ANATOMY
Regional and Applied

By

R. J. LAST

M.B., B.S. (Adel.), F.R.C.S.

Professor of Applied Anatomy, Royal College of Surgeons of England; Examiner in Anatomy for the Primary Fellowship Examination of the College; Examiner in Anatomy for the Licence in Dental Surgery, and past examiner in Anatomy for the Fellowship in Dental Surgery of the College; Superintendent of Dissections and past Examiner in Anatomy to the Examining Board in England; Examiner in Anatomy and Physiology to the London Foot Hospital.

With 309 Illustrations,
many in colour

Reprinted
1956
I

PREFACE

DURING the past seven years I have been closely associated with over 2,000 postgraduate students of anatomy who have come to the Royal College of Surgeons from many parts of the world, and my experience of their problems has formulated my approach to the study of anatomy. Postgraduate anatomy is no more complex than undergraduate anatomy, for the human body remains the same whoever studies it, and I believe that the undergraduate also will find this volume helpful in his revision.

The scope of the book is not encyclopædic ; instead I have attempted to include in the text all those parts of human anatomy which should occupy a place in the knowledge *and in the understanding* of the student or the general clinician, and I have sought to exclude details that have neither practical application nor value in illustrating a general principle. Often a structure insignificant in itself and of no importance in clinical anatomy possesses great interest because it illustrates a basic principle. Nobody would be any the worse off without his rectus sternalis or his coraco-brachialis muscles, yet much may be learned from understanding their significance, and for that reason they and many structures like them are included in the text.

The first section of the book gives a simple account of the nature of the tissues and structures that make up the body, and goes on to some general considerations on the nervous system, early embryology, and the anatomy of the child. To study the body system by system is of limited value to the student or clinician, who must have a comprehensive knowledge of the constituent parts that make up each region of the body. So the book goes on to cover the structure of the body region by region, *and the text is intended to be read with the appropriate bones and the prosected part or a museum specimen close at hand for constant reference.* The accounts of microscopic anatomy should be confirmed by inspection of histological slides.

I now offer the student a word of advice if he has forgotten the detailed anatomy of the part he is about to study. He should try to grasp in clear outline a simple general picture of the whole region and then fill in the details, gradually but uniformly, until he has attained the depth of knowledge he requires ; but he should never lose sight of his simple comprehension of the region as a whole. The study of anatomy is not a matter of committing to memory several hundred pages of disconnected facts. The subject becomes vastly more entertaining when the student appreciates how and why structures exist as they do.

Since memory depends upon understanding I have attempted to explain the general principles that underlie the structure of the various regions of the body. Three approaches can be used to reach the understanding of any particular structure. Embryology, or the manner in which a structure grows in the developing individual, throws light on certain parts of the body ; phylogeny, or the manner in which a structure is supposed to have evolved through different species, illuminates many more parts ; and physiology, or the manner in which structure conforms to functional needs, clarifies the understanding of still more. Throughout this book I have chosen the approaches that seem best suited to the understanding of individual organs and structures, and I have given a good deal of attention to the functional aspects of anatomy. The application to medicine and surgery of the knowledge gained is continually pointed out, and it is with this meaning that the term "applied" appears in the title. The word is not employed in its more usual meaning of "surgical" anatomy, and no operations are described.

In presenting a description of any particular region two problems arise. One concerns some general principle that may be illustrated, and the other is the question of how far away to describe a structure that passes through one region to the next. To comment on each of these in every region involves a good deal of repetition. I have accepted this, and at times I have deliberately repeated myself, partly to avoid undue cross-references and partly because repetition aids memory.

British anatomy has been enriched (or bedevilled) by no less than three terminologies, and an international committee is now engaged on the preparation of a fourth, which may soon be upon us. I have added many eponyms of Old Terminology to the current Birmingham Revision terms, being guided by one principle in my choice—namely, to include those names which are in common use in hospital practice and in medical and surgical textbooks.

