Adapted course for foreign students

Volume I

The weight-bearing and locomotor system

Yerevan 2000
INTRODUCTION
THE SCIENCE OF HUMAN ANATOMY

The science of human anatomy is the study of the form and structure of the human body (and the organs and systems which form it) and the regularities of the development of this structure in relation to its function and external environment.

The study of anatomy previously dealt with a single problem: how the body is built.

The object of the old descriptive anatomy was description of the structure of the body. In modern anatomy, however, description is a means rather than an end, one of the methods used the studying the human body structure. This method gives modern anatomy its descriptive aspect. Modern anatomy, however, attempts to explain not only how the organism is formed, but why it is so formed. To answer this second question, it is necessary to investigate both internal and external relationships of the organism.

Anatomy, therefore, studies not only the structure of the modern adult human being, but investigates the human organism in its historical development. With this in mind, the following three points shut be considered.

1. The development of the human genus in relation to the evolutionary process of the lower life forms. This study is called phylogenesis (Gk. phylon genus, genesis development) and uses the data of comparative anatomy, which compares the structures of various animals and man.

2. The formation and development of the human being in relation to the development of society. The study of anthropogenesis (Gk. anthropos human being), which uses the findings of both comparative anatomy and evolutionary morphology, is based primarily on the data of anthropology, the scientific study of mankind in its development. A branch of anthropology known as anatomical anthropology studies the structure of the human body not in relation to a hypothetical “average” human being but in relation to a given group of people who may vary according to constitution, occupation, and way of life.

3. The process of the development of the individual organism throughout life. Ontogenesis (Gk. anthos being) is concerned with uterine, embryonal (embryogenesis) processes, and extrauterine, postembryonal or postnatal (L post after, natus birth)
processes. The data of embryology (Gk. embryo to grow) and age anatomy are used in the study of ontogenesis. The last period of ontogenesis, ageing, is the subject of gerontology, the study of the ageing process (Gk. geron, gerontos old man). Individual and sexual differences in the shape, structure, and position of the body and its organs as well as the topographic relationships of the organs are also taken into account.

The study of human anatomy is conducted not simply in and of itself. It is rather based on the principle of the unity of theory and practice and has an applied aspect which serves both medical science and physical culture.

In view of the vast material involved and the difficulty of studying the organism as a single entity, it is at first examined according to systems. The approach of systematic anatomy is to divide the organism artificially into parts using the analytical method. In the living organism, however, the separate parts and components of the body’s structure (its systems, organs, tissues and so on) are not isolated but related in origin and development, and each helps shape and form the others.

Besides systematic anatomy there is topographic or regional anatomy which studies the spatial relationships of the organs in the different body regions. Since topographic anatomy has direct, practical significance for clinical work, particularly in surgical practice, it is also called surgical anatomy. Some authors separate from topographic anatomy an aggregate of information concerning the external relief of the body and its regions under the term “relief” anatomy.

Applied anatomy for artists and sculptors studies only the external form and proportions of the body and is known as plastic anatomy.

Anatomy that studies the normal healthy organism is called normal anatomy, as distinct from pathological, or morbid, anatomy, which is concerned with the study of the sick organism and the morbid changes in its organs.

Study of the anatomy of the living human being is especially necessary for the physician. The successes of this branch of anatomy are linked with advanced in X-ray methods of examination which allow physicians to view almost all the organs and systems of the living human organism and constitute an integral part of that branch of modern anatomy designated as X-ray anatomy.

All these branches of anatomical science are different aspects of a single human
anatomy.

The relationships existing in a single organism can be understood only by comparing the anatomical data with the data of other, related disciplines.

Man is the high point in the development of living matter. To understand the human structure, therefore, it is necessary to use the data of biology, the science of the laws of the origin and development of living matter. Just as man is a part of nature, anatomy, the science studying man’s structure is part of biology.

**The unity of form and function in the structure of the organism.** The organism and its components — organs, tissues, and cells — are different types of matter.

To understand the structure of the organism in light of the connection between form and function, anatomy uses the data of physiology, the science of the organism’s vital function. Biology is usually separated into two branches: morphology, the study of form, and physiology, the study of function.

Since the external shape of organs cannot be separated from their internal structure, anatomy is also related closely to histology, the science of tissues, particularly to the branch of histology known as microscopic anatomy. Macroscopic, or gross, anatomy (Gk. markos large, skopein to watch) and microscopic (Gk. micros small) anatomy are in essence a single science divided into two branches according to examination technique.

With the invention of the electron microscope, it became possible to examine submicroscopic structures and even molecules of living matter, which are also the objects of study in chemistry. A new science, cytochemistry was born at the junction of cytology and chemistry. As a result the structure of the human organism is now studied at different levels:

1. At the level of systems and organs: (a) with the naked eye—macroscopic, or gross, anatomy; (b) with a magnifying glass—micro-macroscopic anatomy; (c) with a microscope—microscopic anatomy.

2. At the level of tissues (histology): (a) with a magnifying glass; (b) with a microscope.

3. At the cellular level (cytology): (a) with a light microscope; (b) with an electron microscope.
4. At the molecular level: (a) with an electron microscope and by means of cytohistochemical reactions.

Thus, anatomy and histology are currently divided according to level and technique of examination.

Anatomy, histology, cytology, and embryology constitute the general science of the form, structure, and development of the organism, which is called morphology (Gk. morphe form, shape).

 METHODS OF ANATOMICAL STUDY.

There are two principal methods of anatomical study.

1. Examination of a cadaver by opening the body cavities and dissecting the organs and tissues with surgical instruments. The science of anatomy derives its name from this procedure of dissecting the whole cadaver into parts (Gk. anatome to dissect). Tubular systems (vessels, ducts, and so forth) are injected with various media (injection method) and then exposed to X-rays, clarification, or corrosion. Nerves are treated by elective staining.

2. Examination of a living human being. Every physician begins examination of a patient with this procedure, which includes palpation, percussion, auscultation, various measurements of the body (anthropometry), and endoscopy examination of the hollow organs through the natural body orifices (Gk. endon within).

X-rays provide the best possibilities for studying "living anatomy". They open, as it were, the internal organs of a living human being without a knife and without, pain and make it possible to observe the structure of the organs of a single individual throughout, the course of his life (X-ray anatomy). X-rays are used for making X-ray photographs (radiography) and for visualization on a special screen (radioscopy).

The newest methods of X-ray examination are as follows:

1. Electroradiography produces an X-ray image of the soft tissues (skin, subcutaneous fat, ligaments, cartilages, the connective tissue framework of the parenchymatous organs, etc.) which are invisible on ordinary radiographs because they are radiolucent.

2. Computer tomography produces an image of all the organs in a single plane
of body tissue, much like sections of a frozen cadaver prepared according to the method developed by N.I. Pirogoff.

In addition, experimental anatomy, in which experiments are performed on animals, is an important method of anatomical research.

As can be seen, modern anatomy has at its disposal a rich store of means for studying the structure of both the dead and the living human body.

THE STRUCTURE OF THE HUMAN BODY

THE ORGANISM

Since the object of study in anatomy is the organism, we shall first give a general account of its structure.

The organism is the highest form of unity of protein bodies capable of exchanging substances with the environment and of growing and multiplying. The organism is a historically formed, integral, continuously changing system with a specific structure and developmental pattern. The organism lives only under definite environmental conditions to which it is adapted and beyond which it cannot exist. Continuous exchange of substances with the environment is an essential feature of the organism's life.

THE ORGANISM AND ITS COMPONENTS

The organism is built of separate individual structures, i.e. organs, tissues, and tissue components united into a whole.

In the process of the evolution of living substances, first the noncellular forms (protein moners, viruses, and so on) and later the cellular forms (unicellular and the lowest multicellular organisms) developed.

In the human organism, just as in the organism of all other multicellular animals, the cells exist only as components of the tissues.

Tissues

Tissues are historically formed, individual systems of the organism.

They are composed of cells and their derivatives and possess specific morphophysiological and biochemical properties.
Each tissue is characterized by development, from a definite embryonal bud in ontogenesis, by relationship to the other tissues, and by a particular location in the organism. Tissues are formed morphologically of cells and an intercellular substance.

The great variety of tissues in the human and animal organism may be conditionally divided into four groups: (1) the integumentary tissues, or the epithelium (Gk. epi upon, L tela, tissue fine as a web); (2) tissues of the organism's internal environment, or connective tissues; (3) muscular tissues, and (4) neural tissues.

The integumentary, or epithelial tissues are located on surfaces bordering the external environment (hence the name skin-type epithelium given to some of them) and form the lining of the hollow organs (intestinal-type epithelium) and closed cavities of the body (cellonephrodermal- and ependymoglial-type epithelium). Epithelium lining the vessels is called endothelium. Complexes of epithelial cells in the shape of tubes, saccules, and other structures form glands (glandular epithelium). The main functions of epithelium are tegumentary and secretory.

Tissues of the internal environment, or connective tissues. These tissues are isolated from the external environment, they differ greatly in properties and are joined in one group on the basis of a common function (which also determines the main signs of their structure), the maintenance of homeostasis.

The tissues of the internal environment developed in three main directions: one subgroup became concerned with tropic and protective functions (fluid tissues, the blood and lymph, and the haemopoietic tissues), another group with the supporting function (fibrous connective and skeletal tissues), and a third group with the contractility function (mesenchymal-type unstriated muscular tissue).

Contractile tissues, muscular tissues, are grouped together according to the functional property, the ability to contract.

The smooth, unstriated, or involuntary muscular tissue contracts slowly and consists of spindle-shaped or stellate cells containing fine threads, microfilaments. The skeletal (somatic) muscular tissue consists of long (up to 10-12 cm in length) fibres measuring only 10-15 µm in diameter. The fibrils also contain specific elements in the form of cross striated myofibrils possessing, in turn, a submicroscopic structure. The muscular tissue of the heart is made up of separate cells containing cross striated fibrils
differing in some details of their structure from the fibrils of the skeletal muscular fibres.

**Neural tissues** are made up of nerve cells and auxiliary elements, neuroglia, or, in short, glia (Gk. *glia* glue). The nerve cells are supplied with processes of two types: (1) those which convey the stimulus from the perceiving apparatus to the body of the cell and which branch freely, that is why they are called *dendrites* (Gk. *dendron* tree) and (2) those which arise, each one separately, from the body of the cell and convey the nerve impulse from it to the effector cell which exerts the effect. This process is called the *neurite*; it stretches for a long distance, sometimes for more than 1 m, and forms the axial cylinder of the nerve fibre and is therefore also called an *axon* (L *axis*). The axon may be covered with a myelin sheath of special cells of the neuroglia. According to the details of their structure, white medullated (myelinated) and grey non-medullated (non-myelinated) fibres are distinguished. A nerve cell with all its processes and their end branchings is called a *neuron* (Gk. *neuron* nerve).

**ORGANS**

An **organ** (Gk. *organon* tool, instrument) is the part of the human body that serves as an instrument for the adaptation of the organism to the environment.

An organ is a relatively integral structure which has a definite, inherent only in it, form, structure, development, and position in the organism. It is a historically established system of different tissues (often of all the four main tissues) one or more of which prevail and determine its specific structure and function. The vital activity of the organ occurs under the direct effect of the nervous system.

The heart, for instance, is made up not only of cardiac muscular tissue but of different types of connective tissue (fibrous, elastic), elements of the nervous system (cardiac nerves), endothelium, and unstriated muscle fibres (vessels). The cardiac muscular tissue prevails, however, and it is exactly its property (contractility) that determines the structure and function of the heart as an organ of contraction.

Permanent (definitive) organs, i.e. those characteristic of an adult organism and persisting throughout life and temporary (provisional) organs which appear in a certain stage of the organism's development and then disappear (e.g. some embryonal and
extraembryonal organs) are distinguished from the standpoint of the periods of ontogenesis.

Some organs are made up of many structures which are similar in organization and are themselves formed of several tissues (e.g. the nephron in the kidney). They are called morpho-functional units.

**SYSTEMS OF ORGANS AND APPARATUS**

Some functions cannot be accomplished by only one organ. That is why a complex of organs, systems, form.

The system of organs is a collection of homogeneous organs marked by a common structure, function, and development. It is a morphological and functional assemblage of organs, i.e. organs which have a common plan of structure and a common origin and which are connected with each other anatomically and topographically.

Some organs and systems of organs differing in structure and development may be united for the performance of a common function. Such functional collections of heterogeneous organs are called an **apparatus**. The apparatus of movement, for instance, includes, the bone system, the articulations of bones, and the muscular system.

The following systems of organs and apparatus are distinguished.

1. Organs concerned with the principal process characterizing life, the exchange of substances with the environment. This process is a unity of opposite phenomena, *assimilation* and *dissimilation*. That is why there are organs by means of which the organism incorporates nutrients and oxygen and which form the *digestive* and the *respiratory systems*, and organs which excrete from the body waste substances that have become unfit for use; these make up the *urinary system*. Waste substances are also excreted through the digestive and respiratory organs and the skin.

2. Organs concerned with the maintenance of the species, the reproductive, or sex organs; they form the *genital*, or *reproductive system*.

The urinary and reproductive systems are closely related in development and structure and are therefore united under the term *urogenital system*. 
3. Organs by means of which substances incorporated by the digestive and respiratory systems are distributed throughout the organism while substances which must be excreted are brought to the excretory system. These are the organs of circulation, the heart and vessels (blood and lymph vessels). They make up the cardiovascular system.

4. Organs responsible for the chemical connection and regulation of all processes in the organism. These are the endocrine glands or organs; they form the endocrine apparatus.

The organs of digestion, respiration, and reproduction, the urinary organs, the vessels, and the endocrine glands are grouped under the term organs of vegetative life because similar functions are encountered in plants.

5. Organs concerned with adaptation of the organism to the environment by means of movement form the motor apparatus consisting of movement levers, i.e. the bones (the bone system), their articulations (joints and ligaments), and muscles which make them move (the muscular system).

6. Organs perceiving stimuli from the external environment make up the system of sensory organs.

7. Organs which accomplish the nerve connections and unite the function of all organs into a single whole form the nervous system with which the higher nervous activity (psyche) is associated. In the process of the development of the animal world, the nervous system became the main system providing the integrity of the organism and its unity with the conditions of life. It is responsible for the exchange of substances with the surrounding nature.

As a result the following scheme of the organism's structure can be marked out: the organism—–the system of organs—–the Organ—the morpho-functional unit of the organ—the tissue—the tissue elements

THE MAIN STAGES IN THE INDIVIDUAL DEVELOPMENT OF THE HUMAN ORGANISM

According to the environment in which the individual is developing, the whole ontogenesis is separated into two large periods between which is the moment of birth.
1. The intrauterine period, in which the newly conceived organism develops in the mother’s womb, lasts from the moment of conception to the time of birth.

2. The extrauterine or postnatal (L *natus* birth) period, in which the new individual continues development outside the mother’s body, lasts from the moment of birth until death.

The intrauterine period is separated, in turn, into two phases: (1) the embryonic phase (the first two months) in which the initial development of the embryo occurs and the organs are mainly laid; (2) the foetal phase (3rd to 9th months) in which the foetus develops further.

### THE EXTRAUTERINE DEVELOPMENTAL PERIOD OF THE ORGANISM

The following age periods are distinguished in the life of a human after birth.

1. The neonatal period (the first two or three weeks after birth) in which the organism must become adapted to the new conditions of extrauterine life. The body of the newborn differs drastically from that of an adult in shape and dimensions. The height of a newborn is 50 cm on the average and the weight 3250-3500 g. The head (the cerebral part mainly) is very large and accounts for 1/4 of the height (in an adult the head constitutes 1/7-1/8 of the height), the legs, in contrast, are short (1/3 of the height). The abdomen is larger than the chest and bulges forward because the pelvis is narrow. The upper and lower limbs are approximately equal in length.

2. The suckling period (infancy) from the age of 4 weeks to 12 months.

3. The period of deciduous dentition (natural infancy) from the age of 12 months to 7 years, i.e. from the beginning of the eruption of the deciduous teeth to the beginning of the eruption of the permanent teeth. The secondary sex characters, both in girls and in boys, are poorly pronounced.

   This period is separated into the pre-preschool (12 months to 3 years) and preschool (3 to 7 years) periods.

4. The adolescence period (bisexual childhood) lasts from the age of 7 to 15-16 years, from the beginning of permanent teeth eruption to the end of the eruption of all second molars, to the beginning of puberty. The grade school age
(7-11 years) and the middle school age (12-15-16 years) are distinguished in this period. The middle school age is characterized by intensified formation of secondary sex characters in both sexes and because of this the period is also known as prepuberty.

5. The puberty period or juvenile (L juvenis youth) age. This period begins at the end of eruption of the second molars and lasts till growth ceases and physical maturity is attained.

This period lasts from the age of 13-14 to the age of 18 in girls and from the age of 15-16 to the age of 19-23 in boys. The period between 16 and 18 years of age is also known as the high school age; the middle and high school age are known together as the teen-age period. Secondary sex characters develop during puberty, as a result of which boys become young men, and girls become young women.

In this period the height and body proportions come close to those of adults. Two periods of intensified growth are distinguished: at the end of natural infancy (5 to 7 years of age) and during puberty (girls at the age of 11-14 years and boys at the age of 13-16 years). Growth also continues after the onset of puberty.

6. The change of the organism from the juvenile age to the adult state does not mean that development ceases. It continues but changes in the form and structure of the body are less marked.

The following three stages are distinguished in the development of an adult organism.

1. Prime of adulthood. This stage lasts from the age of 25 to the age of 45 in males and from 20 to 40 years of age in females.

2. Maturity lasting to the time of the appearance of changes associated with old age (attrition and loss of teeth, obliteration of the sutures of the skull).

3. Old age (senium) characterized by progressive involution of the bodily organs and systems which leads to death.

THE FORM, SIZE AND SEX OF THE HUMAN BODY

The human body is made up of the head (caput), neck (collum), trunk (truncus), and two pairs of limbs, or extremities, the upper (membra s. extremitates [BNA] superiores) and lower (membra s. extremitates [BNA] inferiores). The following parts are
distinguished in the head: the forehead (frons); the highest point of the skull (vertex); the back of the head (occiput); the temples (tempora) and the face (facies). The trunk consists of the chest (thorax), the abdomen (abdomen) and the back (dorsum). The following lines are drawn for orientation on the chest surface: 1) midline (linea mediana anterior); (2) sternal line (linea sternalis) stretching along the sternal border; (3) mamillary line (linea mammillaris s. medioclavicularis) passing through the nipple or the middle of the clavicle; (4) parasternal line (linea parasternalis) passing midway between the sternal and mamillary lines; (5) anterior, (6) middle, and (7) posterior axillary lines (lineae axillarea anterior, media and posterior), the first and last passing through the anterior and posterior folds of the axilla, respectively, and the middle line passing through the point midway between these folds; (8) scapular line (linea scapularis) passing through the inferior angle of the scapula.

The abdomen is divided by two horizontal lines, one drawn between the ends of the 10th ribs and the other between both the anterior superior iliac spines, into three parts, one located above another: the upper part of the abdomen (epigastrium), the middle part (mesogastrium) and the lower part (hypogastrium) (Fig. 1).

Fig. 1 Subdivision of the abdomen into regions

Each of these three parts of the abdomen is subdivided by two vertical lines into three secondary regions: the epigastrium is divided into a middle epigastric region (regio
epigastrica) and two lateral regions, the right and left hypochondrium (regiones hypochondriacae dextra and sinistra). The middle abdomen is divided in the same manner into a medial umbilical region (regio umbilicalis) and two lateral, right and left lumbar regions (regiones abdominales laterales, dextra and sinistra). Finally, the hypogastrrium is divided into the pubic region (regio pubica) and two lateral, right and left inguinal regions (regiones inguinales, dextra and sinistra). The upper limb is divided into the arm (brachium), the forearm (antebrachium) and the hand (manus); the palm (palma manus), the back (dorsum manus) and the fingers (digitī manus) are distinguished in the hand. The lower limb, in turn, is divided into the following parts: the thigh (femur), the leg (crus), and the foot (pes), in which the sole (planta), the dorsum of foot (dorsum pedis), and the toes (digiti pedis) are distinguished.

