s.

Diseases of the Rectum and Anus. By W. HARRISON CRIPPS, F.R.C.S., Assistant Surgeon to St. Bartholomew's Hospital, &c. 8vo, with 13 Lithographic Plates and numerous Wood Engravings, 12s. 6d.

Urinary and Renal Derangements and Calculous Disorders. By LIONEL S. BEALE, F.R.C.P., F.R.S., Physician to King's College Hospital. 8vo, 5s.

The Diagnosis and Treatment of Diseases of the Rectum. By WILLIAM ALLINGHAM, F.R.C.S., Surgeon to St. Mark's Hospital for Fistula. Fifth Edition. By HERBERT WM. ALLINGHAM, F.R.C.S., Surgeon to the Great Northern Central Hospital, Demonstrator of Anatomy at St. George's Hospital. 8vo, with 53 Engravings. 10s. 6d.

Syphilis and Pseudo-Syphilis. By ALFRED COOPER, F.R.C.S., Surgeon to the Lock Hospital, to St. Mark's and the West London Hospitals. 8vo, 10s. 6d.

Diagnosis and Treatment of Syphilis. By TOM ROBINSON, M.D., Physician to St. John's Hospital for Diseases of the Skin. Crown 8vo, 3s. 6d.

By the same Author.

Eczema: its Etiology, Pathology, and Treatment. Crown 8vo, 3s. 6d.

Coulson on Diseases of the Bladder and Prostate Gland. Sixth Edition. By WALTER J. COULSON, Surgeon to the Lock Hospital and to St. Peter's Hospital for Stone. 8vo, 16s.

The Medical Adviser in Life Assurance. By Sir E. H. SIEVEKING, M.D., F.R.C.P. Second Edition. Crown 8vo, 6s.

A Medical Vocabulary: An Explanation of all Terms and Phrases used in the various Departments of Medical Science and Practice, their Derivation, Meaning, Application, and Pronunciation. By R. G. MAYNE, M.D., LL.D. Sixth Edition. [*In the Press.*

A Dictionary of Medical Science: Containing a concise Explanation of the various Subjects and Terms of Medicine, &c. By ROBLEY DUNGLISON, M.D. LL.D. Royal 8vo, 28s.

INDEX.

[*Continued on the next page.*

LONDON: 11, NEW BURLINGTON STREET.

Pardon & Sons, Printers,] [*Wine Office Court, Fleet Street, E.C.*