There is much of my own original work in the text. I may point out, for example, the segmental innervation of the limb muscles, the movements of the knee joint and the control on the lateral meniscus exercised by the popliteus muscle, the *role* of the intrinsic muscles of the larynx and of the muscles of the mandible and the floor of the mouth, and there are many other small matters too trivial to mention here. Most of the ideas that are new or different in this book, however, have been suggested to me during my long association with Professor Wood Jones, one of the most eminent of all human and comparative anatomists. I was introduced to the study of anatomy by Wood Jones in 1920, and the foundation he then laid proved invaluable during more than 20 years of active surgical practice. It has been a constant inspiration to have returned to sit at his feet during the past seven years. Almost all the phylogenetic approaches to human anatomy that I have used in this book come wholly or in part from his deep knowledge and insight.

"Our knowledge of regional anatomy as of most other subjects is rarely rendered complete by the contributions of one man but springs from the labours of many." This extract from *The Anatomy of the Bronchial Tree* by R. C. Brock is so true that I quote it here in apology for the absence of acknowledgment of many other sources from which I have gained information. Brock's own work, with the help of the beautiful bronchial casts made by Dr. D. H. Tompsett at the Royal College of Surgeons, is responsible for my account of the bronchial tree. H. A. Harris, lately of Cambridge, has provided useful information on the spleen, on the blood supply of joints, and on many other matters. I have taken account of the work of Negus on the comparative anatomy of the larynx, of Shephard on tarsal movements, of Barnett and Napier on the ankle and on opposition of the thumb, of Sprinz on the masseter, of Morrison on the innervation of the levatores costarum, and of many others who, in person or by correspondence, have given me much information.

Biographical notes, with references, have been kindly compiled for me by Miss Jessie Dobson, the Recorder of the Museum of the Royal College of Surgeons ; they will be found on p. 632. I am very grateful to her.

Finally, I want to say to the student : "I sincerely hope that your reading of the following pages may not only prove profitable to you but will stimulate your permanent interest in a fascinating subject, much of which is still not fully understood."

R. J. LAST.

LONDON.

ACKNOWLEDGMENTS

It is very gratifying to be able to reproduce twenty-six of Dr. Tompsett's drawings of his own prosections in the Museum of the Royal College of Surgeons ; for this privilege I wish to thank the President of the College, Sir Cecil Wakeley, Bt., K.B.E., C.B. I am indebted to the late Dr. Eugene Wolff and Messrs. H. K. Lewis & Co. for their permission to reproduce Figs. 249 and 250 from *The Anatomy of the Eye and Orbit*. Fig. 248 is adapted, by permission of Messrs. John Wright & Sons, from French's *Differential Diagnosis of Main Symptoms*. I am grateful to the proprietors of the *Journal of Bone and Joint Surgery* for permission to reproduce from my articles Figs. 14, 18, 19, 70, 115, 121 and 268, and to the proprietors of the *British Journal of Surgery* for permission to reproduce Figs. 284 to 288 inclusive and Fig. 304. Fig. 67 has been drawn from Testut's *Anatomie Humaine* and Figs. 75 and 77 from Dr. Frank Netter's illustrations in *Ciba Clinical Symposia*.

I thank Dr. Seymour J. Reynolds for the X-ray films from which Figs. 135, 136 and 264 have been made, and Mr. Frederick Mancini for modelling the face and ear on the skull photographed in Fig. 220.

To the directors and staff of Messrs. J. & A. Churchill I am deeply indebted, not only for their permission to reproduce some 20 illustrations from their publications, but for their unfailing courtesy and assistance during the preparation of this book.

Finally, I acknowledge with much gratitude the patience of those students at the College who have so kindly read and criticized the manuscript and proofs of this book. Their enthusiastic encouragement has been a great help.