The sex characters distinguishing a male from a female are divided into primary and secondary. The reproductive organs, the sex glands in the first instance, which determine the sex are the primary characters. All the other characters are secondary. Females are smaller in height (by 12 cm on the average) and weigh less (a female weighs 55 kg on the average). In relation to the body height, the trunk is shorter in a female than in a male, but the lower limbs of a female are longer. The shoulders are narrower in females, but the lower part of the trunk is wider because a female pelvis is wider than the pelvis of males. The chest of a female is shorter and narrower than that of a male as a result of which, as well as because the female pelvis is inclined more to the front, the abdomen of a female is longer. The average total bulk of muscles makes up 40 per cent of total body weight in males but only 32 per cent in females, as a consequence the physical strength of females is in general less than that of males. The adipose tissue is developed more copiously in females. Developed mammary glands are a typical secondary sex character of females; in males these glands are rudimentary. The skin of males is thicker and coarser and, moreover, is more hairy (especially on the face).

<table>
<thead>
<tr>
<th></th>
<th>Body length</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>165 cm</td>
</tr>
<tr>
<td>M</td>
<td>F</td>
</tr>
</tbody>
</table>
### CONSTITUTION

The general concept "organism" defined above does not adequately portray the notion of an actual individual who must be dealt with both in the study of anatomy and in the physician's practice. Closer study of individuals discloses marked differences between them, both morphological and functional. These differences provided the material for the science of the human constitution. Constitution is the totality of those features of build which are associated with specific, mainly biochemical, peculiarities of the organism's vital activity. These peculiarities are manifested morphologically by the deposit of fat and the development of the musculature, which affects the shape of the chest, abdomen, and back.

The term constitution usually means a complex of individual physiological and morphological features, related only to the given individual, that form under definite social and natural conditions and are displayed in the organism's reaction to different influences (pathological among others).

Despite the diversity of individual features encountered among humans, these features may nonetheless be grouped into types of constitution. Three constitutional types are differentiated from the morphological standpoint (Fig. 9).

1. **Hypersthenic**, marked by predominant growth in breadth, massive bulk, and good nourishment. The trunk is relatively long, but the limbs are short. The head,
chest, and abdomen are very large because the corresponding body cavities are greatly
developed. There is relative predominance of the size of the abdomen over that of the
chest and of the transverse dimensions over the longitudinal dimensions.

2. **Asthenic**, characterized by predominant growth in length, just proportions,
slenderness of body build, and poor general development. The limbs predominate
over a relatively short trunk, the chest over the abdomen, and the longitudinal
dimensions over the transverse dimensions.

3. **Normosthenic**, a constitutional type intermediate between the other two.
According to another classification, *three types of body build* are also
distinguished.

1. **Dolichomorphic**, marked by a body that is long or of above average height, a
relatively short trunk, a small chest circumference, narrow or moderately wide
shoulders, long lower limbs, and slight tilting of the pelvis.

2. **Brachymorphic**, characterized by moderate or shorter than average height, a
relatively long trunk, a large chest circumference, relatively wide shoulders, short
lower limbs, and marked inclination of the pelvis.

3. **Mesomorphic** – type is an average body build, intermediate between the
two described above.

**NORM AND ANOMALIES**

In the process of formation the human organism became adapted to the
environment. As a result a definite equilibrium was established between it and the
concrete environmental conditions. This equilibrium, attained because of definite
morphological and functional features of the organism, is designated the *norm* and the
body structure corresponding to the norm is considered normal.

The structure of the organism and its organs has many variations, variants of the
norm, some of which are encountered more and others, less frequently. According to
variation statistics, they form a variation series at the ends of which are extreme forms
of individual changeability. The norm is therefore the sum total of all the structural
variants characteristic of man as a species.

An anomaly (Gk. anomalos irregular) is a deviation from the norm; it is
manifested to different degrees. Anomalies also have variations, some of which result
from improper development but do not disturb the established equilibrium between the organism and the environment and therefore have no effect on function. Location of the heart in the right side (dextrocardia) or abnormal position of the viscera (situs viscerum in versus) serve to illustrate the point. Other anomalies are attended by impaired function of the organism or some of the organs. They disturb the equilibrium between the organism and the environment (e.g. cleft palate) or are even incompatible with life (e.g. absence of the skull or acrania, absence of the heart or acardia, etc.). Such a gross developmental anomaly is called a monstrosity or a teratism. The branch of anatomy and embryology concerned with the study of anomalies and malformations is called teratology (Gk. teras monster, logos science). Teratology is also part of pathological anatomy because it studies structures pathological in essence.

**ANATOMICAL TERMINOLOGY**

A person beginning to study anatomy is struck first of all by the copious terminology that must be firmly understood and completely mastered by every student and physician. These terms usually designate spatial relations, the shape or size of various organs, and so forth.

In mathematics and physical geography, certain initial points and planes are accepted from which distances are measured to establish spatial relations. In anatomy as well, there are generally accepted designations of perpendicular planes by means of which the position of organs or their parts in space is determined exactly. Three such planes are of primary importance: sagittal, frontal, and horizontal. It should be borne in mind that the planes are related to an erect human body (Fig. 10).

The sagittal plane is a vertical plane by means of which we divide the body mentally (for example, a fixed, frozen cadaver) with an arrow (L sagitta arrow) piercing it from front to back and with an arrow along the length of the body. The sagittal plane that passes through the middle of the body and divides it into two symmetrical, right and left, parts is called the median plane (L medius middle) (Fig. 10). A plane drawn also vertically but at right angles to the sagittal plane is called the frontal plane and is parallel to the forehead (L frons forehead). The frontal plane divides the body into the front and back parts. The third, horizontal, plane in accordance with its name passes
horizontally, i.e. at right angles to both the sagittal and the frontal planes. It divides
the body into the upper and lower halves.

The positions of the different points or lines in these planes are designated as
follows: those located nearer to the median plane are called medial \((\textit{medialis})\) \((L \textit{medius}\) middle); those located further from the median plane are designated lateral \((\textit{lateralis})\) \((L \textit{latus}\) side). Points and lines found on a front to back plane are designated as follows:
those located nearer to the front surface of the body are called anterior or ventral
\((\textit{ventralis})\) \((L \textit{venter}\) belly); those nearer to the back are known as posterior or dorsal
\((\textit{dorsalis})\). The following points and lines are distinguished in the vertical plane: those
nearer to the upper end of the body are called upper, superior, or cranial \((\textit{cranialis})\)
\((\text{Gk. } \textit{kranion}\) skull); those nearer to the lower end are referred to as lower, inferior or
caudal \((\textit{caudalis})\) \((L \textit{cauda}\) tail).

![Fig. 2. Diagram of axes and planes of the human body.]

1. vertical axis;
2. transverse axis;
3. one of the frontal planes;
4. horizontal and vertical lines on the frontal plane;
5. the arm is drawn to the trunk (adductio);
6. the left upper limb is flexed at the elbow joint (flexio);
7. and 17, transverse axis, one of the horizontal axes in the frontal plane;
8. transverse plane (one of the horizontal planes), the arrows on it indicate the sagittal direction (from front to back) and the transverse direction (from left to right and from right to left);
9. transverse plane (one of the horizontal planes), the arrows on it indicate the sagittal direction (from front to back) and the transverse direction (from left to right and from right to left);
10. the hand is pronated, the thumb is directed at the trunk (pronatio);
11. change from the pronated position supination, example of rotation (rotatio);
12. the ring and little fingers are flexed (flexio);
13. the hand is supinated, the thumb faces outward (supinatio);
14. the thumb is drawn away from the median line (abduction);
15. sagittal axis;
16. medial margin of the forearm;
17. lateral margin of the forearm;
18. the right upper limb is extended at the elbow joint (extensio);
19. the arm is drawn away from the trunk (abductio);
20. horizontal and vertical lines in the sagittal plane (arrows);
21. one of the parasagittal planes;
22. median plane, plane of symmetry (one of the sagittal planes)

The terms proximal and distal are used in reference to the parts of the limbs. **Proximal** (L proximus nearest) is applied to parts nearer to the point of origin of the limb from the trunk; **distal**, in contrast, is a term applied to parts farthest from the trunk (L distare to be distant). On the upper limb, for instance, the elbow is proximal in comparison to the fingers, while the latter are distal in relation to the elbow.

The terms **external** (externus) and **internal** (internus) are used mainly to designate positions in relation to the body cavities and whole organs, either outward or inward; the terms **superficial** (superficialis) and **deep** (profundus) are used for organs located "less deep" or "more deep" in relation to the surface of the body or organ.

The commonly used terms for size are **great** (magnus); **small** (parvus); **greater** (major), **lesser** (minor). The last two terms, major and minor, are used to designate the comparative size of two related or identical structures. e.g. tuberculum majus and minus on the humerus. The term magnus (great) does not imply the presence of another identical but smaller structure. For instance, nervus auricularis magnus, the great auricular nerve, is called so because of its thick trunk; there is no nervus
auricularis parvus.

An internal skeleton, endoskeleton, is typical of all vertebrates.

GENERAL OSTEOLOGY, OSTEOLOGIA

The skeleton (Gk. skeletos dried up) is a complex of hard structures that originate in the mesenchyme and possess mechanical importance. It consists of separate bones joined to each other by means of connective cartilaginous or bony tissue, which together make up the passive locomotor apparatus (system).

As the endoskeleton developed in the vertebrates, it was at first a support (framework) for the soft tissues. Some parts of the skeleton became levers which could be set in motion by the muscles as a consequence of which the skeleton acquired the locomotor function. Thus the mechanical functions of the skeleton include protection, support, and movement.

Support (weight-bearing) is provided by attachment of the soft tissues and organs to the different parts of the skeleton. Movement is possible because the bones have the structure of long and short levers connected by mobile articulations and set in motion by muscles, which are regulated by the nervous system. Finally, protection is provided by the vertebral canal, which protects the spinal cord; a bone case, the skull, which protects the brain; the thoracic cage, which protects vitally important organs of the thoracic cavity (heart, lungs); and the pelvis, which protects the reproductive organs which are important for the continuance of the species.

The biological function of the bone system is associated with the participation of the skeleton in metabolism, particularly mineral metabolism (the skeleton is a reservoir of mineral salts, phosphorus, calcium, iron, etc.).

The development of the skeleton

In the process of phylogenesis, three types of the skeleton replaced one another in sequence as a phenomenon of adaptation to the environment. This replacement also takes place in the ontogenesis of man during which three stages in the development of the skeleton are encountered:
1. connective-tissue (membranous); (2) cartilaginous, and (3) bony. Almost all bones go through these three developmental stages. The exceptions are the bones of the skull cap, most bones of the face, and parts of the clavicle, which form directly from connective tissue without going through the stage of the cartilage.

BONE AS AN ORGAN

Bone (os, ossis) as an organ of the living organism, consists of several tissues among which bone tissue is most important. The bulk and significance of bone tissue can be demonstrated on macerated bone (removed from the body, freed of the soft tissues, and treated anatomically by soaking and drying). Despite such treatment, the bone preserves its shape, size, structure, and strength. The strength of the bone results from the combination of two main properties, hardness and elasticity, which are the result of certain chemical substances in the bone itself.

The chemical composition and physical properties of bone. Bone matter consists of two types of chemical material: organic (one-third), mainly ossein, and inorganic (two-thirds), mainly calcium salts, calcium phosphate in particular (51.04 per cent). When bone is exposed to an acid solution (hydrochloric, nitric, etc.), the calcium phosphate salts dissolve (decalcification, decalcination), while the organic material remains and preserves the shape of the bone, although it is soft and elastic. If bone is subjected to burning, however, the organic material burns away, while the inorganic material remains and also preserves the shape and hardness of the bone, although the bone is now very fragile. Therefore, the elasticity of bone is determined by ossein, whereas its strength depends on the mineral salts. The combination of inorganic and organic materials in the bone gives it exceptional strength and elasticity. The age changes in bone are also convincing evidence of this. The bones of young children, which contain comparatively greater amounts of ossein, are marked by greater pliability, and their fractures are consequently rare. In contrast, in old age, when the proportion of the organic and inorganic materials changes in favour of the latter, bones become less elastic and more fragile. As a result, bone fractures are encountered most frequently in individuals of old age.)

The structure of bone. The structural unit of bone, visible with a magnifying lens or slight microscopic magnification, is the osteon, or the Haversian system, i.e. a system
of bone lamellae arranged concentrically around a canal (Haversian canal) containing vessels and nerves. The osteons are not densely situated, and the spaces between them are filled with intermediate (interstitial) bone lamellae. The osteons are not scattered at random but are arranged in accordance with the functional load exerted on the bone: parallel to the length of the bone in tubular bones, perpendicular to the vertical axis in spongy (cancellous) bone, and parallel to the bone surface and radially in the flat bones of the skull.

Together with the intermediate lamellae, the osteons form the main middle layer of the bone matter lined inside (as viewed from the endosteum) with an inner layer of general bony lamellae and outside (as viewed from the periosteum) with an outer layer of general lamellae. This last layer is permeated with blood vessels passing from the periosteum into the bone matter in special canals called Volkmann's canals. It can be seen on macerated bone that these canals begin as numerous vascular openings (foramina vasculosa). The blood vessels conveyed in the Volkmann and Haversian canals provide for metabolism in the bone.

Osteons form larger elements of the bone which are visible to the naked eye on a section of bone or on radiographs; these are the trabeculae of the bone matter. Two types of bone substances are built from the trabeculae. Compact substance (substantia compacta) forms if the trabeculae fit tightly to each other. Loosely arranged trabeculae, with bony pores between them, resembling a sponge, form the spongy, or trabecular, substance (substantia spongiosa, s. trabecularis). The distribution of the compact and spongy substances depends on the function of the bone. The compact substance is found in those bones and those parts of bones that are concerned predominantly with the functions of support (stanchion) and movement (levers), e.g. in the diaphysis of tubular bones. The spongy substance forms in bones or their parts that are large in bulk but which must be light and at the same time strong, e.g. in the epiphyses of tubular bones. In the membrane bones of the skull cap, which perform predominantly a protective function, the spongy substance can be distinguished from the spongy substance of other bones which fulfil all three functions of the skeleton. This spongy substance is referred to as diploe (Gk. fold), it consists of irregularly shaped bony compartments lying between two bone tables, the outer (lamina externa) and the inner
(lamina interna). The latter is also called vitreous (lamina vitrea) because it fractures more easily than the outer table in injury to the skull.

The bony compartments contain the bone marrow (medulla ossium), the organ of haemopoiesis and biological protection of the organism. Bone marrow also takes part in nutrition and the development and growth of the bone. In the tubular bones, the medulla also fills the central canal which is consequently called the marrow, or medullary, cavity (cavitas medullaris).

There are two types of bone marrow, red and yellow. Red bone marrow (medulla ossium rubra) (the details of its structure are described in the course in histology), is seen as a fine red mass of reticular tissues in whose meshes lie cells directly concerned with haemopoiesis and bone formation (cells forming bone, osteoblasts, and cells destroying bone, osteoclasts). It is permeated by nerves and blood vessels supplying nutrients to the marrow and the inner layers of the bone. The blood vessels and the blood elements lend the marrow its red colour. Yellow bone marrow (medulla ossium flava) owes its colour to the fat cells, of which it is mainly composed.

Bone, with the exception of the articular surfaces, is covered by periosteum. The periosteum is a thin, strong, pale pink connective-tissue membrane which surrounds the bone on the outer surface and is attached to it with connective-tissue fibres penetrating the bone through special canaliculi. It consists of two layers, an outer fibrous layer and an inner bone-forming (osteogenetic, or cambial) layer. It is rich in nerves and vessels and contributes therefore to the nutrition and the growth of the bone in thickness.

Growth of the bone occurs due to osteoblasts, which are located in the inner (cambial) layer and adhere to the bone. The articulating surfaces of bone are free of the periosteum and are covered by the articular cartilage (cartilago articularis), which has the common structure of hyaline cartilage and is referred to as the epiphyseal cartilage (cartilago epiphysialis).

THE DEVELOPMENT OF BONE

Any bone is formed through the activity of young connective-tissue cells of mesenchymal origin, the osteoblasts, which produce the intercellular bone matter that performs the important function of support. According to the three developmental...
stages of the skeleton indicated above, bones may develop from connective or cartilaginous tissue. Therefore, the following types of ossification (osteogenesis) (L os bone) are distinguished: (1) intramembranous or endesmal; (2) perichondral; (3) periosteal; (4) enchondral.

Intramembranous or endesmal ossification (Gk. en in, into, desmos band) occurs in the connective tissue of the primary (membrane) bones. As a result of osteoblastic activity, islands of bone substance (the center, nucleus, or point of ossification) appear on a certain area of embryonic connective tissue which has the contours of the future bone. This site of the earliest possible appearance of bone tissue on the membrane bones of the skull cap is noticeable as a small tuber. From the primary center the ossification process spreads radially in all directions by apposition of the bone substance on the periphery. The surface layers of the connective tissue giving rise to the membrane bone remain in the form of the periosteum which provides for the growth of bone in thickness.

Perichondral ossification (Gk. peri around, chondros cartilage) takes place on the outer surface of the cartilaginous bone germs with the participation of the perichondrium. The mesenchymal germ which has the contours of the future bone, develops into "bone" of cartilaginous tissue, which is kind of a cartilaginous model of the bone. As a result of the activity of the perichondral osteoblasts covering the cartilage, bone tissue is laid down on its surface directly under the perichondrium. This tissue replaces the cartilaginous tissue gradually and forms a compact bony substance.

With the conversion of the cartilaginous model to a bone model, the perichondrium becomes the periosteum, and further deposition of bone tissue is accomplished by the periosteum; this is periosteal ossification. The perichondral and periosteal types of ossification are therefore connected and one follows the other chronologically.

Enchondral ossification (Gk. en in, into, chondros cartilage) occurs in the cartilaginous germs with the participation of the perichondrium, which gives off processes containing vessels into the cartilage. In penetrating deep into the cartilage together with the vessels, the bone-forming tissue destroys the cartilage which had undergone calcification (the deposition of lime into the cartilage and degeneration of
its cells) and forms an island of bone tissue (the nucleus, or point of ossification) in the center of the cartilaginous bone model. The spread of enchondral ossification from the center to the periphery leads to the formation of the spongy bone substance. Thus, the cartilage does not transform directly into bone, but is destroyed and then replaced by new bone tissue.

**Growth of bone.** The long-term growth of the organism and the tremendous difference between the dimensions and shape of the embryonic and final bone are such that its reorganization during growth is inevitable; in the process of reorganization, the formation of new osteons is paralleled by the *resorption* of the old ones whose remnants can be seen among the newly forming Haversian systems (the "intermediate” or interstitial system of lamellae).

Resorption is the result of the activity of specific cells, osteoclasts (Gk. osteon bone, klasis breaking) in the bone. Owing to their work almost the entire diaphyseal epichondral bone undergoes resorption, and a cavity (the marrow cavity) forms in it. The layer of perichondral bone also undergoes resorption, but new layers are laid down from the periosteum in place of the disappearing bone tissue. As a result the young bone grows in thickness.

The layer of cartilage between the epiphysis and the metaphysis, known as the meta-epiphyseal cartilage, or growth lamellae, persists throughout the childhood and juvenile periods. The bone grows in length at the cost of this cartilage, owing to the multiplication of its cells which deposit the interstitial cartilaginous substance.

The following parts are distinguished in every tubular bone according to the described development and function.

The body (shaft) or **diaphysis**, is a bone tube containing yellow bone marrow in adults and mainly is concerned with the function of support and protection.

The ends of the diaphysis which adjoin the meta-epiphyseal cartilage are the **metaphyses**. They develop together with the diaphysis but are concerned with the growth of bones in length and consist of spongy substance. The compartments of the "bony sponge" are filled with red bone marrow.

The articulating ends of each tubular bone, located on the other side of the meta-epiphyseal cartilage, are the **epiphyses**. They are also composed of spongy
substance containing red bone marrow.