CONTENTS

PAGE

SECTION 3

THE LOWER LIMB

SECTION 4

THE THORAX

PAGE

SECTION 5

THE ABDOMEN

PAGE

SECTION 6

THE HEAD AND NECK

SECTION 7

THE CENTRAL NERVOUS SYSTEM

Section 1

TISSUES AND STRUCTURES

SOME general remarks will, it is hoped, assist the student to a better understanding of the various tissues and structures that make up the body. The following accounts are not in any sense complete, but are intended to give the student an outline of the tissues whose arrangements in the body make up the subject of his study.

The Skin. Do not confuse the epidermis with the skin. The essential skin is the **dermis** or corium, a strong and tough fibrous tissue rich in blood vessels, lymphatics and nerves. When dried it makes greenhide, when tanned it makes leather. It cannot function without its surface layer of cells, the **epidermis.** If the epidermis is lost the moist dermis loses lymph or blood and

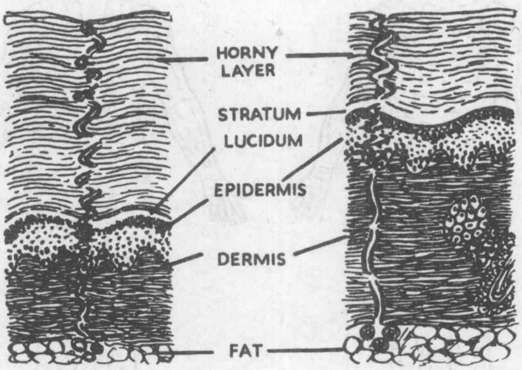

FIG. 1. SKINS OF EQUAL THICKNESS (× 30). On the left the skin of the sole ; the thickness is due mainly to the dead stratum corneum (horny layer). On the right the skin of the back ; the thickness is due mainly to the living dermis. The epidermis is of comparable thickness in each.

becomes invaded by bacteria ; an ulcer is formed. The epidermis consists of several layers of cells, which become flatter towards the surface ; i.e., squamous stratified epithelium. The surface cells change into a dead horny layer that is rubbed off in scales (dandruff). Squamous stratified epithelium covers surfaces that are subject to wear and tear.

The thickness of the whole skin depends on two factors, namely the thickness of the horny layer and the thickness of the dermis itself (Fig. 1). On palms and soles the horny layer is responsible for the great thickness, the dermis being here rather thin. These areas are subject to great wear, hence the thickness of the protective horny layer and the absence of hairs. The thickness of the dermis usually differs between flexor and extensor surfaces. It tends to be thicker on extensor surfaces. The thick skin of the back makes sole leather, the thin belly skin is more suitable for upper leather, gloves, etc. The character of flexor and extensor skin differs in other respects than mere thickness. Flexor skin of the limbs tends to be less hairy than extensor skin and usually it is far more sensitive, having a richer nerve supply.

The skin is bound down to underlying structures to a variable extent. On the dorsum of the hand or foot it can be pinched up and moved readily. On the palm and sole this is impossible, for here the dermis is bound firmly to the underlying aponeurosis, a necessary functional requirement to improve the grip of the hand and foot.

The *creases* in the skin are flexure lines over joints. The skin always folds in the same place. Along these flexure lines the skin is thinner and is bound more firmly to the underlying structures (usually deep fascia). The site of the flexure lines does not always correspond exactly to the topography of the underlying structures. For example, the anterior flexure line for the hip lies below the inguinal ligament, the posterior flexure line is not influenced by the oblique lower border of gluteus maximus and lies horizontally, to make the fold of the buttock.

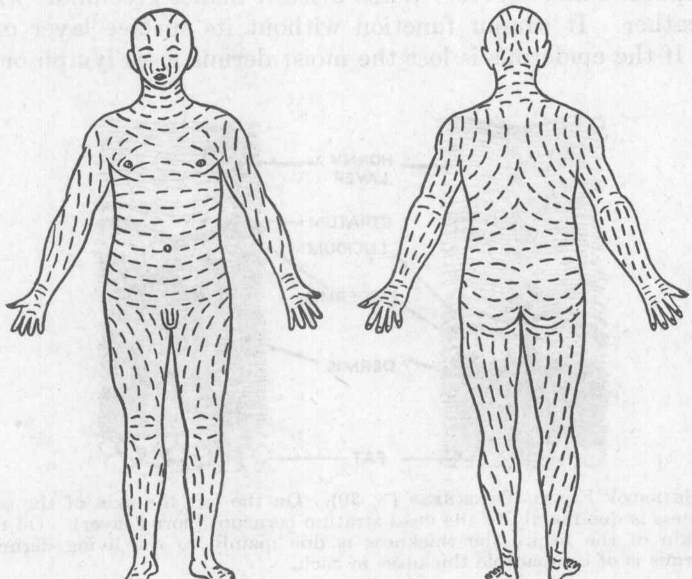

FIG. 2. THE CLEAVAGE LINES (LANGER'S LINES) OF THE SKIN.

Lines of cleavage in the skin have been known to exist since Langer described them in 1861. They were re-investigated by Cox very completely in 1941. Their existence is due to the fact that the collagen fibres of the human dermis lie mostly in parallel bundles (this is not so in many animals). A conical object plunged through human skin splits the dermis and leaves a linear wound when it is withdrawn; the parallel collagen fibres have been forced apart without being ruptured. Surgical incisions made along Langer's lines heal with a minimum of scar tissue, incisions across the lines heal with a heaped up or broad scar. The directions of Langer's lines all over the body are of obvious importance to every surgeon, yet few surgeons and fewer anatomists know of them. Where crease lines exist (i.e., near joints) the cleavage lines usually coincide. Elsewhere in the body the cleavage lines tend to be longitudinal in the limbs and circumferential in the neck and trunk (Fig. 2).

Yellow elastic fibres occur in the dermis and impart to it an elasticity that gradually diminishes with advancing years, as the elastic fibres progressively atrophy.

Embryology of the Skin. The appendages of the skin are the sweat glands, the nails, the hair follicles and the sebaceous glands. All these are formed as downgrowths from the surface epithelium. The epidermis and the downgrowths are all of ectodermal origin. The fibrous tissue (collagen) and the yellow elastic fibres of the dermis are derived from mesoderm.

Subcutaneous Tissue. The skin is connected to the underlying bones or deep fascia by a layer of areolar tissue that varies widely in character in different species. In some animals it is loose and tenuous with a minimum of fat, so that it is a simple matter to skin the animal. In others, including man, fat is plentiful and fibrous bands in the fat tether the skin to the deep fascia. Such an animal is more difficult to skin; it has a blanket of fat beneath the skin, called the panniculus adiposus. The panniculus adiposus is well developed in man, and in it nerves, blood vessels and lymphatics pass to the skin.

The term superficial fascia is so ingrained in nomenclature that there is no hope of discarding it. Yet the tissue bears no possible resemblance to the other so-called "deep" fasciæ, and the names panniculus adiposus, subcutaneous tissue or subcutaneous fat are greatly to be preferred.

In the panniculus adiposus are flat sheets of muscle called the *panniculus carnosus*. The degree of their development varies widely in different animals. In domestic quadrupeds such as sheep and horses the sheet is present over most of the body wall. It can be seen on the carcass in a butcher's shop, lying on the surface of the fat, generally incised in parallel slits to make an attractive pattern. It can be seen in action when a horse twitches the skin over its withers. The essential point about the panniculus carnosus is that one end of each muscle fibre is attached to the skin, the other end being usually attached to deep fascia or bone.

In man the sheet is well developed and highly differentiated to form the muscles of the scalp and face including the platysma, and remnants persist in such subcutaneous muscles as the palmaris brevis and as unstriped muscle in the corrugator cutis ani, in the dartos sheet of the scrotum and in the subareolar muscle of the nipple.