Bony projections, or **apophyses**, are located close to the epiphysis and are the site of attachment of muscles and ligaments.

**BONE CLASSIFICATION**

The skeleton of an adult contains more than two hundred separate bones, of which 34 to 40 are located on the midline of the body and are not paired. The rest are paired bones.

Bones are classified according to appearance: long, short, flat, and mixed.

It is therefore more proper to classify bones according to the three principles on which any anatomical classification should be based, i.e. form (structure), function, and development. The following classification of bone can be suggested from this standpoint (M.G. Prives):

1. **Tubular bones.** These are composed of spongy and compact substance forming a tube with a marrow cavity; they perform all three functions of the skeleton (support, protection, and movement). *Long tubular bones* (arm bone, forearm bones, thigh bone, and leg bones) are supports and long levers of movement and they have enchondral ossification foci in both epiphyses (biepiphyseal bones) but not in the diaphysis. *Short tubular bones* (metacarpal, metatarsal, phalanges) are short levers of movement; an enchondral ossification focus is found only in one (true) epiphysis (monoepiphyseal bones).

2. **Spongy bones.** These bones consist mainly of spongy substance covered with a thin layer of compact substance. *Long* (ribs and
sternum) and *snort* (vertebrae, carpal, tarsal) *spongy bones* are distinguished. The group of spongy bones also includes *sesamoid bones*, i.e. bones which resemble sesame seeds in shape, hence their name (the knee cap, or patella, the pisiform bone, the sesamoid bones of the fingers and toes); sesamoid bones act as accessory devices in the work of muscles and develop by enchondral ossification in the thickness of the tendons, which they strengthen. The sesamoid bones are located close to the joints, take part in their formation, and promote movements in them but are not joined directly to the bones of the skeleton.

**Flat bones**: (a) the *flat bones of the skull* (frontal and parietal) perform a function that is mainly protective (membrane bones). Their structure is diploe, and they ossify from connective tissue; (b) the *flat bones of the girdles* (shoulder blades, pelvic bones) perform supportive and protective functions. Their structure is primarily spongy substance. Ossification occurs in cartilaginous tissue.

**Mixed bones** (bones of the base of the skull) are formed by the fusion of several parts, which differ in function, structure, and development.

The skeleton of the human trunk

The *skeleton of the human trunk has the following characteristic features* determined by the upright posture and the development of the upper limb as an organ of labour:

- a vertical vertebral column with curvatures, particularly in the sacral region, where an anterior prominence (promontorium) forms;
- gradual increase in the size of the vertebral bodies in the direction from top to bottom where, in the region of their connection with the lower limbs through the pelvic girdle they fuse to form a single bone, the sacrum, consisting of five vertebrae;
- a wide and flat thoracic cage with a predominant transverse dimension and an extremely small anteroposterior dimension.

**THE VERTEBRAL COLUMN**

The *vertebral column* (*columna vertebralis*) or the spine has a metameric structure (a feature connecting the vertebrae with the earliest invertebrates) and consists of separate bone segments, vertebrae, placed one over another in a series; they are short
spongy bones.

*Function of the spine.* The spine acts as the axial skeleton supporting the body. It protects the spinal cord enclosed in its canal and takes part in the movements of the trunk and head. The position and shape of the vertebral column are determined by the upright position of man.

Common features of the vertebrae. In accordance with the three functions of the spine, each vertebra (Gk. *spondylos*) has the following features:

- an anterior part, which is responsible for support and which thickens in the shape of a short column, this is the **body (corpus vertebrae)**;
- an **arch (arcus vertebrae)**, which is attached to the posterior surface of the body by two pedicles (pediculi arcus vertebrae) and contributes to the formation of the **vertebral foramen (foramen vertebrae)**; a series of these foramina forms the **vertebral, or spinal, canal (canalis vertebrae)**, which protects the spinal cord lodged in it from external injury. The vertebral arch, therefore, primarily fulfils a protective function;
- the arch also carries structures permitting movement on the vertebra called processes. A spinous process (*processus spinosus*) arises from the arch on the midline; a transverse process (*processus transversus*) projects laterally on each side; paired superior and inferior articular processes (*processus articulares superiores* and *inferiores*) project upward and downward. The articular processes bind notches on the posterior aspect; these are the paired **incisurae vertebrae superiores** and **inferiores** from which the intervertebral foramina (*foramina intervertebralia*) form when one vertebra is placed on another. The foramina transmit the nerves and vessels of the spinal cord. The articular processes serve for the formation of intervertebral joints at which movement of the vertebrae is accomplished; the transverse and the spinous processes serve for the attachment of ligaments and muscles which make the vertebrae move.

Some parts of the vertebrae in the different parts of the spine have a distinctive size and shape and the following vertebrae are consequently distinguished: cervical (seven), thoracic (twelve), lumbar (five), sacral (five), and coccygeal (one to five).

**INDIVIDUAL TYPES OF VERTEBRAE**

**Cervical vertebrae (vertebrae cervicales)** (Fig. 26). Since the load suffered by the cervical vertebrae is lighter than that suffered by the more distally located spinal
segments, their bodies are correspondingly smaller. The bodies are transverse-oval in shape, and the upper and lower surfaces are concave. Each transverse process is characterized by the presence of a hole (*foramen transversarium*), which forms as a result of fusion of the transverse process with the rib rudiment (*processus costarius*). The canal which forms from a series of these foramina protects the vertebral artery and the vein that it transmits. This fusion is manifested on the ends of the transverse processes as two *tubercles* (*tuberculum anterius* and *posterius*). The anterior tubercle of the sixth vertebra is enlarged and is called the *carotid tubercle* (*tuberculum caroticum*). The carotid artery can be compressed against it to arrest bleeding. The spinous process is bifid, with the exception of that of the sixth and seventh vertebrae. The seventh cervical vertebra is distinguished by a large spinous process, and for that reason it is called the *vertebra prominens*. This vertebra is easily located in a living person and is often helpful in making diagnosis (Fig. 27).

The first and second cervical vertebrae have a specific shape because they form the mobile articulation with the skull. Most of the body of the first vertebra, the atlas, remains separate and joins the second vertebra as a tooth-like process, the *dens*. As a result only the anterior arch is left; to make up for this, the vertebral foramen that receives the dens is larger. The *anterior* (*arcus anterior*) and *posterior* (*arcus posterior*) *arches* of the atlas are connected to each other by *lateral masses* (*massae laterales*). The superior and inferior surfaces of each arch articulate with the adjoining bones: the convex *superior articular facet* (*fovea articularis superior*) receives the corresponding condyle of the occipital bone; the flattened *inferior articular facet* (*fovea articularis inferior*) receives the articular surface of the second cervical vertebra.

The outer surfaces of the anterior and posterior arches carry *tubercles* (*tuberculum anterius* and *posterius*) (Fig. 28).

The second cervical vertebra, the *axis* (consequently the axial vertebra) s. *epistropheus* (BNA) (Gk. *epistrephomai* pivot, consequently the pivotal vertebra) differs sharply from all the other vertebrae by the presence of the tooth-like process, the *dens* (Fig. 29). The dens has articular surfaces, which on the anterior aspect serve to articulate with the anterior arch of the atlas and on the posterior aspect to attach the transverse ligament. Another distinction of the axis is that its superior articular surfaces
articulating with the atlas are not on the arch but on the superior surface of the body to the sides of the dens.

2. **Thoracic vertebrae** (*vertebrae thoracicae*) (Fig. 30) articulate with the ribs. Their distinctive feature, consequently, is the presence of articular facets for the ribs, **costal facets** (*fovea costales*), on the body of each vertebra close to the base of the arch. Since the ribs usually articulate with two adjoining vertebrae, most vertebral bodies have two incomplete (half) costal facets: one on the superior edge of the vertebra (*fovea costalis superior*) and the other on the inferior surface (*fovea costalis inferior*). When one vertebra is placed on the other, the two half-facets form a single whole articular facet, which receives the head of the rib. The first thoracic vertebra is an exception: it has a complete articular facet on the superior edge for the first rib and a half-facet on the inferior edge for the second rib. The tenth vertebra has only one half-facet for the tenth rib, whereas the eleventh and twelfth ribs each have a complete facet for articulating with the corresponding ribs. These vertebrae (first, tenth, eleventh, and twelfth) can, therefore, easily be distinguished from the others. In accordance with the greater weight they bear, the bodies of the thoracic vertebrae are larger than the bodies of the cervical vertebrae. The articular processes are positioned frontally. The transverse processes are directed laterally and to the back. They have a small articular surface, **transverse costal facet** (*fovea costalis processus transversus*) for articulating with the tubercle of the ribs. The transverse processes of the last two vertebrae (eleventh and twelfth) lack these facets. The spinous processes of the thoracic vertebrae are long and are inclined sharply downward, as a result of which they overlie one another like tiles, mainly in the middle of the thoracic part of the spine. Such direction of the processes limits extension of the spine here, which is a protective accommodation for the heart.

3. **Lumbar vertebrae** (*vertebrae lumbales*) are distinguished by a massive body since they carry weight that is still greater than that borne by the part of the spine proximal to them (see Fig. 30). The spinous processes are directed horizontally, to the back. The articular processes are in the sagittal plane. The main part of the transverse process is a rudimentary rib fused completely with a true transverse
process, and a small part is preserved as a small process on the posterior aspects of its root and erroneously called the accessory process (processus accessorius) (Fig. 31).

4. Sacral vertebrae (vertebrae sacrales) fuse in youth to form a single bone, the sacrum (Fig. 32). This fusion is an adaptation to the considerable load carried by the sacrum because of the upright posture of the human. The sacrum is triangular in shape, and its base (basis ossis sacri) faces upward, while the apex (apex ossis sacri) faces downward. The anterior border of the base together with the body of the last lumbar vertebra forms an angle projecting forward, a prominence (promontorium). The ventral or pelvic surface of the sacrum (facies pelvina) is concave. The sites of the fusion of the vertebral bodies are seen on it as transverse lines (lineae transversae) with the anterior sacral foramina (foramina sacralia pelvina) at their ends. On the dorsal surface there are, correspondingly, the posterior sacral foramina (foramina sacralia dorsalia). Five crests formed by fusion of different parts of the vertebrae stretch lengthwise on the dorsal surface: an unpaired spinous tubercles of the sacrum on the median line (crista sacralis mediana) formed as the result of fusion of the spinous processes; the articular tubercles of the sacrum (cristae sacrales intermediae) (from fusion of the articular processes); and, lateral to these, the transverse tubercles of the sacrum (cristae sacrales laterales) (sites of fusion of the transverse processes). Lateral to the sacral foramina are the lateral parts of the sacrum (partes laterales) formed by fusion of the transverse processes and the sacral ribs. They have on their lateral aspect an articular surface curved like the auricle, which is called the auricular surface (fades auriculares). It serves for joining with the iliac bone. At the back of each auricular surface is the sacral tuberosity (tuberositas sacralis) (the site of attachment of muscles and ligaments). The sacral canal (canalis sacralis) passes in the sacrum. It is a continuation of the vertebral canal. As a consequence of the disappearance of the tail and reduction of the tail musculature in man, the corresponding parts of the sacral vertebrae are reduced, therefore, the sacral canal is not closed in its distal part but opens as the sacral hiatus (hiatus sacralis). Lateral to this hiatus are the sacral cornua (cornua sacralia), remnants of the last sacral vertebra, which articulate with similar cornua of the coccyx.
5. **Coccygeal vertebrae** (*vertebrae coccygeae s. caudales*) are remnants of the tail and rudimentary structures fusing at middle age to form a single bone, the *coccyx* (*os coccygis*). The first coccygeal vertebra is larger than the rest and has on the dorsal surface two processes (*cornua coccygea*), which are directed upward to meet the sacral cornua.

**THE THORACIC CAGE**

Joining posteriorly with the thoracic vertebrae and anteriorly with the unpaired breast-bone, or sternum, the ribs form the thoracic cage, the thorax, or the chest.

**THE STERNUM**

The breast-bone (*sternum*) resembling a dagger in shape, consists of three parts: the upper part, the manubrium sterni, the middle part, the body (*corpus sterni*), and the lower part, the xiphoid process (*processus xiphoideus*). The manubrium has a jugular notch (*incisura jugularis*) on its superior border and lateral to this, a clavicular notch (*incisura clavicularis*) on each side, by means of which the sternum articulates with the sternal end of the clavicle. The inferior border of the manubrium and the superior border of the body join at an anteriorly protruding angle, the angle of the sternum (*angulus sterni*). The lateral border of the sternal body has costal facets (*incisurae costales*) for articulation with the cartilages of the ribs, beginning with the second rib.

**THE RIBS**

There are twelve ribs on each side, and all articulate by their posterior ends with the bodies of the thoracic vertebrae. The anterior ends of the upper seven ribs are joined directly to the sternum by cartilages. These are the **true ribs** (*costae verae*). The next three ribs, eighth, ninth, and tenth, are joined by their cartilages not to the sternum but to the cartilage of the rib next above, and are referred to as **false ribs** (*costae spuriae*). The anterior ends of the eleventh and twelfth ribs lie free, and these ribs are called **floating ribs** (*costae fluctuantes*). The ribs (*costae*) are narrow curved plates which in their longest, posterior part are formed of bone, *os costale*, belonging to the group of long spongy bones, and in the narrower anterior part, of cartilage, *cartilage costalis*. On the anterior end the bony part of the rib fuses closely with the cartilaginous part. Posterior and anterior ends and
a shaft of the rib (corpus costae) between them are distinguished in each bony rib. The posterior end is slightly enlarged to form the head of the rib (caput costae), which has an articular facet separated by a ridge; the rib articulates by means of this facet with the vertebral bodies. The facet of the first, eleventh, and twelfth ribs does not have a separating ridge. A narrowed part, the neck of the rib (collum costae), immediately succeeds the head; it has a longitudinal crest of the neck of the rib (crista colli costae) on its superior border. The first and last ribs lack this crest. At the junction of the neck and shaft, there is a tubercle of the rib (tuberculum costae), which carries a facet for joining with the articular surface of the transverse process of the corresponding vertebra. The eleventh and twelfth ribs do not have this tubercle because they do not articulate with the last thoracic vertebrae. Lateral to the tubercle, the rib curvature is greatly accentuated and the angle of the rib (angulus costae) is located here posteriorly on the shaft. The angle and the tubercle coincide on the first rib. On the other ribs the distance between them increases down to the eleventh rib, while on the twelfth rib there is no angle. A groove (sulcus costae) is detectable on the inferior border of the inner surface of the middle ribs; it conducts the intercostal vessels.

The superior surface of the first rib carries the scalene tubercle (tuberculum m. scaleni anterioris), which is of practical importance because it gives attachment to the scalenus anterior muscle (m. scalenus anterior). Immediately posterior to this tubercle, a small groove, the groove for the subclavian artery (sulcus a. subclaviae), can be seen, into which the subclavian artery fits when it curves over the first rib. Another, flatter groove for the subclavian vein (sulcus v. subclaviae) is found to the front of the tubercle.

THE SKELETON OF THE UPPER LIMB THE SHOULDER GIRDLE

The shoulder girdle (cingulum embri superioris) consists of two paired bones, the clavicle (collar bone) and the scapula (shoulder blade).

THE CLAVICLE

The clavicle (clavicula) is the only bone fastening the upper limb to the skeleton of the trunk. It is of high functional importance because it holds the shoulder joint at the needed distance from the thoracic cage and thus permits greater freedom of movement of the limb. The clavicle is a tubular bone, and a body (shaft) and two ends, medial and lateral, are distinguished in it. The thickened medial, or sternal end
(extremitas sternalis) carries a saddle-shaped articular surface for uniting with the sternum. The lateral, or acromial end (extremitas acromialis) has a flat articular surface for articulating with the acromial process of the scapula. On the inferior surface of the acromial end is the conoid tubercle (tuberculum conoideum) (the site of attachment of ligaments).

**THE SCAPULA**

The shoulder blade or scapula is a flat triangular bone lying on the posterior surface of the thoracic cage in the space between the second and seventh ribs. According to the shape of the bone, three borders are distinguished in it: the medial border (*margo medialis*), facing the spine, the lateral border (*margo lateralis*), and the superior border (*margo superior*), on which is the scapular notch (*incisura scapulae*). The three borders meet at three angles, one of which, the inferior angle (*angulus inferior*) is directed downward while the other two, the superior angle (*angulus superior*) and lateral angle (*angulus lateralis*) are at the ends of the superior border of the scapula. The lateral angle is greatly thickened and supplied with a shallow depression, a laterally positioned articular glenoid cavity (*cavitas glenoidalis*). The edge of the cavity is separated from the rest of the scapula by a constriction, the neck of the scapula (*collum scapulae*). Above the superior edge of the cavity is the supraglenoid tubercle (*tuberculum supraglenoidale*) which provides attachment for the tendon of the long head of the biceps.

A similar infraglenoid tubercle (*tuberculum infraglenoidale*) for attachment of the long head of the triceps is found at the inferior edge of the fossa. The coracoid process (*processus coracoideus*) (the former coracoid) arises from the superior border of the scapula in the vicinity of the glenoid cavity. The anterior, costal surface of the scapula (*facies costalis*) forms a hollow depression called the subscapular fossa (*fossa subscapularis*) which gives attachment to the subscapular muscle. The spine of the scapula (*spina scapulae*) projects from the dorsal surface of the scapula (*facies dorsalis*) and divides it into two recesses of unequal size, the supraspinous and infraspinous fossae (*fossa supraspinata* and *fossa infraspinata*). The spine of the scapula stretches laterally and is continuous with
the acromion overhanging the glenoid cavity at the back and above. The acromion carries the **articular facet** (*facies articularis* acromii) for articulation with the clavicle.

**THE SKELETON OF THE FREE UPPER LIMB**

The skeleton of the free upper limb consists of the humerus, two forearm bones, and the bones of the hand.

The Humerus

The humerus is a long lever of movement, which develops like a typical long tubular bone. In conformity with this function and development, it is made up of a diaphysis, metaphyses, epiphyses, and apophyses. Its upper end is supplied with a spherical head (caput humeri) (the proximal epiphysis), which articulates with the glenoid cavity of the scapula. The head is separated from the rest of the bone by a narrow groove called the anatomical neck (collum anatomicum). Directly below it are two tubercles for attachment of the muscles. The greater tubercle (tuberculum majus) is on the lateral side; the lesser tubercle (tuberculum minus) is a little to the front of it (apophyses). Bony crests (for attachment of the muscles) run downward from the tubercles, the lateral lip of the bicipital groove (crista tuberculi majoris) and the medial lip of the bicipital groove (crista tuberculi minoris). The intertubercular groove (sulcus intertubercularis) passes between both tubercles and crests and lodges the tendon of the long head of the biceps muscle. The part of the humerus directly below the tubercles at the junction with the diaphysis is called the surgical neck (collum chirurgicum) (where fractures often occur). The upper part of the body (shaft) of the humerus has cylindrical outlines, but its lower part has a distinctly trihedral shape, in which a posterior surface (facies posterior), an anterolateral surface (facies anterior lateralis), and an anteromedial surface (facies anterior medialis) are distinguished. The two anterior surfaces are separated from the posterior surface by lateral and medial borders (margo lateralis and margo medialis). About the middle of the shaft, on its anterolateral surface, is the deltoid tuberosity (tuberositas deltoidea), to which the deltoid muscle is attached. A sloping spiral, shallow groove of the radial nerve (sulcus nervi radialis, s. sulcus spiralis) passes
behind the tuberosity on the posterior surface of the body from the medial to the lateral border.

The widened distal part of the humerus, the condyle (condylus humeri) is bent slightly forward and has two rough projections on its sides, the medial and lateral epicondyles (epicondylus medialis and epicondylus lateralis), which are continuous with the medial and lateral borders of the bone and provide attachment for the muscles and ligaments (apophyses). The medial epicondyle is more prominent than the lateral one and has on its posterior surface a groove for the ulnar nerve (sulcus nervi ulnaris).

An articular surface for uniting with the forearm bones (distal epiphysis) is situated between the epicondyles. Two parts are distinguished in it. Medially is the pulley-shaped trochlea grooved in the middle; it articulates with the ulna and is embraced by its notch (incisura trochlearis ulnae). Above the trochlea are two fossae, one, the coronary fossa (fossa coronoidea) in front, and the other, the olecranon fossa (fossa olecrani) behind. These fossae are so deep that the bony septum separating them is thin enough to be transparent and may even be perforated. Laterally of the trochlea is an articular surface the shape of a segment of a sphere, the capitulum of the humerus (capitulum humeri) for articulation with the radius. A small radial fossa (fossa radialis) lies above it in front.

**BONES OF THE FOREARM**

The forearm bones belong to the group of long tubular bones. There are two of them, the ulna, which is the medial bone, and the radius, the lateral bone.

**The Ulna**

The ulna (s. cubitus). The upper (proximal) thickened end of the ulna (epiphysis) is separated into two processes: the thicker, posterior process, olecranon and the smaller anterior, coronoid process (processus coronoideus). Between these two processes is the trochlear notch (incisura trochlearis) for articulation with the trochlea of the humerus. The radial side of the coronoid process has a small radial notch (incisura radialis), the site of articulation with the head of the radius; in front, under the coronoid process, there is the tuberosity of the ulna (tuberositas ulnae), to which attaches the tendon of the brachial muscle. The lower (distal) end of the ulna
carries a spherical head with a flat inferior surface (caput ulnae) (epiphysis) from the medial surface of which the styloid process (processus styloideus) (apophysis) projects. The head carries on its circumference an articular surface (circumferentia articularis), by means of which it articulates with the adjacent radius.

The Radius

The radius, in contrast to the ulna, has a distal end that is thicker than the proximal end. The proximal end forms a rounded head (caput radii) (epiphysis), which has a concave surface for articulation with the head of the humerus. One third or one half of the head circumference is also occupied by an articular surface (circumferentia articularis) articulating with the radial notch of the ulna. The head of the radius is separated from the rest of the bone by a neck (collum radii) directly below which on the anteroulnar side is the radial tuberosity (tuberositas radii) (apophysis), providing attachment for the biceps muscle of the arm. The lateral border of the distal end of the radius (epiphysis) is continuous with the styloid process (processus styloideus) (apophysis). The carpal articular surface (facies articularis carpea) on the distal epiphysis is concave and serves for articulation with the scaphoid and lunate carpal bones. The medial border of the distal radial end has a small ulnar notch (incisura ulnaris) for articulation with the circumferentia articularis of the ulnar head.

THE BONES OF THE HAND

The bones of the hand are subdivided into the carpal and metacarpal bones and the bones which are the components of the fingers, the phalanges.

The Carpus

The carpus (Fig. 86) is an aggregate of eight short, spongy bones, carpal bones (ossa carpi) arranged in two rows of four bones each.

The proximal, or first row, nearest to the forearm, is made up of the following bones (named from the thumb): the scaphoid bone (os scaphoideum), the lunate bone (os lunatum), the triquetral bone (os triguetrum), and the pisiform bone (os pisiforme). The first three bones unite to form an ellipsoid convex surface facing the forearm for articulation with the distal end of the radius. The pisiform bone does not take part in this articulation and is attached to the triquetral bone separately. It is a
sesamoid bone developing in the tendon of the ulnar flexor muscle of the wrist.

The *distal* or *second carpal row* consists of the following bones: the trapezium, or larger multangular bone (*os trapezium, s. os multangulum majus*) [BNA], the trapezoid, or smaller multangular bone (*os trapezoideum, s. os multangulum minus*) [BNA], the capitate bone (*os capitatum*), and the hamate bone (*os hamatum*). The names of the bones reflect their shape. Each bone carries facets on its surfaces for articulation with the neighbouring bones. The carpal bones form collectively a vault-like convexity on the dorsal aspect and a trough-shaped concavity on the palmar surface. The carpal sulcus (*sulcus carpi*) is bounded on the radial side by a prominence (*eminencia carpi radialis*) formed by the tubercles on the scaphoid and trapezium bones; on the ulnar side it is bound by another *eminence* (*eminencia carpi ulnaris*) consisting of the hamulus of the hamate bone and the pisiform bone.

**The Metacarpus**

The metacarpus consists of five metacarpal bones (*ossa metacarpalia*), which are related in type to short tubular bones with one true epiphysis (monoepiphyseal bones) and are numbered in sequence, beginning with the thumb: first, second, third, fourth, and fifth. Each carpal bone has a base (*basis*), a diaphysis (*body, shaft*) (*corpus*) and a rounded head (*head*) (*caput*).

**Bones of the Fingers**

The bones of the fingers (*ossa digitorum manus*), called phalanges, are small, short, consecutive, tubular bones with one true epiphysis (monoepiphyseal bones). Each finger, with the exception of the thumb, is made up of three phalanges: proximal (*phalanx proximalis*), middle (*phalanx media*), and distal (*phalanx distalis*) or ungual phalanx. The thumb has only two phalanges, the proximal and the distal phalanx. In all animals the thumb is less developed than the other fingers; it is highly developed only in man.

**THE SKELETON OF THE LOWER LIMB**

**THE PELVIC GIRDLE**

The pelvic girdle is made up of the paired hip or innominate bone the hip bone (*os coxae*) is a flat bone concerned with the function of movement (takes part in articulations with the sacrum and femur), protection (shields the pelvic organs),
and support (transfers the weight of the whole proximal part of the body to the lower limbs). The latter function prevails, and this determines the complex structure of the hip bone and its formation from fusion of three separate bones, the ilium (os ilium), the pubis (os pubis) and the ischium (os ischii). These bones fuse in the region bearing the greatest weight, namely, in the region of the acetabulum, the articular cavity of the hip joint, by means of which the pelvic girdle is connected to the free lower limb. The ilium is above the acetabulum, the pubis below and to the front of it, and the ischium is below and to the back of the acetabulum. In individuals under 16 years of age these bones are separated one from another by layers of cartilage which in an adult undergo ossification, i.e. synchondrosis changes to synostosis. As a result the three bones fuse to form a single bone possessing great strength necessary for bearing the weight of the whole trunk and head. The acetabulum ("vinegar curet" from L acetum vinegar) is on the lateral surface of the hip bone and serves for articulation with the head of the femur. It is a rather deep, cup-shaped cavity with a high rim, in the medial side of which is a notch (incisura acetabuli). The smooth articular surface of the acetabulum (facies lunata) is crescent-shaped: the centre, the acetabular fossa (fossa acetabuli) and the part nearest to the notch are rough.

**THE IliUM**

The ilium fuses by means of its short, thick, inferior part, called the body (corpus ossis ilii), with the other parts of the hip bone in the region of the acetabulum; the superior fan-shaped and fairly thin part of the ilium forms the wing or ala (ala ossis ilii).

The superior free border of the wing, for instance is a sinuous crest (crista iliaca) to which three broad abdominal muscles are attached. The crest ends anteriorly as the anterior superior iliac spine (spina iliaca anterior superior) and posteriorly as the anterior posterior iliac spine (spina iliaca posterior superior). Below each of these spines are another two spines on the anterior and posterior iliac borders, the anterior and posterior inferior iliac spines (spina iliaca anterior inferior and spina iliaca posterior inferior). The inferior spinae are separated from the superior spinae by notches. Below and to the front of the anterior inferior spine at the junction of the ilium with the, pubis is the iliopubic eminence (eminentia iliopectinea)
and below the posterior inferior spine is the deep greater sciatic notch (*incisura ischiadica major*), continuous downward with the ischial spine (*spina ischiadica*), which is on the ischium. The inner (medial) surface of the iliac wing is smooth, slightly concave, and forms the iliac fossa (*fossa iliaca*) produced from supporting the viscera in vertical posture of the body. Posterior to and below the fossa is an ear-shaped articular surface, auricular surface (*facies auricularis*) the site of articulation with the corresponding surface of the sacrum. Behind and above the auricular surface is the iliac tuberosity (*tuberositas iliaca*) giving attachment to the interosseous sacro-iliac ligaments. The iliac fossa is separated from the medial surface of the distally located iliac body by an arched edge, the arcuate line (*linea arcuata*). Occasionally conspicuous rough lines, marks of the origin of the gluteal muscles, are seen on the external (lateral) surface of the iliac wing.

**THE PUBIS**

The pubic bone (*os pubis*) has a short thickened body (*corpus ossis pubis*) adjoining the acetabulum, and the superior and inferior rami (*ramus superior* and *ramus inferior ossis pubis*) forming an angle. At the apex of the angle facing the midline is an oval symphyseal surface (*facies symphysialis*) for articulation with the contralateral pubic bone. A small pubic tubercle (*tuberculum pubicum*) lies 2 cm lateral of this surface; the pectineal line (*pecten ossis pubis*) runs from the tubercle along the posterior border of the superior surface of the superior ramus and is continuous posteriorly with the arcuate line on the ilium described above. The inferior surface of the superior pubic ramus carries a small groove, the obturator groove (*sulcus obturatorius*) transmitting the obturator vessels and nerve.

**THE ISCHIUM**

The ischium (*os ischii*) has, like the pubis, a body (*corpus ossis ischii*), which forms part of the acetabulum, and a ramus (*ramus ossis ischii*). The body and the ramus meet at an angle, the apex of which is greatly thickened and is the ischial tuberosity (*tuber ischiadicum*). On the posterior border of the body, upward from the ischial tuberosity, is the lesser sciatic notch (*incisura ischiadica minor*) separated from the greater sciatic notch (*incisura ischiadica major*) by the ischial spine (*spina ischiadica*). The ischial ramus branching from the ischial tuberosity fuses with the
inferior pubic ramus. As a result the rami of the pubis and ischium surround the obturator foramen (*foramen obturatum*) which is located inferior and medial to the acetabulum and is triangular with rounded angles.

**THE SKELETON OF THE FREE LOWER LIMB**

The skeleton of the lower limb consists of the femur, or thigh bone, two leg bones, and the bones of the foot. Besides, a small (sesamoid) bone, the patella, adjoins the thigh bone.

**The Femur**

The femur, or thigh bone, is the largest and thickest long tubular bone. Like all such bones it is a long lever of movement and has a diaphysis, metaphyses, epiphyses, and apophyses in accordance with its development. The upper (proximal) end of the femur carries a spherical articular head (*caput femoris*) (epiphysis); a little downward from the centre of the head is a small rough depression (*jovea capitis femoris*), where the ligament of the head is attached. The head is connected with the rest of the bone by a neck (*collum femoris*) (metaphysis), which meets the axis of the femoral shaft at an obtuse angle (about 130 degree's); in the wider female pelvis this angle is closer to 90 degrees. Two bony prominences called trochanters (apophyses) are found at the junction of the neck with the shaft of the femur. The greater trochanter (*trochanter major*) is the upper end of the femoral shaft. On its medial surface, facing the neck, is the trochanteric fossa (*fossa trochanterica*). The lesser trochanter (*trochanter minor*) is at the inferior margin the neck on the medial surface and a little to the back. Both trochanters are joined on the posterior surface of the femur by an oblique intertrochanteric crest (*crista intertrochanterica*) and on the anterior surface by the intertrochanteric line (*linea intertrochanterica*). All these structures, the trochanters, crest, line, and fossa, developed as a result of the attachment of muscles.

The body (shaft) of the femur is slightly convex forward and has a rounded trihedral shape; its anterior and lateral surfaces are smooth, while the posterior surface bears a mark of attachment of the thigh muscles, *linea aspera* (a rough line) which has two lips: *lateral* (*labium laterale*) and *medial* (*labium mediale*). Both lips bear marks of muscle attachment in their proximal part: *tuberositas glutea* on the
lateral lip for attachment of the glutens maximus muscle and \textit{linea pectinea} on the medial lip for attachment of the pectineus muscle. Below the lips diverge and enclose a smooth triangular \textit{popliteal surface (facies poplitea)} on the posterior surface of the femur.

The lower (distal) thickened end of the femur forms two rounded, posteriorly turned medial and lateral condyles (\textit{condylus medialis} and \textit{condylus lateralis}) (epiphysis); the medial condyle protrudes downward more than the lateral. Despite the difference in the size of these two condyles, however, they are located on the same level because the femur in its natural position stands obliquely with its lower end closer to the midline than the upper end. Anteriorly the articular surfaces of the condyles blend with each other to form a small concavity in the sagittal direction. This common part of the articular surfaces is called \textit{facies patellaris} because the posterior surface of the patella abuts against it in extension at the knee joint. On the posterior and inferior surfaces, the condyles are separated by a deep intercondylar fossa, or notch (\textit{fossa intercondylaris}). Rough prominences are found on the sides of each condyle above the articular surface. These are the medial and lateral epicondyles (epicondylus medialis and epicondylus lateralis) (apophyses).

\textbf{The Patella}

The patella, or knee-cap, is none other than a large sesamoid bone lodged in the tendon of the quadriceps femoris muscle stretching over the anterior surface of the knee joint. A superior wide end, the base (basis patellae), and a pointed inferior end or apex (apex \textit{patellae}) are distinguished. The anterior surface of the patella is rough, while the posterior surface has smooth \textit{articular surface (facies articular is)} by which the patella comes into contact with the patellar surface of the femur described above.

\textbf{THE SKELETON OF THE LEG}

The skeleton of the leg (Fig. 102) consists of two bones of unequal thickness, the tibia and the fibula. The first is on the medial and the second on the lateral side. Only the tibia articulates with the femur by means of the knee joint.

\textbf{The Tibia}

The proximal end of the tibia (epiphysis) forms two condyles, medial (\textit{condylus}}
medialis) and lateral (condylus lateralis). On the surface facing the femur the condyles are supplied with shallow articular surfaces (facies articularis superior) for articulation with the condyles of the femur. The articular surfaces of the tibial condyles are separated one from the other by an intercondylar eminence (eminentia intercondylaris) which has two intercondylar tubercles (tuberculum intercondylare mediate and tuberculum intercondylare laterale). The eminence has two small intercondylar depressions on its ends: area intercondylaris anterior on the anterior end and area intercondylar is posterior on the posterior end (all these structures formed from attachment of the intra-articular ligaments). The articular surfaces are surrounded by a thickened rim (a mark of attachment of the articular capsule, metaphysis). A little below the rim, but on the anterior surface of the tibia, there is a rather massive, roughened convexity called tuberosity of the tibia (tuberositas tibiae) for attachment of the patellar ligament (apophysis). A small flat articular surface (facies articularis fibularis) is in the posterolateral part of the lateral condyle. It is the site of articulation with the head of the fibula. The body (shaft) of the tibia is trihedral. Three margins, or borders are therefore distinguished in it: the anterior border (margo anterior), the medial border (margo medialis), and lateral border, facing the fibula and providing attachment for the interosseous membrane; it is called for that reason the interosseous border (margo interossea). Between the three borders are the following three surfaces: posterior (facies posterior); medial (facies mediales); lateral (facies lateralis). The medial surface and the anterior (the sharpest) border are easily palpated under the skin. The lower, distal end of the tibia (epiphysis) has a strong process, the medial malleolus (malleolus medialis) below on its medial side. Behind the malleolus is a flat bony groove (sulcus malleolaris) made by tendons. The lower end of the tibia carries adjustment for articulation with the bones of the foot, facies articular inferior, and on the lateral side of the medial malleolus, facies articularis malleoli. The fibular notch (incisura fibularis) for articulation with the fibula is on the lateral border of the distal end.

The Fibula

The fibula (Gk. perone) is a long thin bone with thickened ends. The upper (proximal) epiphysis forms the head (caput fibulae) which articulates with the lateral
condyle of the tibia by means of a hollow rounded articular facet (facies articularis capitis fibulae). A little to the back and lateral of this surface the apex of the head (apex capitis fibulae) projects upward. The body of the fibula is trihedral and twisted somewhat on its longitudinal axis. The anterior (margo anterior), interosseous (medial) (margo interossea) and posterior (margo posterior) borders are distinguished. The three surfaces between the borders are slightly concave. The lower (distal) fibular epiphysis thickens to form the lateral malleolus (malleolus lateralis), which carries a smooth articular facet (facies articularis malleoli). On the posterior surface of the lateral malleolus is a distinct hollow malleolar fossa (fossa malleoli lateralis) lodging the tendons of the peroneal muscles.

THE BONES OF THE FOOT

The tarsus, metatarsus, and the bones of the toes are distinguished in the foot.

The Tarsus

The tarsus is made up of seven short spongy bones (ossa tarsi), which are arranged in two rows similar to the carpal bones. The posterior, or proximal, row is formed of two comparatively large bones, the talus and the calcaneus lying below it. The anterior, or distal, row consists of a medial and lateral part. The medial part is formed by the navicular and three cuneiform bones, the lateral part by a single cuboid bone.

1. The talus (ankle bone) consists of a body (corpus tali), which extends anteriorly as a constricted neck (collum tali). The neck is continuous with an oval convex head (caput tali), carrying a surface for articulation with the navicular bone (facies articularis navicularis). The body of the talus has a trochlea tali on its superior surface for articulation with the leg bones. The superior articular surface of the trochlea (facies superior), the site of articulation with the distal articular surface of the tibia, is convex from front to back and slightly concave in the frontal direction. The trochlea has two articular surfaces on its sides, the medial and lateral malleolar facets (facies malleolares medialis and lateralis) for articulation with the malleoli. The facet of the lateral malleolus (facies malleolaris lateralis) curves downward onto a projecting lateral tubercle of the talus (processus lateralis tali). Behind the trochlea, the body of the talus gives rise to a posterior tubercle of the tali (processus lateralis tali), which is
separated by a groove lodging the tendon of the m. flexor hallucis longus. On the inferior surface of the talus are two (anterior and posterior) articular facets for union with the calcaneus. A deep rough groove (sulcus tali) passes between them.

2. The calcaneus (heel bone) has two articular surfaces (anterior and posterior) on its superior surface, which correspond to the inferior articular facets on the talus. The calcaneus gives off a medial process called the sustentaculum (L support) tali, so called because it supports the head of the talus. The articular facets on the anterior part of the calcaneus are separated from the posterior articular surface of this bone by a groove (sulcus calcanei), which adjoins a similar sulcus on the talus and forms together with it the bone canal (sinus tarsi) opening on the lateral surface of the dorsal surface of the foot. A groove for the tendon of the long peroneal muscle passes on the lateral surface of the calcaneus.

The Metatarsus

The metatarsus consists of five metatarsal bones (ossa metatarsalia) related to the short (monoepiphyseal) tubular bones and resembling the carpals of the hand. Just as in the hand, a proximal end, or base (basis), a middle part, or body (corpus), and a distal end, or head (caput), are distinguished in each metatarsal. They are arranged one next to the other and are separated by interosseous spaces (spatia interossea metatarsi). They are numbered from the medial border of the foot.

Bones of the Toes

The bones of the toes, the phalanges (phalanges digitomm pedis) are short tubular monoepiphyseal bones distinguished from the finger phalanops by their small size. The toes, like the fingers, consist of three phalanges, with the exception of the great toe, which has two phalanges differing from the phalanges of the other toes in their relatively large size. The ungual phalanges have a raised bony mass on their distal end (tuberositas phalangis distalis), which is their main distinguishing feature.

Sesamoid bones are found in the metatarsophalangeal joints (always in that of the big toe) and in the interphalangeal joint of the big toe.

THE SKELETON OF THE HEAD

The head is related to the locomotor system only in part. Its skeleton (the
skull, cranium) is primarily the receptacle for the most highly developed part of the nervous system, the brain and the sensory organs connected with it; moreover, it encloses the initial part of the digestive and respiratory tracts communicating with the external environment. In accordance with this, the skull of all vertebrates is divided into two parts: the cerebral cranium (neurocranium) and the visceral cranium (cranium viscerale). The skull-cap, or vault (calvaria) and the base (basis) are distinguished in the cerebral cranium.