Deep Fascia. The limbs and body wall are wrapped in a membrane of fibrous tissue called the deep fascia. It varies widely in thickness. In the ilio-tibial tract of the fascia lata, for example, it is very well developed, while over the rectus sheath and external oblique aponeurosis of the abdominal wall it is so thin as to be scarcely demonstrable. In other parts, such as the

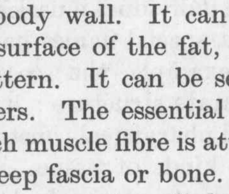

FIG. 3. Deep fascia does not cross over bone; it blends with the periosteum. This principle is illustrated by a section through the shaft of the tibia.

face and the ischio-rectal fossa, it is entirely absent. A feature of the deep fascia of the body and limbs is that it never passes freely over bone but is always anchored firmly to the periosteum. A pin thrust into a muscle will pass through skin, panniculus adiposus and deep fascia, one thrust into a subcutaneous bone will pass through skin, panniculus adiposus and periosteum only (Fig. 3).

The deep fascia serves for attachment of the skin by way of fibrous strands in the subcutaneous tissue. In many places, it gives an additional area for attachment of the fibres of underlying muscles.

Fascia in General. As well as the investing layer of deep fascia on the surface of the body there are many other fascial layers in deeper parts. It is one of the greatest misfortunes of descriptive nomenclature that the term fascia has come to be applied to structures of widely differing character. On the one hand a named fascia may be a well developed membrane (e.g., fascia lata) while, on the other hand, it may be nothing more than a loose and indefinite collection of areolar tissue quite impossible to demonstrate as a membrane (e.g., fascia transversalis). In general it may be said that where fasciæ lie over non-expansile parts (e.g., muscles of the pelvic wall, prevertebral muscles) they are well developed membranes readily demonstrable, able to be sutured after incision ; but where they lie over expansile parts (e.g., muscles of the pelvic floor, cheek, pharynx) they do not exist as demonstrable membranes, being indefinite and thin collections of loose areolar tissue, often too tenuous to retain a suture.

Descriptive anatomy has been further complicated by the naming as fascia of a third type of structure, the epimysium (p. 6). This areolar tissue clothing muscles is very important, because it is impervious to fluid collections and directs pus along the tissue spaces between individual muscles ; but it does not clarify the understanding of anatomy that special names have been given to certain of these muscle envelopes. For example, the so-called " bucco-pharyngeal fascia " has no existence as a separate structure ; it is merely the epimysium on the surface of the buccinator and pharyngeal constrictor muscles.

Ligaments. Ligaments are made of two kinds of tissue. White fibrous tissue, (collagen) comprises most of the ligaments of the body. It has the physical property of being non-elastic and unstretchable. Only if subjected to prolonged strain will white fibrous tissue elongate, and undue mobility is then possible in the joints (e.g., in flat foot). White fibrous tissue ligaments are so arranged that they are never subjected to prolonged strain, with the curious exception of the sacro-iliac ligaments, which are never free from the strain of the whole weight of the body except in recumbency.

The second type of ligament is composed of elastic tissue, which regains its former length after stretching. It is yellow in colour, hence the name of the ligamenta flava between the laminæ of the vertebræ. The capsular ligaments of the joints of the auditory ossicles are made of yellow elastic tissue.

Much has been written on the phylogenetic aspect of ligaments. Interest in the subject dates from the post-Darwinian enthusiasm for seeking " vestiges " of a more primitive ancestor. Bland-Sutton wrote widely on this subject. Most ligaments in the body have by one author or another been counted as " degenerated " tendons of muscles possessed by a supposed ancestor (fish, reptile or even bird !) and if one is to believe all the speculations it is almost to suppose that the primitive ancestor of the mammals had no ligaments at all ! The subject of ligaments is touched upon under the heading of joints (p. 18).