The human cerebral cranium consists of the unpaired occipital, sphenoid, frontal, and ethmoid bones and the paired temporal and parietal bones. The visceral cranium is formed by the paired maxilla, inferior turbinate, palatine, zygomatic, nasal, and lacrimal bones and the paired vomer, mandible, and the ethmoid and hyoid bones.

**Development of the skull.**

The principal line of evolution comprises the following:

1. replacement of the membranous and cartilaginous skull by a bony skull;

2. fusion of the bones of the cerebral cranium and a reduction in their number and simultaneous complication of their structure and development as mixed bones;

3. conversion of the visceral arch cartilages to bones of the visceral skull;

4. union of the cerebral skull with the visceral skull;

5. progressive development of the cerebral cranium and its predominance over the visceral skull which is most pronounced in man.

In reflection of this line of evolution, the human skull goes through three developmental stages in ontogenesis: (1) connective-tissue; (2) cartilaginous, and (3) bony. The change from the second to the third stage, i.e. the formation of secondary bones in cartilage, occurs throughout man's life. Remnants of cartilaginous tissue persist between the bones as their cartilaginous joints (synchondroses) even in adults. The calvaria, which serves only for protection of the brain, develops directly from the membranous skull without going through
the cartilage stage. The conversion of connective tissue to bony tissue also occurs here throughout man's life. The remnants of unossified connective tissue persist between the skull bones as fontanelles in the newborn and as sutures in children and adults.

The configuration of the skull is mainly determined by the development of the brain and masticatory apparatus and the relationship between the brain capsule and the masticatory apparatus.

In man, the nasal cavity, together with the facial part of the skull, moves under the brain case not only because the brain is enlarged, but also because the masticatory apparatus (the jaws and teeth) reduce.

The calvaria of the human skull is raised above the other parts of the skull as a consequence of the powerful development of the brain and is convex and rounded. The capacity of the cranial cavity is approximately 1500 cm$^3$ in man, only 400-500 cm$^3$ in anthropoid apes, and about 900 cm$^3$ in the Pithecanthropus. The surface of the human cranium is even and smooth. In anthropoid male apes, in contrast, the cranial surface has sharply pronounced ridges consequent upon powerfully developed muscles of mastication. The skull of a very young anthropoid ape is more like the human skull in shape, although it is distinguished by greatly protruding jaws. Moreover, the superciliary elevations stand out noticeably in monkeys but are reduced in man. They still protrude markedly in fossil skulls (of Neanderthal man).

**THE BONES OF THE CEREBRAL CRANIUM**

**THE OCCIPITAL BONE**

The **occipital bone** (*os occipitale*) forms the posterior and inferior walls of the brain case and is thus a part of the calvaria and a part of the base of the skull. It is made up of four parts, which are laid down separately and fuse to form a single bone only between the ages of 3 and 6. These parts, which form the borders of the **foramen magnum** (where the spinal cord is continuous with the medulla oblongata and passes from the vertebral canal into the cavity of the skull), are as follows: anteriorly, the **basilar part** (*pars basilaris*) (*os basilaris* in animals); laterally, the **condylar parts** (*partes laterales*) (*ossa lateralia* in animals);
and posteriorly, the **squamous part** (*squama occipitalis*) (os superius in animals).

The **squamous part of the occipital bone** (*squama, occipitalis*) as a membrane bone is shaped like a plate, improperly rounded, with a convex external surface and a concave internal surface. The attachment of muscles and ligaments lends it the external relief. The **external occipital protuberance** (*protuberantia occipitalis externa*) (the site of the appearance of the ossification nucleus) is in the center of the external surface. A curved **superior nuchal line** (*linea nuchae superior*) passes laterally from the protuberance on each side. A less conspicuous **highest nuchal line** (*linea nuchae suprema*) is encountered a little higher. The **external occipital crest** (*crista occipitalis externa*) extends from the occipital protuberance downward on the midline to the posterior edge of the foramen magnum. The **inferior nuchal lines** (*lineae nuchae inferiores*) pass laterally from the middle of the crest. The relief of the internal surface is determined by the shape of the brain and the attachment of its meninges; as a result this surface is divided by two crests intersecting at a right angle into four fossae. These two crests form the **cruciate eminence** (*eminentia cruciformis*) and the **internal occipital protuberance** (*protuberantia occipitalis interna*) at the site of their intersection.

The lower half of the longitudinal crest is sharper and is called the **internal occipital crest** (*crista occipitalis interna*) while the upper half of this crest and both halves (or usually the right half) of the transverse crest are supplied with clearly pronounced sulci: **sagittal groove** (*sulcus sinus sagittalis superioris*) and **groove for the transverse sinus** (*sulcus sinus transversi*) (prints of venous sinuses of the same name which are lodged here).

Each **lateral part** (*pars lateralis*) contributes to the union of the skull with the spine and therefore carries on its inferior surface the **occipital condyle** (*condylus occipitalis*), the place of articulation with the atlas. The **anterior condylar canal** (*canalis hypoglossi*) penetrates the bone approximately at the middle of the occipital condyle. Behind the condyle is the **condylar fossa** (*fossa condylaris*) on whose floor an opening of a **posterior condylar canal** (*canalis condylaris*) is sometimes present (for the transmission of a vein). The **jugular
process (processus jugularis) projects laterally to the condyle; it is homologous with the transverse processes of the vertebrae. The sigmoid groove (sulcus sinus sigmoidei) (a mark left by the sigmoid venous sinus), is on the superior surface of pars lateralis, next to the jugular process, while the jugular notch (incisura jugularis) is on its margin.

The basilar part (pars basilaris) fuses with the sphenoid bone by the age of 18 to form a single bone in the center of the cranial base (os basilaris). A sloping area, clivus, made up of two fused parts, is located on the superior surface of this bone; it lodges the medulla oblongata. The groove for the inferior petrosal sinus (sulcus sinus petrosi inferioris) is seen on the lateral edges of the basilar part of the occipital bone; it lodges the inferior petrosal sinus. The inferior surface, which is a component of the superior pharyngeal wall, carries the pharyngeal tubercle (tuberculum pharyngeum) to which the fibrous capsule of the pharynx is attached.

THE SPHENOID BONE

The sphenoid bone (os sphenoidale) is an unpaired bone whose structure is even more complex than that of the occipital bone. The sphenoid bone resembles a bat or a flying insect, which explains the names of its parts (wings, pterygoid processes, Gk. pterygoïd wing). The name "sphenoid" probably appeared by mistake. In Galen’s manuscript this bone was called sphocoid (resembling a wasp), but apparently the copyist made an error and wrote sphenoid (wedged, Gk. sphen wedge).

The following parts can be distinguished: (1) the body (corpus) (in animals, the unpaired basisphenoid and presphenoid); (2) the greater wings (alae minores) (in animals, the paired alisphenoid); (3) the lesser wings (alae minores) (in animals, the paired orbitosphenoid) and (4) the pterygoid processes (processus pterygoidei) (the medial plate of the bone, the former paired pterygoid, develops on the basis of connective tissue whereas the other parts of the bone develop from cartilage).

The body (corpus) has on the midline of its superior surface a depression, the shape of a Turkish saddle, the sella turcica, on the floor of which is a
depression for the cerebral hypophysis (*fossa hypophysialis*). To the front of the depression is an elevation, the *tuberculum sellae*, on which the *sulcus chiasmatis* lodging the crossing (chiasma) of the fibres of the optic nerve passes transversely. The *optic foramina* (*canales optici*) transmitting the optic nerves from the orbital cavity into the cranial cavity, are found at the ends of the sulcus chiasmatis. The sella turcica is bounded posteriorly by a bony plate the *dorsum sellae*.

A curved *carotid groove* (*sulcus caroticus*) lodging the internal carotid artery passes on the lateral surface of the body.

A ridge, the crest of the *sphenoid* (*crista sphenoidalis*) is seen on the anterior surface of the body, which is a part of the superior wall of the nasal cavity. The crest continues down to become a pointed vertical prominence, the *rostrum of the sphenoid* (*rostrum sphenoidale*), which fits between the wings of the vomer. The sphenoidal crest articulates in front with the perpendicular plate of the ethmoid bone. Irregularly shaped openings, *apertures of the sphenoidal sinus* (*aperturae sinus sphenoidalis*) are seen to the sides of the crest. They open into an air cavity, the *sphenoidal sinus* (*sinus sphenoidalis*) located in the body of the sphenoid bone and divided by a *septum of the sphenoidal sinus* (*septum sinuum sphenoidalium*) into two halves. The sinus communicates with the nasal cavity by means of these openings. These sinuses are very small in the newborn and start growing rapidly only at about 7 years of age.

The lesser *wings* (*alae minores*) are two flat triangular plates arising by two roots from the anterosuperior edge of the body of the sphenoid bone and extending forward and laterally. The *superior orbital fissure* (*fissura orbitalis superior*) leading from the cranial into the orbital cavity, is between the lesser and greater wings.

The greater *wings* (*alae majores*) spring from the sides of the body laterally and upwards. A *round opening* (*foramen rotundum*) leading in front into the pterygopalatine fossa, is located close to the body, to the back of the superior orbital fissure; it transmits the second branch of the trigeminal nerve, *n. trigemini*.

It is the *spinous foramen* (*foramen spinosum*) through which the middle
meningeal artery passes. A much larger **oval foramen** (*foramen ovale*) is seen to the front of it; it transmits the third branch of the trigeminal nerve.

The greater wings have the following four surfaces: **cerebral** (*facies cerebralis*); **orbital** (*facies orbitalis*); **temporal** (*facies temporalis*), and **maxillary** (*facies maxillaris*). Their names indicate which cranial surface they face. The last two surfaces are separated by the **infratemporal crest** (*crista infratemporalis*).

The pterygoid processes (*processus pterygoidei*), drop vertically downward from the junction of the greater wings and the body of the sphenoid bone. Their base is pierced by a pterygoid canal (*canalis pterygoideus*) directed sagittally, which transmits the pterygoid nerve and vessels. Its anterior opening communicates with the pterygopalatine fossa.

Each process is made up of two plates, one **medial** and one **lateral** (*lamina medialis* and *lamina lateralis*), between which the **pterygoid fossa** (*fossa pterygoidea*) forms posteriorly. The inferior portion of this fossa is continuous with the **pterygoid fissure** (*fissura pterygoidea*). In the intact skull the pyramidal process of the palatine bone fits into this notch. The inferior part of the medial plate bends over to form a hook-like process called the **hamulus pterygoideus**.

**THE TEMPORAL BONE**

The **temporal bone** (*os temporale*) is a paired bone whose structure is very complicated and consists of three parts: (1) **squamous part** (*pars squamosa*) (in animals, *os squamosum*); (2) **tympanic part** (*pars tympanica*) (in animals *tympanicum*), and (3) **petrous part** (*pars petrosa*) (in animals, *petrosum*). A fourth part of the temporal bone, mastoid (*pars mastoidea*) was previously distinguished.

Within the first year of life the parts fuse into a single bone and thus form the **external acoustic meatus** (*meatus acusticus externus*) with the squamous part to the top, the petrous part in a medial position, and the tympanic part to the back, bottom, and front. The traces of fusion of the separate parts of the temporal bone persist throughout life in the form of sutures and fissures namely: **petrosquamous fissure** (*fissura petrosquamosa*) on the border between the squamous and petrous parts on the anterosuperior surface of the latter; the
tympanosquamous fissure (*fissura tympanosquamosa*) in the depth of the mandibular fossa separated by the process of the petrous part into *fissura petrosquamosa*, and *pectrotympanic fissure* (*fissura petrotympanica*) (through which the chorda tympani nerve passes).

The **squamous part** (*pars squamosa*) contributes to the formation of (the lateral walls of the skull.

The **cerebral surface** (*facies cerebralis*) of the squamous part bears marks of the brain, impressions for cerebral gyri (*impressiones digitatae*) and an ascending groove lodging the middle meningeal artery (*a. meningea media*). The smooth external surface of the squama contributes to the formation of the temporal fossa and is therefore called the **temporal surface** (*facies temporalis*). It gives rise to the **zygomatic process** (*processus zygomaticus*), which passes forward to join the zygomatic bone. The zygomatic process has two roots at its origin, an anterior and a posterior root, with a depression—**articular fossa** (*fossa mandibularis*) for articulating with the lower jaw between them. The inferior surface of the anterior root carries an **articular tubercle** (*tuberculum articulare*), which prevents anterior dislocation of the head of the mandible when the mouth is opened very wide.

The **tympanic part** (*pars tympanica*) of the temporal bone forms the anterior, inferior, and part of the posterior border of the external acoustic meatus.

The **external auditory meatus** (*meatus acusticus externus*) is a short canal directed medially and somewhat anteriorly and leading into the tympanic cavity. The superior edge of its external opening, **porus acusticus externus**, and part of the posterior edge are formed by the squama of the temporal bone. The other edges are formed by the tympanic part of the bone.

The external acoustic meatus is incompletely formed in the newborn because the tympanic part is an incomplete ring (anulus tympanicus) closed by the tympanic membrane. Since the tympanic membrane is so near the external environment, newborns and infants often suffer from diseases of the membrane. The tympanic ring grows and is converted to a tube during the first year of life; this tube pushes the petrous
part medially and forms most of the bony external acoustic meatus whose roof is the squamous part. The tympanic membrane, now moves deeper into the external acoustic meatus and separates it (i.e. the external ear) from the tympanic cavity, cavum tympani (and becomes external in relation to the tympanic cavity).

The petrous part (pars petrosa) (Gk. petros stone) is an important component of the temporal bone. It is so named because its bony substance is strong. It is a part of the base of the skull and at the same time is a bony encasement for the organs of hearing and equilibrium, which have a very fine structure and must be protected reliably from injuries. The petrous part develops in cartilage. This part is also called the pyramid because it is shaped like a trihedral pyramid with the base facing externally and the apex facing anteriorly and internally toward the sphenoid bone.

The pyramid has three surfaces: anterior, posterior, and inferior.

The anterior surface of the pyramid lies a small depression near its apex. This is the trigeminal impression (impressio trigemini), which lodges the ganglion of the trigeminal nerve (n. trigeminus). Lateral to it pass two small grooves, a medial sulcus of the greater petrosal nerve (sulcus n. petrosi majoris) and a lateral sulcus of the lesser petrosal nerve (sulcus n. petrosi minoris). They lead to two openings of the same name, a medial opening (hiatus canalis n. petrosi majoris) and a lateral opening (hiatus canalis n. petrosi minoris). The arcuate eminence (eminentia arcuata) is lateral to these openings; it forms due to prominence of the vigorously developing labyrinth, particularly the superior semicircular canal. The bone surface between the petrosquamous fissure and the arcuate eminence forms the roof of the tympanic cavity (tegmen tympani).

In about the middle of the posterior surface of the pyramid is the porus acusticus internus leading into the internal auditory meatus (meatus acusticus internus), which transmits the facial and auditory nerves and the internal auditory artery and veins.

The inferior surface of the pyramid that faces the base of the skull gives off a slender tapering styloid process (processus styloideus) for attachment of the muscles. Between the styloid and mastoid processes is the stylomastoid foramen
(foramen stylomastoideum) transmitting the facial nerve and one of the arteries. The deep jugular fossa (fossa jugularis) is medial to the styloid process. To the front of the jugular fossa and separated from it by a sharp ridge is the external opening of the carotid canal (foramen caroticum externum).

The pyramid has three edges: anterior, posterior, and superior. The short anterior edge forms a sharp angle with the squama, in which is found the musculotubal canal (canalis musculotubarius) leading to the tympanic cavity. The canal is divided by a septum into two parts: superior and inferior. The superior, smaller semicanal (semicanalis m. tensoris tympani) lodges the tensor tympani muscle, while the lower, larger semicanal (semicanalis tubae auditivae) is the bony part of the auditory tube for the conduction of air from the pharynx to the tympanic cavity.

The superior edge of the pyramid that separates the anterior and posterior surfaces bears a clearly detectable groove, groove for the superior petrosal sinus (sulcus sinus petrosi superioris) lodging the superior petrosal venous sinus.

The posterior edge of the pyramid joins the pars basilaris of the occipital bone to the front of the jugular fossa and together with this bone forms the groove for the inferior petrosal sinus (sulcus sinus petrosi inferioris) lodging the inferior petrosal sinus.

The external surface of the base of the pyramid provides attachment for the muscles; this determines its relief (process, notches, areas of roughness). Its lower end stretches out to form the mastoid process (processus mastoideus) to which the sternocleidomastoid muscle is attached.

The medial surface of the mastoid process bears a deep mastoid notch (incisura mastoidea), the site of attachment of m. digastricus, and, still closer to the midline, a small occipital groove (sulcus a. occipitalis). A smooth triangle on the external surface of the base of the mastoid process is the operative approach to the air cells of the process when they are filled with pus. The suprameatal spine (spina suprameatum) projects in front of the triangle.

The mastoid process contains compartments or cells (cellulae mastoidea), which are air cavities separated by bone trabeculae. They receive air from the tympanic cavity
with which they communicate by means ol the mastoid antrum (antrum mastoideum). A deep sigmoid groove (*sulcus sinus sigmoidei*) is found on the cerebral surface of the base of the pyramid. The canal of the venous emissary opens into this sulcus; its external opening, mastoid foramen (*foramen mastoideum*), varying greatly in accordance with the size of the canal, is near to or in the occipitomastoid suture.

**The canals of the temporal bone.** The largest is the *carotid canal (canalis caroticus)*, which transmits the internal carotid artery. It begins as the *external carotid foramen (foramen caroticum externum)* on the interior surface of the pyramid, then ascends and bends at a right angle and opens by its *internal foramen (foramen caroticum internum)* at the apex of the pyramid medial to the canalis musculotubarius. The *canal for the facial nerve (canalis facialis)* begins in the depth of porus acusticus internus and then passes at first forward and laterally to the hiatus in the anterior surface of the pyramid. There the canalis facialis, still horizontal, bends at a right angle laterally and backward to form the geniculum of the facial canal (*geniculum canalis facialis*); it then descends and ends as the stylomastoid foramen (*foramen stylomastoideum*) on the inferior surface of the pyramid of the temporal bone.

**THE PARIETAL BONE**

The *parietal bone (os parietale)* is a paired bone forming the middle part of the vault of the skull. Its structure, therefore, is relatively simple; it is a quadrangular plate with convex external and concave internal surfaces. Its four borders articulate with the adjoining bones, namely: the *frontal border (margo frontalis)* with the frontal bone; the posterior, *occipital border (margo occipitalis)* with the occipital bone; the superior, *sagittal border (margo sagittalis)* with the contralateral bone, and the inferior, *squamosal border (margo squamosus)* with the squama of the temporal bone. The first three borders are serrated, while the last is adapted for the formation of a squamous suture. The four angles are as follows: the *frontal angle (angulus frontalis)* unites with the frontal bone; the *sphenoidal angle (angulus sphenoidalis)* joins with the sphenoid bone; the *occipital angle (angulus occipitalis)* articulates with the occipital bone; and the *mastoid angle (angulus mstoideus)* unites with the mastoid process of the temporal bone. The relief of the external convex surface is determined by the attachment of
muscles and fasciae. In its centre is a prominence, the **parietal eminence (tuber parietalis)** (where ossification begins). Below it are two curved **temporal lines (linea temporalis superior and inferior)** for attachment of the temporal fascia and muscle. An opening, the **parietal foramen (foramen parietale)** for the artery and the venous emissary is seen near to the superior border. The relief of the internal concave surface (**facies interna**) is determined by the brain and especially the dura mater, which fit close to it. The sites of attachment of the dura mater to the bone are marked by a **sagittal groove (sulcus sinus sagittalis superioris)** (lodging the superior sagittal sinus) on the superior border, and a transverse **groove (sulcus sinus sigmoidei)** (lodging the sigmoid sinus), in the region of the angulus mastoideus. The vessels of the dura mater have left imprints forming a pattern of branching grooves on almost the entire internal surface. Pits for **pacchionian granulations (foveolae granulares)** are seen on either side of the sulcus sinus sagittalis superioris.

**THE FRONTAL BONE**

The **frontal bone (os frontale)** an unpaired, membrane bone, contributes to the formation of the vault of the skull and develops in connective tissue.

The frontal bone is made up of two parts: a vertical part, **squama (squama frontalis)** and a horizontal part. According to its relation to the organs of vision and smell, the paired **orbital part (pars orbitalis)** and an unpaired **nasal part (pars nasalis)** are distinguished in the horizontal part. As a result, the following four parts are distinguished in the frontal bone.

1. The **frontal squama (squama frontalis)** as any membrane bone, has the shape of a plate, externally convex and internally concave. It ossifies from two ossification points, which are apparent even in an adult as two **frontal tubers (tuberas frontalia)** on the **external surface (facies externa)**. They are pronounced only in man due to the development of the brain. They are absent not only in anthropoid apes but also in extinct forms of man. The inferior border of the squama is called the **supraorbital border (margo supraorbitalis)**. Approximately at the junction of the medial and middle third of this border is the **supraorbital notch (incisura supraorbitalis)** (which transforms sometimes into a **foramen**
supraorbitale), transmitting the supraorbital arteries and nerve. Eminences, the superciliary arches (arcus superciliares) varying greatly in size and length, are seen immediately above the supraorbital border; they are continuous medially on the midline with a more or less prominent area, the glabella, the superior part of the bridge of the nose. The glabella is an important feature in distinguishing the skull of modern man from a fossil skull. The lateral end of the supraorbital border stretches out to form the zygomatic process (processus zygomaticus), which articulates with the zygomatic bone. A clearly detectable temporal line (linea temporalis) extends upward from the process; this line delimits the temporal surface (facies temporalis) of the squama. A small groove, sagittal groove (sulcus sinus sagittalis superioris) runs on the midline of the internal surface (facies interna) from the posterior border and is continuous at the lower end with the frontal crest (crista frontalis). These structures provide attachment for the dura mater. Depressions for the pacchionian granulations (arachnoid villi) are seen near the midline.

2 and 3. The orbital parts (partes orbitales) are two horizontal plates whose inferior concave surface faces the orbit. The superior surface faces the cranial cavity, and the posterior border articulates with the sphenoid bone. The superior cerebral surface bears marks of the brain; namely cerebral ridges of cranium (juga cerebralis) (BNA) (L juga yoke), and digitate impressions (impressiones digitatae). The inferior surface (facies orbitalis) forms the superior orbital wall and bears marks of adjacent accessories of the eye: the lacrimal fossa (fossa glandulae lacrimalis) near the zygomatic process; trochlear fossa (fovea trochlearis) near the supraorbital notch; and trochlear spine (spina trochlearis) where the trochlea for the tendon of one of the muscles of the eye is attached. The orbital parts are separated by the ethmoid notch (incisura ethmoidalis), which in an intact skull is filled by the ethmoid bone.

4. The nasal part (pars nasalis) occupies the anterior part of the ethmoid notch on the midline. A projection ending as a sharp process, the nasal spine (spina nasalis), is found here; it helps to make up the nasal septum. On either side of the spine are depressions, which serve as the superior wall for the sinuses of the ethmoid bone. To
the front of them is an opening leading into the **frontal sinus** (*sinus frontalis*) located in the thickness of the bone to the back of the superciliary arches; the sinus varies greatly in size. The frontal sinus contains air and is separated by the septum of the frontal **inus** (*septum sinuum frontalium*).

**THE ETHMOID BONE**

The **ethmoid bone** (*os ethmoidale*) is an unpaired bone usually described in the group of bones of the cerebral cranium, although most of it helps to make up the visceral cranium. The ethmoid bone is located centrally between the bones of the face and comes in contact with most of them to form the nasal cavity and orbit. Formed of thin bone plates surrounding the air sinuses, it is light and fragile. The ancient Egyptians made use of these properties when they removed the brain from the skull through the ethmoid bone for embalment.

The bony plates of the ethmoid bone are arranged in the form of the letter "T" in which the vertical line is the **perpendicular plate** (*lanina perpendicularis*) and the horizontal is the **cribriform plate** (*lamina cribrosa*). From the lamina cribrosa, on either side of the perpendicular plate, hang the **ethmoidal labyrinths** (*labyrinthi ethmoidales*). As a result four parts are distinguished in the ethmoid bone.

1. **Lamina cribrosa** is a rectangular plate fitting into the ethmoid notch of the frontal bone. It is perforated by small openings like a sieve, hence its name (Gk. *ethmos* sieve, *eidos* form). These perforations transmit the branches of the olfactory nerve (about 30 of them). The crista galli projects upward from the midline of the cribriform plate (for attachment of the dura mater).

2. **Lamina perpendicularis** is a part of the nasal septum.

3 and 4. **Labyrinthi ethmoidales** make up a paired complex of bony air cells, **cellulae ethmoidales**, covered laterally by a thin orbital plate (*lamina orbitalis*) which forms the medial wall of the orbit. On the medial surface of the labyrinth are two **nasal conchae** (*conchae nasales superior and media*), although sometimes there is a third, **highest nasal concha** (*concha nasalis suprema*).

The **conchae** (Gk. *konche* shell) are thin, curved plates

**THE BONES OF THE VISCERAL CRANIUM**

**THE UPPER JAW BONE**
The upper jaw bone (maxilla) is a paired bone of a complex structure (determined by the diversity of its functions. The maxilla consists of a body and four processes.

A. The body (corpus maxillae) contains a large maxillary air sinus (sinus maxillaris s. antrum Highmori, BNA) (hence highmoritis, inflammation of the maxillary sinus), which communicates with the nasal cavity by a wide opening, the maxillary hiatus (hiatus maxillaris). The following four surfaces are distinguished on the body.

The anterior surface (facies anterior), is concave in modern man since his food is prepared and the function of mastication is consequently weaker. Inferiorly it is continuous with the alveolar process, in which a series of depressions (juga alveolaria) between the ridges of the tooth roots are seen. The ridge corresponding to the canine tooth is most pronounced. The canine fossa (fossa canina) is above and lateral to it. Superiorly the anterior surface of the maxilla is separated from the orbital surface by the infraorbital margin (margo infraorbitalis). Immediately below it is the infraorbital foramen (foramen infraorbitale) through which the infraorbital nerve and artery leave the orbit. The medial border of the anterior surface is formed by the nasal notch (incisura nasalis) whose edge extends forward to form the anterior nasal spine (spina nasalis anterior).

The infratemporal surface (facies infratemporalis) is separated from the anterior surface by the zygomatic process and carries several small perforations (transmitting the nerves and vessels to the upper teeth), the maxillary tuber (tuberosity of maxilla) (tuber maxillae) and the greater palatine sulcus (sulcus palatinus major).

The nasal surface (facies nasalis) is continuous inferiorly with the superior surface of the palatine process. The conchal crest (crista conchalis) is seen on it. To the back of the frontal process is the nasolacrimal groove (sulcus lacrimalis) which, with the lacrimal bone and the inferior nasal concha, is converted into the nasolacrimal canal (canalis nasolacrimalis).

The smooth, flat orbital surface (facies orbitalis) is triangular. On its medial
border, behind the frontal process, is the **lacrimal notch (incisura lacrimalis)** lodging the lacrimal bone. The infraorbital groove (*sulcus infraorbitalis*) originates near the posterior border of the orbital surface and is converted anteriorly into the infraorbital canal (*canalis infraorbitalis*), which opens into the anterior surface of the maxilla by means of the infraorbital foramen mentioned above. The alveolar canals (*canales alveolares*) arise from the infraorbital canal; they transmit nerves and vessels passing in the thickness of the anterior maxillary wall to the anterior teeth.

**B. Processes.** 1. The **frontal process (processus frontalis)** projects upward and joins the pars nasalis of the frontal bone. Its lateral surface is divided into two parts by a vertical **lacrimal crest (crista lacrimalis anterior)**, which is continuous downward with the infraorbital margin. The medial surface carries the **ethmoidal crest (crista ethmoidalis)** for attachment of the middle nasal concha.

2. The alveolar process (*processus alveolaris*) carries on its inferior border, alveolar arch (*arcus alveolaris*), dental sockets (*alveoli dentales*) for the eight upper teeth; the sockets are separated by **septa interalveolaria**.

3. The **palatine process (processus palatinus)** forms most of the hard **bony palate (palatum osseum)** by joining the contralateral process in the midline. Where they meet, the **nasal crest (crista nasalis)** rises on the superior surface facing the nasal cavity and articulates with the inferior edge of the vomer. Near the anterior end of the nasal crest on the superior surface is an opening that leads into the **incisive canal (canalis indisivus)**. The superior surface of the process is smooth, whereas the inferior surface, facing the oral cavity, is rough (impressions of the musocal glands) and carries longitudinal palatine grooves (sulci palatini) lodging the nerves and vessels. The incisive suture (*sutura incisiva*) is often seen in the anterior part. It delimits the os incisivum which fuses with the maxilla. In many animals this bone exists as an independent bone (*os intermaxillare*), but in man it is rarely encountered.

4. The **zygomatic process (processus zygomaticus)** articulates with the zygomatic bone to form a thick support through which pressure produced during mastication is transmitted to the zygomatic bone.
THE PALATINE BONE

The **palatine bone** (*os palatinum*) is a paired bone.

It is a thin bone consisting of two plates uniting at a right angle and supplementing the maxilla.

1. The horizontal plate (*lamina horizontalis*) complements the maxillary palatine process posteriorly to form the **hard palate** (*palatum osseum*). Its medial border meets the medial border of the contralateral bone to form the **hard palate** (*palatum osseum*). Its medial border meets the medial border of the contralateral bone to form the **nasal crest** (*crista nasalis*). On the inferior surface of the horizontal plate is the **greater palatine foramen** (*foramen palatinum majus*), through which palatine vessels and nerves leave the canalis palatinus major (see below).

2. The **perpendicular plate** (*lamina perpendicularis*) adjoins the nasal surface of the maxilla. Along its lateral surface runs the **greater palatine sulcus** (*sulcus palatinus major*), which together with the maxillary sulcus of the same name forms the canalis palatinus major. The medial surface has two crests for two nasal conchae, the middle (*crista ethmoidalis*) and the inferior (*crista conchalis*). The palatine bone has three **processes**. One of them, the **pyramidal process** (*processus pyramidalis*) projects backward and laterally from the junction of the horizontal and perpendicular plates. In an intact skull the pyramidal process fits into the pterygoid fissure of the sphenoid bone. Nerves and vessels penetrate it vertically through the **lesser palatine canals** (*canales palatini minores*). The other two processes project from the superior edge of the perpendicular plate and form the **sphenopalatine notch** (*incisura sphenopalatina*), which meets the body of the sphenoid bone to form the **sphenopalatine foramen** (*foramen sphenopalatinum*) transmitting the sphenopalatine vessels and nerves. The anterior process forms the posterior corner of the orbit and is therefore known as the **orbital process** (*processus orbitalis*); the posterior process adjoins the inferior surface of the body of the sphenoid bone and is called the **sphenoid process** (*processus sphenoidalis*).

THE INFERIOR NASAL CONCHA
The inferior nasal concha or inferior turbinate bone (*concha nasalis inferior*) is a paired bone. As distinct from the superior and middle nasal conchae, which are components of the ethmoid bone, the inferior nasal concha is an independent bone. It is a thin, curled plate of bone whose upper edge is attached to the lateral wall of the nasal cavity;

**THE NASAL BONE**

The nasal bone (os nasale) joins the contralateral bone to form the ridge of the nose at its root.

The lacrimal bone (os lacrimale), a paired bone, is a thin plate found in the medial wall of the orbit immediately behind the frontal process of the maxilla. Its lateral, surface carries the crest of the lacrimal bone (*crista lacrimalis posterior*). To the front of the crest runs the lacrimal groove (*sulcus lacrimalis*), which meets the sulcus of the frontal process of the maxilla to form the fossa of the lacrimal sac (fossa sacci lacrimalis).

**THE VOMER**

The vomer (Fig. 61), an unpaired bone, is an irregularly quadrangular plate, which resembles a plowshare (hence its name: L vomer plowshare) and forms part of the bony nasal septum. Its superior border is split into two wings (*alae vomeris*), which fit over the rostrum of the sphenoid bone. The upper half of the anterior edge articulates with the perpendicular plate of the ethmoid bone, and the lower part with the cartilaginous nasal septum. The inferior edge articulates with the nasal crests of the maxilla and palatine bone. The free, posterior edge is the posterior border of the bony nasal septum separating the posterior openings of the nasal cavity, choanae by means of which the nasal cavity communicates with the nasopharynx.

**THE ZYGOMATIC BONE**

The zygomatic bone (*os zygomaticum*) is a paired bone, the strongest bone of the skull. According to the location of the bone, three surfaces and two processes are distinguished in it. The lateral surface (*facies lateralis*) is shaped like a four-point star and bulges slightly. The smooth posterior surface faces the temporal fossa and is called the temporal surface (*facies temporalis*). The third orbital surface (*facies
orbitalis) takes part in the formation of the orbital walls. The superior frontal process of the zygomatic bone (processus frontalis) articulates with the zygomatic process of the frontal bone and the greater wing of the sphenoid bone. An eminence for attachment of the muscles and ligaments of the eyelids is often found on its orbital surface. The lateral temporal process (processus temporalis) articulates with the zygomatic process of the temporal bone to form the zygomatic arch, the site of origin of the masseter muscle.

THE LOWER JAW BONE

The lower jaw bone or the mandible (mandibula) is a mobile skull bone. The mandible consists of a horizontal part or body (corpus mandibulae), which carries the teeth, and a vertical part in the form of two rami mandibulae, which serve for the formation of the temporomandibular joint and for attachment of the muscles of mastication. The horizontal and the vertical parts meet at an angle called the angle of the mandible (angulus mandibulae), on the external surface of which the masseter muscle is inserted into the masseteric tuberosity (tuberositas masseterica). On the inner surface of the angle is the pterygoid tuberosity (tuberositas pterygoidea) for insertion of another muscle of mastication, m. pterygoideus medialis.

The structure and relief of the body of the mandible are determined by the teeth and by the fact that the mandible takes part in the formation of the mouth. For instance, the upper, alveolar part of the body (pars alveolaris) bears teeth as a consequence of which its border, the alveolar arch (arcus alveolaris) has sockets for the teeth (alveoli dentalis), with interalveolar septa (septa interalveolaria) and corresponding depressions on the external surface (juga alveolaria). The rounded massive and thick inferior border of the body forms the base of the mandible (basis mandibulae). At old age when the teeth are lost, the alveolar part atrophies and the whole body of the mandible becomes thin and low. The ridge on the symphysis on the midline of the body is continuous with a triangular mental protuberance (protuberantia mentalis), the presence of which is characteristic of modern man. Among all mammals only man, and modern man at that, has a pronounced chin.

On each side of this protuberance is a mental tubercle (tuberculum
mentale). On the lateral surface of the body, in the space between the first and second premolars, is the mental foramen (foramen mentale), which is an opening of the mandibular canal (canalis mandibulae), transmitting a nerve and vessels. An oblique line (linea obliqua) runs to the back and upward from the mental tubercle. Two mental spines (spinae mentales) project from the inner surface of the symphysis; these are the sites of attachment of the tendon of the genioglossus muscle.

On both sides of the mental spine, nearer to the inferior border of the mandible is the site for attachment of the digastric muscle, the digastric fossa (fossa digastrica). Further to the back is the mylohyoid line (linea mylohyoidea), running backward and upward; it serves for attachment of the mylohyoid muscle.

The ramus of the mandible (ramus mandibulae) rises on each side from the posterior part of the body of the mandible. On its inner surface is the mandibular foramen (foramen mandibulae), leading into the mandibular canal mentioned above. The medial edge of this foramen projects as the lingula of the mandible (lingula mandibulae), to which is attached the sphenomandibular ligament; the lingula is developed more in man than in apes. The mylohyoid groove (sulcus mylohyoideus) originates behind the lingula and runs downward and forward; it lodges the mylohyoid nerve and vessels. Superiorly the ramus of the mandible terminates as two processes, anterior coronoid process (processus coronoideus) (it forms under the effect of traction exerted by the strong temporal muscle) and a posterior condylar process (processus condylaris). A crest for the attachment of the buccinator muscle (crista buccinatoria) runs on the inner surface of the ramus upward from the surface of the alveoli of the last molars, towards the coronoid process.

The condylar process has a head (caput mandibulae) and a neck (collum mandibulae). On the anterior surface of the neck is the pterygoid pit (fovea pterygoidea) for attachment of the lateral pterygoid muscle.

THE HYOID BONE

The hyoid bone (os hyoideum) is situated at the base of the tongue between
the mandible and the larynx. It consists of a **body** (*corpus*) and two pairs of **horns** (*cornua*). The **greater horns** (*cornua majora*) are continued from both ends of the body and extend backwards and somewhat laterally; they are at first joined to the body by cartilage which later is replaced by bone. The **lesser horns** (*cornua minora*) arise from the junction of the body and the greater horns.

**THE TEMPOROMANDIBULAB JOINT**

The temporomandibular joint (*articulatio temporomandibularis*) is formed by the head of the mandible and the mandibular fossa of the temporal bone. The articulating surfaces are complemented by a fibrous articular disc (*discus articularis*) located between them. The edges of the disc are joined to the articular capsule as a result of which the joint cavity is separated into two isolated compartments. The articular capsule is attached along the border of the mandibular fossa up to the petrotympanic fissure and thus encloses the articular tubercle and embraces the neck of the mandible inferiorly. Near the temporomandibular joint are three ligaments only one of which, the lateral ligament (*lig. laterale*), is directly related to the joint. It passes obliquely backward on the lateral side of the joint from the zygomatic process of the temporal bone to the neck of the condylar process of the mandible. The lateral ligament prevents excessive movement of the articular head to the back. The remaining two ligaments (*lig. sphenomandibulare* and *lig. stylomandibulare*) are at a distance from the joint and are actually not ligaments but artificially separated areas of fascia, which form a loop-like structure to help to suspend the mandible.

Both temporomandibular joints function simultaneously and are therefore a single combined articulation from the mechanical standpoint. The temporomandibular articulation is a condyloid joint, but because of the articular disc, it permits movements in three directions. The mandible makes the following **movements**: (1) downward and upward movements with opening and closure of the mouth; (2) forward and backward movements; (3) lateral movements (rotation of the mandible to the right and to the left as it occurs in chewing).

**THE SKULL AS A WHOLE,**

The **external surface of the skull.** Part of the external surface of the skull
examined from the front (norma facialis s. frontalis) consists of the forehead superiorly and two orbits, with the piriform aperture of the nose between them.

The **orbits**, or **eyesockets** (*orbitae*) contain the organ of vision and are cavities in the shape of somewhat rounded, four-sided pyramids. The base of the pyramid corresponds to the **opening into the orbit** (*aditus orbitae*), while the apex is directed backward and medially. The **medial orbital wall** (*paries medialis*) is formed by the frontal process of the maxilla, the lacrimal bone, the orbital plate of the ethmoid bone, and the body of the sphenoid bone to the front of the optical canal. The orbital surfaces of the zygomatic bone and greater wings of the sphenoid bone form the **lateral wall** (*paries lateralis*). The **superior wall** (*paries superior*) or the roof of the orbit is formed by the orbital part of the frontal bone and lesser wings of the sphenoid bone; the inferior wall (*paries inferior*) or floor of the orbit is made up of the zygomatic bone and maxilla, and in the posterior portion by the orbital surface of the orbital process of the palatine bone. Two openings are seen at the apex of the pyramid: a large lateral opening, the **superior orbital fissure** (*fissura orbitalis superior*), and a smaller round medial opening, the **optic canal** (*canalis opticus*); by means of both openings the orbit communicates with the cranial cavity. In the corner formed by the lateral and inferior orbital walls is the **inferior orbital fissure** (*fissura orbitalis inferior*), which is bounded laterally by the greater wing of the sphenoid bone and medially by the edge of the maxilla; its posterior end leads into the pterygopalatine fossa and the anterior end into the infratemporal fossa. The fossa of the lacrimal sac (*fossa sacci lacrimalis*) is in the anterior part of the medial wall; it is bounded by the frontal process of the maxilla in front and by the lacrimal bone in the back and leads into the nasolacrimal canal (*canalis naso-lacrimalis*). The other end of the lacrimal canal opens into the inferior nasal meatus. Further to the back, in the suture between the frontal and ethmoid bones, are two openings, the anterior and posterior ethmoidal foramina (*foramina ethmoidale anterius* and *posterius*), transmitting the anterior and posterior ethmoidal vessels and nerves. The anterior foramen loads into the cranial cavity, the posterior foramen into the nasal cavity.