Raphés. A raphé is an interdigitation of the short tendinous ends of fibres of flat muscle sheets. It can be elongated passively by separation of its attached ends. There is, for example, no such structure as a pterygo-mandibular *ligament*; if there were, the mandible would be fixed, since ligaments do not stretch. The buccinator and superior constrictor interdigitate in the pterygo-mandibular *raphé*, the length of which varies with the position

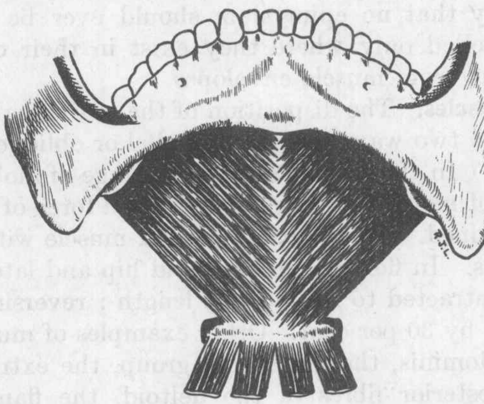

FIG. 4. The right and left halves of the mylo-hyoid muscle interdigitate in a midline raphé which extends from the symphysis menti to the hyoid bone.

of the mandible. The mylo-hyoid raphé (Fig. 4), pharyngeal raphé and ano-coccygeal raphé are further examples.

Cartilage. Most of the gristle in the body is composed of **hyaline cartilage.** The living cells of this tissue lie in a ground substance whose main feature is its complete avascularity. The ground substance is not truly structureless; the presence of fibres can be demonstrated by special methods. The substance is capable of a certain amount of deformation without fracture, it is not rigid like bone; it has great resistance to wear. It clothes the articular surfaces of almost all the synovial joints, certainly of all the weight-bearing ones. It is incapable of repair when fractured.

Some cartilage of the body possesses obvious fibres in the matrix and these may be of two kinds, white (collagen) or yellow (elastic). **Fibro-cartilage** as found in discs in joints is badly named, being almost all white fibrous tissue and practically no cartilage. To the naked eye it is white and glistening, like hyaline cartilage, but microscopically it consists of densely packed collagen fibres lying in parallel lamellæ, between which are many oval cells with well developed nuclei; but there is no cartilage around them. Both hyaline cartilage and fibro-cartilage tend to calcify and even ossify in later life. **Yellow elastic cartilage** is found in the pinna of the ear and the epiglottis. Its cells are large and oval-shaped, and the ground substance contains yellow elastic fibres. It never calcifies or ossifies.

Muscles

The ordinary skeletal musculature, the red meat of the butcher, consists of non-branching striated muscle fibres, bound together by a loose areolar tissue rich in nucleated connective tissue cells. This connective tissue is condensed like the skin of a sausage on the surface of all muscles, forming a membrane of varying thickness and density well known to every dissector;

it is the material dissected away and discarded in the process of " cleaning " a muscle for demonstration purposes. The membranous envelope, or *epimysium*, is impervious to the spread of fluid such as pus. It is seldom of such a nature as to warrant special description as a named fascia. Nevertheless, many such epimysia have been named, especially in the neck, to the complication of descriptive anatomy and to the perplexity of the student. It is no over-simplification to say that no epimysium should ever be named, and that fasciæ should be labelled only where they exist in their own right as membranes *per se*, distinct from muscle envelopes.

The Form of Muscles. The disposition of the individual fibres in a muscle can be in one of only two ways, namely, parallel or oblique to the line of pull of the whole muscle. In the former maximum range of mobility is assured, in the latter the range of mobility is less but increased force of pull of the muscle is correspondingly gained. A good example of a muscle with parallel fibres is provided by sartorius. In flexing the knee and hip and laterally rotating the hip the muscle is contracted to its shortest length ; reversing the movements elongates the muscle by 30 per cent. Other examples of muscles with parallel fibres are rectus abdominis, the infrahyoid group, the extrinsic eye muscles, the anterior and posterior fibres of the deltoid, the flank muscles of the abdomen, and the intercostals.