The **anterior bony aperture of the nose** (*apertura piriformis nasi*) is below
and partly between the orbits. Laterally and inferiorly it borders on the maxilla and superiorly and partly laterally on the free edges of the nasal bones. The anterior nasal spine (spina nasalis anterior) projects forward on the midline on the inferior margin of the piriform aperture. It is continuous posteriorly with the bony septum of the nose.

On examination of the skull from the side (norma lateralis), the temporal lines (lineae temporales) (superior and inferior), strike the eye first of all. Each line rises at the zygomatic process of the frontal bone, curves upward and to the back to intersect the coronary suture, and then passes over to the parietal bone on which it runs in the direction of the mastoid angle and, curving anteriorly, extends to the temporal bone. It marks the attachment of temporal muscle and fascia.

The following depressions merit special description because of their important topographical relations: (1) the temporal fossa (fossa temporalis); (2) the infratemporal fossa (fossa infratemporalis); and (3) the pterygopalatine fossa (fossa pterygopalatina)

The temporal fossa (fossa temporalis) is bounded superiorly and posteriorly by the temporal line, inferiorly by the infratemporal crest and the inferior margin of the zygomatic arch, and anteriorly by the zygomatic bone. Thus the frontal and parietal bones, the greater wing of the sphenoid bone, the squama of the temporal bone, and the zygomatic bone take part in its formation. The temporal fossa lodges the temporal muscle.

The infratemporal fossa (fossa infratemporalis) is continuous downward with the temporal fossa, and their borderline is the infratemporal crest of the greater wing of the sphenoid bone. The medial wall of the infratemporal fossa is formed by the lateral plate of the pterygoid process. The anterior wall is formed by the infratemporal surface of the maxilla and the lower part of the zygomatic bone. The superior wall is formed by the inferior surface of the greater wing of the sphenoid bone and the oval and spinous foramina in it, as well as by a small area of the squamous part of the temporal bone. The infratemporal fossa is covered partly on the external surface by the mandibular ramus. It communicates
with the orbit through the inferior orbital fissure and with the pterygopalatine fossa through the pterygomaxillary fissure.

The pterygopalatine fossa (fossa pterigopalatina) is located between the back of the maxilla (anterior wall) and the front of the pterygoid process (posterior wall). Its medial wall is the vertical plate of the palatine bone isolating the pterygopalatine fossa from the cavity of the nose.

The following five openings are found in the pterygopalatine fossa: (1) a medial opening, the sphenopalatine foramen (foramen sphenopalatinum) leading into the nasal cavity and transmitting the sphenopalatine nerve and vessels; (2) a round posterosuperior opening (foramen rotundum) leading into the middle cranial fossa and transmitting the second branch of the trigeminal nerve which leaves the cranial cavity; (3) anterior opening, the inferior orbital fissure (fissura orbitalis inferior) leading into the orbit and transmitting the nerves and vessels; (4) an inferior opening, the greater palatine canal (canalis palatinus major) leading into the oral cavity; it is formed by the maxilla and the greater palatine sulcus of the palatine bone and is a funnel-shaped narrowing of the lower part of the pterygopalatine fossa and transmits the nerves and vessels leaving this fossa; (5) a posterior opening, the pterygoid canal (canalis pterygoideus) transmitting the vegetative nerves (n. canalis pterygoidei) and leading to, the base of the skull.

On examination of the skull from above (norma verticalis), its roof and the sutures are seen: the sagittal suture (sutura sagittalis) between the medial border of the two parietal bones; the coronal suture (sutura coronalis) between the frontal and the two parietal bones; and the lambdoid suture (sutura lambdoidea) (from its resemblance to the Greek letter lambda) between the two parietal bones and the occipital bone.

The external surface of the base of the skull (basis cranii externa) is made up of the inferior surfaces of the visceral (without the mandible) and the cerebral cranium. It extends from the incisors anteriorly to the superior nuchal line (linea nuchae superior) posteriorly; its lateral border stretches from the infratemporal crest to the base of the mastoid process. Three parts are distinguished in the
external surface of the base of the skull: anterior, middle, and posterior. The anterior part is formed of the **hard palate** (*palatum osseum*) and the alveolar arch of the maxilla; a **transverse suture** (*sutura transversa*) is seen in the posterior part of the hard palate at the junction of its components, the palatine process of the maxilla and the horizontal plate of the palatine bone. A **median palatine suture** (*sutura mediana*) joining the paired parts of the hard palate runs on the midline and its anterior end is continuous with the incisive foramen. In the posterior part of the hard palate, near to the alveolar arch, is the **greater palatine foramen** (*foramen palatinum majus*), the exit from the greater palatine canal; still further to the back, on the inferior surface of the pyramidal process, are the openings of the lesser palatine canals.

The middle part extends from the posterior edge of the hard palate to the anterior margin of foramen magnum. On the anterior border of this part are openings, *choanae*. They are isolated from each other by the vomer; they are bounded above by the body of the sphenoid bone, below by the horizontal plates of the palatine bones, and laterally by the medial plates of the pterygoid processes. In the posterior part of the base of the skull is the **jugular foramen** (*foramen jugulare*), formed by the jugular fossa of the temporal bone and the jugular notch of the occipital bone. The jugular foramen transmits the ninth, tenth, and eleventh cranial nerves, and the jugular vein originates here.

The **upper surface of the base of the skull** (*basis cranii interna*) can be examined only on a horizontal or sagittal section of the skull. The internal or superior surface of the base of the skull is separated into three fossae. The anterior and middle fossae lodge the cerebrum, while the posterior fossa lodges the cerebellum. The posterior edges of the lesser wings of the sphenoid bone are the borderline between the anterior and middle fossae, and the superior edge of the pyramids of the temporal bones is the borderline between the middle and posterior fossae.

The **anterior cranial fossa** (*fossa cranii anterior*) is formed by the orbital part of the frontal bone, the cribriform plate of the ethmoid bone, and the lesser wings of the sphenoid bone. It is distinguished by pronounced digitate
impressions and cerebral ridges (juga cerebralia).

The middle cranial fossa (fossa cranii media) is located deeper than the anterior fossa. Its median part is formed by the sella turcica. The lateral parts are made up of the greater wings of the sphenoid bone, the squamous part of the temporal bones, and the anterior surface of their pyramids. The openings of the middle fossa are as follows: the optic canal, the superior orbital fissure, foramen rotundum, the oval foramen, and the spinous foramen.

The posterior cranial fossa (fossa cranii posterior) is the deepest and largest of the three fossae. Its components are the occipital bone, the posterior parts of the body of the sphenoid bone, the petrous part of the temporal bone, and the inferoposterior angle of the parietal bone. The following openings are found in it: foramen magnum, hypoglossal canal, jugular foramen, condylar canal (sometimes absent), mastoid foramen (occurring most regularly), porus acusticus internus (on the posterior surface, of the pyramid).

The cavity of the nose (cavum nasi) is the initial part of the respiratory tract and lodges the organ of olfaction. The piriform aperture leads into the cavity in front, and the paired openings, the choanae, connect it with the cavity of the pharynx. The bony septum of the nose (septum nasi osseum) divides the nasal cavity into two halves, which are not quite symmetrical, in most cases the septum deviates to one of the sides from the sagittal plane. Each half of the nasal cavity has five walls: superior, inferior, lateral, medial, and posterior.

The lateral wall is the most complex in structure; it is formed of the following (from front to back) bones: the nasal bone, the nasal surface of the body and frontal process of the maxilla, the lacrimal bone, the labyrinth of the ethmoid bone, the inferior concha, the perpendicular plate of the pterygoid process of the sphenoid bone.

The medial wall, or the osseus nasal septum (septum nasi osseum) is formed by the perpendicular plate of the ethmoid bone and the vomer, above by the nasal spine of the frontal bone, posteriorly by the maxilla and palatine bone.

The superior wall is made up of a small area of the frontal bone, the cribiform plate of the ethmoid bone, and partly the sphenoid bone.
The *inferior wall*, or floor, is formed by the palatine process of the maxilla and the horizontal plate of the palatine bone which make up the bony hard palate (palatum osseum); the opening of the incisive canal (canalis incisivus) is seen in its front part.

The *posterior wall* is very short and is found only in the superior part because the choanae are located below it. It is formed by the nasal surface of the body of the sphenoid bone with the paired aperture of the sphenoid sinus.

Three nasal conchae project downward into the nasal cavity from the lateral wall, they separate the three nasal meatuses — superior, middle, and inferior — from each other. The **superior nasal meatus** (*meatus nasi superior*) is between the superior and middle conchae of the ethmoid bone; it is half the length of the middle meatus and is found only in the posterior part of the nasal cavity; it communicates with the sphenoid sinus and sphenopalatine foramen and the posterior air cells of the ethmoid bone open into it. The **middle nasal meatus** (*meatus nasi medius*) passes between the middle and inferior canchae. The anterior and middle cells of the ethmoid bone and the maxillary sinus open into it and a projection of the **ethmoidal labyrinth** (*bulla ethmoidalis*) (a rudiment of an accessory concha) is seen lateral to the middle concha. To the front of and a little below the bulla is a funnel-shaped passage (*infundibulum ethmoidale*) by means of which the middle nasal meatus communicates with the anterior ethmoidal cells and the frontal sinus. These anatomical communications explain the spread of the inflammatory process to the frontal sinus (frontitis) in rhinitis. The **inferior nasal meatus** (*meatus nasi inferior*) is between the inferior nasal concha and the floor of the nasal cavity. The nasolacrimal canal opens into its anterior part; through this canal the tears flow into the nasal cavity. That is the reason the amount of nasal discharge increases when a person cries and, conversely, the eyes “water” in rhinitis. The space between the conchae and the nasal septum is known as the **common meatus of the nose** (*meatus nasi communis*).

**AGE FEATURES OF THE SKULL**

The **skull of the newborn** is characterized by a small visceral cranium as compared to the cerebral part.
The **fontanelles** (*fonticuli*) are another characteristic feature of a newborn’s skull. The following fontanelles are distinguished: (1) a rhomboid **anterior fontanelle** (*fonticulus anterior*) located on the midline at the intersection of four sutures (saggital, frontal, and two halves of the coronary sutures); it closes in the second year of life; (2) a triangular **posterior fontanelle** (*fonticulus posterior*), at the posterior end of the sagittal suture between the two parietal bones in front and the squama of the occipital bone at the back; it closes in the second month after birth, (3) paired lateral fontanelles, two on each side; the anterior one is called **sphenoidal** (*fonticulus sphenoidalis*) and the posterior one is called **mastoid** (*fonticulus mastoideus*). The sphenoidal fontanelle is at the junction of the mastoid angle of the parietal bone, the greater wing of the sphenoid bone, and the squama of the temporal bone; it closes in the second or third month of life. The mastoid fontanelle is between the mastoid angle of the parietal bone, the base of the pyramid of the temporal bone, and the squama of the occipital bone. The sphenoidal and mastoid fontanelles are mostly found in premature infants; some full-term infants may also have no occipital (posterior) fontanelle.

At mature age, the cranial sutures disappear (obliterate) because the syndesmoses between the bones of the vault are converted to synostosis. At old age, the bones of the skull are often thinner and lighter. As the result of the loss of teeth and the atrophy of the alveolar margins of the jaw bones, the face becomes shorter and the lower jaw protrudes forward, while the angle formed by the ramus and the body increases.

**GENERAL INFORMATION ON BONE ARTICULATIONS**

**GENERAL SYNDESMOLOGY**

Bone fusion by connective or (later) cartilaginous tissue was the elementary form of bone joining (in lower aquatic vertebrates). Such compact joining of bones, however, limits the volume of movements. With the formation of bony levers of movement, slits and cavities began appearing in the interstitial tissue between the bones because of its resorption. As a result a new type of bone joining, interrupted joining, articulation, developed.

Thus, two types of bone joining developed in the process of phylogenesis:
the elementary, compact joining with a limited range of movements and a later, interrupted type allowing wide movements. According to development, structure, and function, all bone articulations (articulationes ossium) can be divided into two large groups

1. *Contiguous* articulations, *synarthroses* (BNA), earliest in development, fixed in function or allowing slight movement.

2. *Interrupted* (synovial) articulations, *diarthroses* (BNA), latest in development and permitting more movements functionally. Between these forms there is a transitional form, from contiguous to interrupted or vice versa. It is characterized by the presence of a small gap which does not have the structure of a true articular cavity, and because of this the articulation is called a half-joint, or *hemiarthrosis*.

Schematically Representation of Bone Joining

**CONTIGUOUS ARTICULATIONS (SYNARTHROSES)**

The following three types of synarthroses are distinguished

I. If connective tissue remains in the space between the bones after birth, they become joined by means of this tissue and the joint is called *fibrous* (*articulationes fibrosa*), or syndesmosis (Gk. *syndesmos* ligament).
II. If the intermediate connective tissue transforms to cartilaginous tissue, which remains after birth, the bones become joined by means of cartilaginous tissue, and the joint is called cartilaginous (articulationes cartilaginae) or synchondrosis (Gk. syn together, chondros cartilage).

III. Finally, if the connective tissue between the bones transforms to bone tissue (in desmal osteogenesis) or first to cartilaginous and then to bone tissue (in chondral osteogenesis), the bones become joined by means of bone tissue, and the joint is called synostosis (BNA).

TYPES OF SYNDESMOSES

Syndesmosis (articulatio fibrosa) is contiguous joining of bones by means of connective tissue.

1. If the connective tissue fills a large space between the bones, the articulation acquires the form of interosseous membranes (membrana interossea), for instance between the bones of the forearm or leg.

2. If the connective tissue between the bones has the structure of fibrous bundles, fibrous ligaments (ligamenta) form in all the joints. In some places (e.g. between the vertebral arches), the ligaments are composed of elastic connective tissue (synelastosis, BNA) and are consequently yellow in colour (ligamenta flava).

3. Until wide remnants of the primary connective tissue remain between the bones of the skull-cap, the joints are called fontanelles (fonticuli).

4. When the intermediate connective tissue takes the character of a thin layer between the skull bones, sutures (suturae) form. The following sutures are distinguished according to the shape of the articulating bone margins:

   (a) serrate (sutura serrata), when the projections on the margin of one bone fit between the projections on the opposing bone (most bones of the skull-cap articulate in this fashion);

   (b) squamous (sutura squamosa), when the margin of one bone overlaps that of the opposing, bone (articulation between the margins of the temporal and parietal bones);
(c) plane (sutura plana), apposition of smooth margins (joining of the bones of the facial cranium)

**TYPES OF SYNCHONDROSES**

According to the property of the cartilaginous tissue (whether hyaline or fibrous), the following types of synchondrosis are distinguished: (1) *hyaline*, e.g. between the ribs and the sternum, and (2) *fibrous*. Fibrous synchondrosis occurs in places of high resistance to mechanical factors, for instance, between the vertebral bodies. Because of its resilience it serves as a buffer of jolts and shocks.

The following synchondroses are distinguished according to the duration of their existence:

1. **Temporary**, existing only to a definite age after which they are replaced by synostoses, for instance, synchondrosis between the epiphysis and metaphysis or between the three bones of the pelvic girdle which fuse to form a single pelvic bone. Temporary synchondroses are the second phase of skeletal development.

2. **Permanent**, existing throughout life, for instance, synchondroses between the pyramid of the temporal bone and the sphenoid bone, between the pyramid and the occipital bone.

**INTERRUPTED (SYNOVIAL) ARTICULATIONS, JOINTS**

**DIARTROSES**

A joint is an interrupted, cavitary, mobile articulation (*articulatio synovialis*) (Gk. *arthron* joint, hence *arthritis*, inflammation of a joint). Articular surfaces of the articulating bones, the articular capsule enclosing the articular ends of the bones, and a joint cavity within the capsule between the bones are distinguished in each joint.

1. The **articular surfaces** (*facies articales*) are covered by **articular cartilage** (*cartilago articularis*), which is hyaline, less frequently fibrous, and 0.2-0.5 mm thick.

2. The articular capsule (*capsula articularis*) encloses the joint cavity hermetically and is attached to the articulating bones along the margin of the articular surfaces or at some distance from them. It consists of an outer **fibrous membrane** (*membrana fibrosa*) and an inner **synovial membrane** (*membrana
The synovial membrane surface facing the joint cavity is lined with a layer of endothelial cells which makes it smooth and shiny. The membrane secretes a sticky, clear synovial fluid (synouia) into the cavity of the joint.

3. The joint cavity (cavitas articularis) is a closed, air-tight slit bounded by the articular surfaces and the synovial membrane. Under normal conditions it is not an empty cavity but contains synovial fluid which moistens and lubricates the articular surfaces and lessens the friction between them.

JOINT BIOMECHANICS

In the organism of a living human, joints play a triple role

(1) they help to maintain body posture; (2) they contribute to the transposition of body parts in relation to one another; (3) they are organs of locomotion of the body in the environment.

The following types of movements at the joints are distinguished:

1. Movement on the frontal transverse (horizontal) axis: flexion (flexio), i.e. a reduction of the angle formed by the articulating bones, and extension (extensio), i.e. increase of this angle.

2. Movements on the sagittal (horizontal) axis: adduction (adductio), i.e. drawing towards the median plane, and abduction (abductio), i.e. drawing away from it.

3. Movements on the vertical axis, i.e. rotation (rotatio), inward and outward or to the right and to the left.

4. Movement in a circular manner, circumduction (circumductio), by changing from one axis to another with one end of the bone describing a circle and the whole bone describing the figure of a cone.

CLASSIFICATION AND GENERAL CHARACTERISTICS OF JOINTS

The classification of joints can be based on the following principles: (1) the number of articular surfaces; (2) the shape of the articular surfaces; and (3) function.

The following joints are distinguished according to the number of articular surfaces

1. Simple joint (art. simplex), which has only two articular surfaces, e.g. the interphalangeal joints.
2. **Compound joint** (*art. composita*), which has more than two articulating surfaces, e.g. the elbow joint.

3. **Complex joint** (*art. complexa*) contains an intra-articular cartilage in the articular capsule. This cartilage divides the joint into two compartments (a bilocular joint) either completely (if the intra-articular cartilage is shaped like a disc, e.g. in the temporomandibular joint) or incompletely (if the cartilage is a crescentic meniscus, e.g. in the knee joint).

4. **Combined joint** is a combination of several isolated joints, located separately but functioning together. Such are, for example, the two temporomandibular joints, the proximal and distal radio-ulnar joints, and others.

*According to shape and function, joints are classified as follows.*

The function of a joint is determined by the number of axes on which the movement occurs. The number of axes on which movements are accomplished in the given joint, in turn, depends on the *shape* of the articulating surfaces.

**UNIAXIAL JOINTS**

1. **Trochoid joint** (*art. trochoidea*). This is a cylindrical or wheel-like articular surface (Gk. *trochos* wheel, *eidos* form) whose axis is a vertical line running parallel to the long axis of the articulating bones or to the vertical body axis; it permits movements on one vertical axis, i.e. rotation; it is also called the *pivot joint*.

2. **Hinge joint** (*ginglymus*) (Gk. *ginglymos* hinge). An example are the interphalangeal joints of the fingers and toes. The articular surface is a cylinder stretching transversely whose long axis is a transverse line running in the frontal plane perpendicular to the long axis of the articulating bones; as a result movements at a hinge joint are made on this frontal axis (flexion and extension). A guiding groove and crest on the articulating surfaces prevent lateral slipping and facilitate movement on a single axis,

**BIAXIAL JOINTS**

1. **Ellipsoid joint** (*articulatio ellipsoidea*) (for instance, the radiocarpal or wrist joint). The articulating surfaces are segments of an ellipse: one of them is
convex, oval and unequally curved in two directions; the other is correspondingly concave. They allow movements on two horizontal axes which are perpendicular to each other: flexion and extension on the frontal axis and adduction on the sagittal axis.