Muscles whose fibres lie oblique to the line of pull of the whole muscle fall into four patterns :—

1. **Unipennate Muscles.** The tendon forms along one margin of the muscle and all the fibres slope into one side of the tendon, giving a pattern like a feather split longitudinally. A good example is flexor pollicis longus.

2. **Bipennate Muscles.** The tendon forms centrally, usually as a fibrous septum which enlarges distally to form the tendon proper. Muscle fibres slope into the two sides of the central tendon, like an ordinary feather. An example is rectus femoris (in which muscle the fibres slope *upwards* towards the central septum).

3. **Multipennate Muscles.** These are of two varieties : (*a*) a series of bipennate masses lying side by side, as in the acromial fibres of the deltoid, the subscapularis, etc. ; (*b*) a cylindrical muscle within which a central tendon forms. Into the central tendon the sloping fibres of the muscle converge from all sides. An example is the tibialis anterior.

Mechanics of Muscle Form. In the case of a muscle whose fibres run parallel with its line of pull a given shortening of muscle fibres results in equal shortening of the whole muscle. In the case of unipennate and multipennate muscles a given shortening of muscle fibres results in less shortening of the whole muscle. The loss of shortening is compensated by a corresponding gain in force of pull. Obliquity of pull of a contracting fibre involves a loss of mechanical efficiency. But the *number* of oblique fibres is much greater than the number of longitudinal fibres required to fill the volume of a long muscle belly. The greater number of oblique fibres, though each fibre loses some efficiency, results in an overall gain of power in the muscle as a whole. Such muscles are found where great power and less range of movement are needed.

The Surface Appearance of Muscles. Whether or not the anatomist should have a minutely detailed knowledge of osteology is arguable. Certainly it is of more practical value to know the surface appearance of those muscles that are distinctive. There are many such muscles. Beneath the transparent epimysium there is a great difference, not only in the general shape and contour but also in the amounts of red flesh and white fibres that produce their surface appearance. Some muscles are wholly fleshy, some largely aponeurotic, while many have a quite characteristic mixture of the two. Such variations provide an illustration of the relation of form to function. If the surface of a muscle bears heavily on an adjacent structure it will be covered by a glistening aponeurosis ; where there is no pressure there is usually flesh. Examples are manifold, and in this book the surface appearances of many muscles are described. Here one may use the rectus femoris as a good example. The anterior surface of this bipenniform muscle is fleshy where it lies beneath the fascia lata, being aponeurotic only at its upper end, where it plays against a fibro-fatty pad that separates it from sartorius. Its deep surface is exactly the reverse. At the upper end is flesh, but the remainder of the posterior surface is wholly aponeurotic, where the muscle plays heavily on a corresponding aponeurosis of the anterior surface of vastus intermedius. The advantage of knowing the surface characteristics of muscles should be obvious to both physician and surgeon. In the case of the physician for example, the diagnosis of "rheumatic" pain or tenderness will often hinge on whether the site is over aponeurosis or flesh, for where there is an aponeurosis there is a bursa. Such bursæ are often very extensive and are usually open at one end, so that effused fluid never distends them, but a "dry" inflammation comparable to "dry" pleurisy will produce pain on movement and tenderness on pressure over these aponeuroses. The surgeon sees muscles far more often than bones, and instant recognition of a muscle by its surface appearance gives great confidence and accuracy at operation.

Origins and Insertions of Muscles. There is no reality in these terms, though the sanctity of long usage and failure to find satisfactory substitutes force their continued use. Which end of a muscle remains fixed and which end moves depend on circumstances, and vary with most muscles.

Bone Markings. Fleshy origins generally leave no mark on the bone, though often the area is flattened or depressed and thus visible on the dried bone (e.g., pectoralis major on the clavicle). Contrary to usual teaching, insertions of pure tendon, like the attachments of ligaments, almost always leave a *smooth* mark on the bone, though the area may be raised into a plateau or depressed into a fossa (spinati, tibialis anterior, ligamentum patellæ, cruciate ligaments on femur, psoas, obturator tendons on femur, etc.). Rough marks are made where there is an admixture of flesh and tendon, or where there is a lengthy insertion of aponeurosis (e.g., ulnar tuberosity, gluteal crest, linea aspera).

A characteristic of flat muscles that arise from flat bones and play over their surfaces is that the muscle origin does not extend to the edge of the flat bone. The origin of the muscle is set back from the edge of the bone in a curved line. Between the edge of the bone and the curved line is a bare area, over which the contracting muscle slides. This allows a greater range of movement of the contracting muscle fibres. The bare area is invariably occupied by a bursa, and such bursæ are always of large size. The bursa may communicate with the nearby joint (e.g., subscapularis, iliacus) in which case infection of one cavity necessarily involves the other. Some of these bursæ remain separate from the nearby joint (e.g., supraspinatus, usually infraspinatus, obturator internus). The temporalis muscle is an exception to this rule, for its fibres arise from the whole of the temporal fossa down to the infratemporal crest, and there is no bursa beneath it.

The origin of a muscle acting on a joint is very often so proximal that the muscle crosses, in fact, two joints (e.g., biceps and triceps both cross the shoulder joint). In such cases, and there are many, the action of these muscles on the proximal joint is merely to steady it while acting as prime movers on the more distal joint.

The insertion of a tendon when, as usually, it is near a joint, is almost always into the epiphysis. An exception is the tendon of adductor magnus, the insertion of which into the adductor tubercle is bisected by the epiphyseal line of the femur.

Phylogenetic Degeneration of Muscles. In the period immediately following the publication of Darwin's "Origin of Species" the new concept of evolution produced many naïve ideas. The enthusiastic search for "vestiges" and the comparison of similar structures found in different species gave rise to a great deal of speculation. Much of that speculation persists into the present day. The speculation may coincide with the truth or it may not; but it should be remembered that it is no more than speculation. With that proviso in mind, it may be permitted to describe what is generally accepted to be the series of changes that take place in a muscle that is being lost from the species. The most common change is that the muscle belly shortens and the tendon correspondingly lengthens (e.g., plantaris). A further change is that the distal end of the tendon becomes attached to both bones of the joint across which it passes. The muscle thus comes to be inserted into a more proximal bone, and the doubly attached distal part of the tendon "degenerates" into a ligament (e.g., adductor magnus and medial ligament of knee, long head of biceps and sacro-tuberous ligament). An interesting example is supplied by the coccygeus muscle and the sacro-spinous ligament, which are merely the pelvic muscular and gluteal ligamentous surfaces of the same structure.

Action of Muscles. A single muscle rarely contracts alone, and its action is influenced accordingly by its companions in contraction.

To appreciate muscle actions it should be remembered that it is excessively rare for any muscle, or group of muscles with similar actions, not to have an opponent. It makes for greater simplification if muscles are therefore studied in opposing groups, and no group of muscles should ever be thought of without thinking of the opposing group in the same context.

Moreover, muscles acting as prime movers on a certain joint have a different action when a more distal segment of the limb is in motion. In such a case they act usually as synergists, to brace and steady proximal joints while distal joints are in action. For instance, the short scapular muscles are in almost constant contraction to stabilize the shoulder joint during movements of elbow, wrist and fingers. Acting as prime movers they rotate the humerus, medially or laterally as the case may be, but this is a much less frequent event in the everyday use of the upper limb.

Action of Paradox. A multiplicity of common movements are aided by gravity. The opposing muscles of such movements are then in contraction,