2. **Condyloid joint** (*articulatio condylaris*) (e.g. the knee joint). A condyloid joint has a convex articular head in the form at a protruding rounded process which resembles an ellipse in shape and is called a *condyle* (*condylus*) (Gk. *kondylos knuckle*).

3. **Saddle joint** (*articulatio sellaris*) (e.g. the carpometacarpal joint of the thumb). This joint is formed by two saddle-shaped articulating surfaces, one "astride" the other moving lengthwise and across the other. As a result this joint allows movement on two mutually perpendicular axes: frontal (flexion and extension) and sagittal (abduction and adduction).

Biaxial joints also permit a change of movement from one axis to another, i.e. movement in a circular manner (circumduction).

**MULTIAXIAL JOINTS**

1. **Ball-and-socket joint** (*art. spheroida*) (e.g. the shoulder joint). One of the articular surfaces forms a convex spherical head, the other—a correspondingly concave articular cavity. Theoretically, movements can occur on many axes which correspond to the radii of a sphere. Practically, however, only the following three main axes, perpendicular to each other and intersecting in the center of the head, are distinguished: (1) the transverse (frontal) axis, the site of forward flexion, anteflexion, when the moving part together with the frontal plane forms an angle open to the front, and of backward flexion, retroflexion, when the angle is open to the back; (2) the anteroposterior (sagittal) axis, on which abduction and adduction are accomplished; and (3) the vertical axis, on whose circumference inward and outward rotation occurs. Circumduction takes place when movement changes from one axis to another. The ball-and-socket joint is the most freely mobile joint.

A variety of the ball-and-socket articulation is the **cotyloid joint** (*art. cotylica*) (Gk. *kotyle cup*). Its articular fossa is deep and embraces the greater part of the head. As a result movement is more restricted at the joint than at a
typical ball-and-socket joint. An example of this type of articulation is the hip joint in which the construction lends greater stability to the joint.

2. Plane joints (art. plana) (e.g. the intervertebral joints). The articular surfaces in these joints are almost flat. They can be regarded as the surfaces of a sphere with a very large radius. They consequently allow movement on all three axes, but the range of movement is small because the articular surfaces differ only slightly.

**JOINTS BETWEEN THE VERTEBRAL BODIES**

The vertebral bodies forming the vertebral column proper which supports the trunk unite one with another (and also with the sacrum) by means of synchondroses called intervertebral cartilages or discs (disci intervertebrales) or by means of hemiarthroses if there are clefts between them. Each disc is a fibrocartilaginous plate whose periphery is formed of concentric layers of connective-tissue fibres. These fibres form a very strong peripheral fibrous ring (anulus fibrosus), while the central part of the plate is a gelatinous nucleus (nucleus pulposus) consisting of soft fibrous cartilage (remnant of the notochord). This nucleus is under considerable pressure and continuously tends to distend (on cross-section of the disc it protrudes markedly above the level of the section) and is therefore resilient and acts as a buffer.

The column of vertebral bodies united by the intervertebral discs is reinforced by two longitudinal ligaments running in front and back on the median line. The anterior longitudinal ligament (lig. longitudinale anterius) stretches on the anterior surface of the vertebral bodies and discs from the tubercle on the anterior arch of the atlas to the upper part of the pelvic surface of the atlas where it is lost in the periosteum. This ligament prevents abnormal backward extension of the spine. The posterior longitudinal ligament (lig. longitudinale posterius) extends from the second cervical vertebra downward on the posterior surface of the vertebral bodies in the vertebral canal to the upper end of the canalis sacralis. It hinders flexion and is a functional antagonist of the anterior longitudinal ligament.
JOINTS BETWEEN THE VERTEBRAL ARCHES

The arches are united by joints and ligaments located both between the arches themselves and between their processes.

1. Union between the articular processes is accomplished by the intervertebral joints (articulationes intervertebrales). Since these are flat, tight joints, which are limited in movement, they limit flexibility of the spine and give it a definite direction in conformity with the position of the articular surfaces in the different parts of the spine (multiaxial joints).

2. The spaces between the arches are filled by elastic fibres of yellow colour which are, therefore, called yellow ligaments (ligamenta flava).

3. The ligaments between the spinous processes, the interspinous ligaments (ligamenta interspinalia), are developed most markedly in the lumbar region. A roundish band continuous with the interspinous ligaments in the back stretches over the apices of the spinous processes as a long supraspinous ligament (lig. supraspinale). In the cervical part of the spine the interspinous ligaments stretch beyond the apices of the spinous processes and form the sagittal nuchal ligament (lig. nuchae). It is triangular. One of its sides is attached to the spinous processes, another to the external occipital crest, while the third, free side stretches from the seventh cervical vertebra to the external occipital protuberance.

4. Ligaments between the transverse processes, the intertransverse ligaments (ligamenta intertransversaria), limit lateral movements of the spine to the contralateral side.

JOINTS BETWEEN THE SACRUM AND COCCYX

The joints between the sacrum and coccyx are similar to those between the vertebrae described above but are less pronounced because the coccygeal vertebrae are rudimentary. The body of the fifth sacral vertebra unites with the coccyx by means of the intervertebral cartilage; the cartilage has a small cavity in it which allows the coccyx to bend backward during childbirth.

THE UNION OF THE VERTEBRAL COLUMN WITH THE SKULL

The vertebral column is joined to the skull by a combination of several joints permitting movement on three axes as in a ball-and-socket joint.
1. The **atlanto-occipital joint** (*art. atlantooccipitalis*) is a condyloid joint; it is formed by two condyles of the occipital bone, spondyli occipitales, and the concave articular surfaces (facets) of the atlas, fovea articaulares superiores atlantis. Both pairs of the articulating surfaces are enclosed in separate articular capsules but move simultaneously, forming a single combined joint. There are the following auxiliary ligaments: (1) the **anterior atlanto-occipital membrane** (*membrana atlantooccipitalis anterior*) stretched between the anterior arch of the atlas and the occipital bone; (2) the posterior atlanto-occipital membrane (*membrana atlantooccipitalis posterior*) located between the posterior arch of the atlas and the posterior margin of the foramen magnum. The atlanto-occipital joint allows *movement* on two axes, the frontal and the sagittal.

2. The atlas and the axial vertebra unite by means of three joints. Two lateral atlanto-axial joints (*articulationes atlantoaxiales laterales*) are formed by the inferior articular surfaces of the atlas and the similar superior surfaces of the axis contiguous to them, thus making up a combined joint. The odontoid process (*dens axis*) located in the middle is joined with the anterior arch of the atlas and the transverse ligament of the atlas (*lig. transversum atlantis*) stretched between the inner surfaces of the lateral masses of the atlas.

   The transverse ligament is fibrocartilaginous at its articulation with the dens. The dens is therefore enclosed in a osteofibrous ring formed by the anterior arch of the atlas and the transverse ligament, as a result of which a trochoid joint forms, the **median atlanto-axial joint** (*art. atlanto-axialis mediana*).

   Two fibrous bands which had separated from the posterior longitudinal ligament of the spine arise from the superior and inferior edges of the transverse ligament: one stretches upward to the anterior edge of the foramen magnum, the other passes downward to the posterior surface of the axial body. Together with the transverse ligament these two bands form the **cruciform ligament of the axis** (*lig. cruciforme atlantis*).

   An accessory ligament of the joints described is the apical ligament of the odontoid process (*lig. apicis dentis*) extending from the tip of the dens to the
anterior edge of the foramen magnum. Two strong ligaments, alar ligaments of
the odontoid process (ligamenta alaria) pass from the lateral surfaces of the dens
and are attached to the medial surfaces of the condyles of the occipital bone.
The whole apparatus of ligaments described is covered posteriorly from the aspect
of the vertebral canal by the membrana tectoria stretching from the clivus of the
sphenoid bone and anterior edge of the foramen magnum to the body of the
second cervical vertebra (it is continuous with the posterior longitudinal ligament
of the spine).

The atlanto-axial joints permit only a single type of movement, rotation of
the head on the vertical axis (turning right and left, an expression of
disagreement) passing through the dens of the axial vertebra; the head moves
about the dens together with the atlas (trochoid joint). Movements occur the
same time at the lateral atlanto-axial joints.

THE VERTEBRAL COLUMN AS A WHOLE

Although the spine is a vertical column, it is not straight but curved in the
sagittal plane. The curvatures in the thoracic and sacral parts are posteriorly
convex, while those in the cervical and lumbar segments are anteriorly convex.
A curvature posteriorly convex is called kyphosis; an anteriorly convex curvature
is called lordosis. The spine of a newborn is almost straight and the curvatures
are hardly formed. When the infant begins to raise his head, a curvature forms
in the neck, and the head, whose greatest part is held to the front of the spine,
tends to bend down. To hold the head raised, the spine curves forward. As a
result a cervical lordosis forms. Then, when a sitting posture is adopted, the
thoracic kyphosis increases, and later, when the child learns to stand and walk,
the main curvature, the lumbar lordosis, forms. With the formation of the lumbar
lordosis, the pelvis, to which the limbs are attached, tilts; to remain in the vertical
position, the spine must curve in the lumbar region as a result of which the
centre of gravity is displaced to the back of the hip joint axis. This prevents the
trunk from falling forward, important in that they absorb the jerks and shocks
directed along the spine in jumping and even in simple walking; the force of the
shock is spent on increasing the curvature, without reaching fully the skull and
the brain at full force. Besides the mentioned curvatures in the sagittal plane, a less pronounced convex to the right (less frequently to the left) thoracic curvature in the frontal plane is detectable. This lateral curvature, called scoliosis, has been given different explanations. According to the latest data, it is a pathological condition not inherent in healthy individuals and is acquired after birth. For instance, marked lateral deformity of the spine may develop in schoolchildren who sit motionless for a long time in an improper, bent posture, particularly when writing; the condition is called school scoliosis. Some occupations involving habitual distortion of the trunk also lead to drastic scoliosis. Rational physical exercises are necessary to prevent scoliosis.

JOINTS OF THE RIBS

A. Joints of the ribs and the sternum. The seven true ribs articulate with the sternum by means of their cartilages; the cartilage of the first rib fuses directly with the sternum (synchondrosis), while the remaining costal cartilages commonly form sternocostal joints (articulationes sternocostales). The joint capsule here is replaced by perichondrium, continuous with the periosteum of the sternum. Anteriorly and posteriorly the joints are strengthened by sternocostal ligaments (ligamenta sternocostalia radiata) which together with the periosteum on the anterior surface of the sternum form the thick sternal membrane (membrana sterni). Each false rib (eighth, ninth, and tenth) is connected by the anterior end of its cartilage to the inferior border of the cartilage of the rib above by dense connective tissue fusion (syndesmosis).

According to some data, the tenth pair of ribs usually fails to fuse with the cartilage of the rib above and is free, mobile and does not contribute to the formation of the costal arch, in which event the arch is formed by the seventh, eighth, and ninth ribs. Interchondral joints (articulationes interchondrales) form between the cartilages of the sixth, seventh, eighth and, sometimes, the fifth ribs; the perichondrium is their articular capsule.

B. Joints of the ribs and vertebrae, costovertebral joints (Fig. 40). 1. Joints of the heads of ribs (articulationes capitis costae) are formed by the articular facets of the heads of the ribs and the fovea costales of the thoracic vertebrae. The
facets on the heads of the second to tenth ribs articulate each with the fovea costales of two adjacent vertebrae. An intra-articular ligament of the joint of the head of the rib (lig. capitis costae intraarticulare) runs from the crest of the costal head to the intervertebral disc; it separates the joint cavity into two compartments. Since the heads of the first, eleventh, and twelfth ribs articulate with a single fovea costalis on the body of the corresponding vertebra and therefore have no crest, these joints do not have an interarticular ligament. The articulationes capitis costae are surrounded by a thin articular capsule, which is strengthened anteriorly by an accessory radiate ligament of the joint of the head of a rib (lig. capitis costae radiatum).

2. Costotransverse joints (articulationes costotransversariae) form between the tubercles of the ribs and the articular facets of the transverse processes. The last two (eleventh and twelfth) ribs do not have these joints.

The costotransverse joints are strengthened by accessory inferior costotransverse ligaments (ligamenta costotransversaria). Both articulations of the ribs with the vertebrae function as a single combined joint (pivotal) with the pivotal axis passing through the neck of the rib.

THE THORACIC CAGE AS A WHOLE

The thoracic cage (compages thoracic, thorax) is ovoid with a narrow upper end and a wider lower end. Both ends are cut slantwise, the upper part from the front upward to the back and the lower part in the opposite direction. In addition, the thorax is somewhat compressed from front to back. The anterior wall, of which the sternum is a component is shorter than the posterior wall in the formation of which the vertebral column takes part. The thoracic cavity (cavum thoracis) has two apertures: the superior aperture (inlet) (apertura thoracis superior) and the inferior aperture (outlet) (apertura thoracis inferior), which is closed by a muscular partition the diaphragm.

The anterior border of the inferior aperture has an incisure shaped like an angle, the infrasternal angle of the thorax (angulus infrasternalis) the xiphoid process is located at its apex. The vertebral column protrude into the thoracic cavity on the
midline and the above-mentioned wide pulmonary sulci (sulci pulmonales) form to the sides of the column between it and the ribs; the posterior margins of the lungs are lodged in them. The spaces between the ribs are called **intercostal spaces** (spatia intercostalia).

**THE JOINTS OF THE SHOULDER GIRDLE**

1. The **sternoclavicular joint** (*articulatio sternoclavicularis*) is formed by the sternal end of the clavicle and the clavicular notch of the sternum. The articular surfaces are complemented by an **intra-articular disc** (*discus articularis*). The articular cavity is fastened by ligaments: the anterior and posterior sternoclavicular ligaments (*ligamenta sternoclavicularare anterius* and *posterius*) in front and behind; the **costoclavicular ligament** (*lig. costoclaviculare*) below (to the cartilage of the first rib); and the **interclavicular ligament** (*lig. interclaviculare*) above (between the clavicles, above the jugular notch). The articulation resembles a spheroid joint to a certain measure. The main *movements* are made on the sagittal (anteroposterior) axis, on raising and lowering the clavicle, and on the vertical axis, in forward and backward movements of the clavicle. Rotation of the clavicle on its long axis is also possible.

2. The **acromioclavicular joint** (*articulatio acromioclavicularis*) joins the acromial process of the scapula with the acromial end of the clavicle whose flat articular surfaces are often separated by an intra-articular disc (*discus articularis*). The articular capsule is reinforced by the acromioclavicular ligament (*lig. acromioclaviculare*), and the whole joint is strengthened by a powerful coracoclavicular ligament (*lig. coracoclavicularis*) stretching between the inferior surface of the clavicle and the coracoid process of the scapula.

3. **The ligaments of the scapula.** In addition to the ligaments connecting the clavicle to the scapula, the scapula has three ligaments of its own which have no relation to the joints. One of them, the **coracoacromia ligament** (*lig. coracoacromiale*) extends as a vault above the shoulder joint between the anterior edge of the acromial process and the coracoid process. Another, the **superior transverse scapular ligament** (*lig. transversum scapulae superius*),
stretches above the scapular notch and converts it into a foramen. Finally, a third ligament, the **inferior transverse scapular ligament** (*lig. transversus scapulae inferius*) is weaker and passes from the base of the acromial process through the scapular neck to the posterior border of the glenoid cavity; the suprascapular artery runs under it.

### The Shoulder Joint

The shoulder joint (*articulatio humeri*) connects the humerus, and through it, the whole free upper limb, with the shoulder girdle, the scapula in particular. The head of the humerus contributing to the formation of the joint is spherical. The glenoid cavity of the scapula articulating with it is shallow. On the circumference of the cavity is a cartilaginous glenoid lip (*labrum glenoidale*), which increases its depth without limiting the range of movements and also absorbs the jerks and shocks during movement of the head. The articular capsule of the shoulder joint is free and thin; it is attached to the bony edge of the scapular glenoid cavity, embraces the humeral head, and terminates on the anatomical neck; it bridges the intertubercular groove with the long head of the biceps muscle lodged here. The **coracohumeral ligament** (*lig. coracohumerale*), stretching from the root of the coracoid process to the greater tubercle of the humerus, is a slightly thicker bunch of fibres serving as an accessory ligament.

The synovial membrane lining the capsule of the joint has two extraarticular protrusions. The first, the **intertubercular synovial sheath** (*vagina synovialis intertubercularis*) encompasses the long head of the biceps muscle passing in this groove like a cylinder; the other protrusion, the **subtendinous bursa of the subscapularis muscle** (*bursa subtendinea m. subscapularis*) is above the upper part of the subscapular muscle and extends to the root of the coracoid process.

The shoulder joint, typical ball-and-socket joint, is distinguished by freedom of movement. As with all joints of this general type, movement at the shoulder joint takes place on three main axes: frontal, sagittal, and vertical. Circumduction is also possible.

### The Elbow Joint

The **elbow joint** (*articulatio cubiti*). Three bones articulate in the elbow
joint (Fig. 84): the distal end of the humerus and the proximal ends of the ulna and radius. The articulating bones form three joints invested in a common capsule (a compound joint): the **humeroulnar articulation** (*articulatio humeroulnaris*), the **humeroradial articulation** (*articulatio humeroradialis*), and the **proximal radioulnar articulation** (*articulatio radioulnaris proximalis*). The latter functions with the distal radioulnar articulation, thus forming a **complex joint**.

The **humeroulnar articulation** is a hinge joint with spirally deviating articular surfaces. The articular surface of the humerus is the trochlea; the groove (guiding) in it is not perpendicular to its axis but forms a certain angle with it, which facilitates spiral movements. The trochlea is joined with the ulnar trochlear notch, which has a guiding crest corresponding to a similar notch on the trochlea of the humerus.

The **humeroradial articulation** is formed by union of the humeral head with the concave surface of the radial head. Although this articulation is a ball-and-socket joint in shape, it actually permits movement on only two axes at the elbow joint since it is merely a part of this joint and is connected to the ulna, which limits its movement.

The **proximal radioulnar articulation** is formed by the articulating surfaces, the circumferentia articularis radii and the incisura radialis ulnae and is cylindrical.

The articular capsule embraces the cubital fossa on the posterior surface of the humerus and the coronary and radial fossae on the anterior surface but leaves the epicondyles free. It is attached on the ulna to the edge of the trochlear notch and on the radius to the neck and forms a protrusion of the **synovial membrane** (*recessus sacciformis*) in front. In front and behind the capsule is free, but on its sides are accessory ligaments, the **ulnar collateral** (lateral) and the **radial collateral** (medial) **ligaments** (*lig. collaterale ulnare* and *collaterale radiale*), **the anular ligament of** the radius (*lig. anulare radii*).

Movements at the elbow joint are of two kinds. Firstly, flexion and extension of the forearm on the frontal axis occur; these movements take place at the articulation of the ulna with the trochlea of the humerus.
The second movement consisting in rotation of the radius on the longitudinal axis occurs in the humeroradial articulation as well as in the proximal and distal radioulnar articulations, which are thus a combined pivotal joint from the mechanical standpoint. Since the hand is joined to the lower end of the radius it follows this bone in movement. The movement during which the rotating radius crosses the ulna at an angle while the hand turns so that its dorsal surface faces upward (with the limb extended forward) is called *pronation* (the state of being prone). The opposite movement, in which the forearm bones are parallel while the hand is turned with the palm facing upward, is called *supination* (a position on the back).

**Joints of the Hand Bones**

1. The **joints of the hand** (*articulationes manus*) join the forearm with the hand. They are a complex joint consisting of two parts, proximal and distal which are separated by the first row of carpal bones playing the role of a bony meniscus.

   A. The proximal part, the radiocarpal, or wrist joint (*art. radiocarpea*). In most mammals it is pulley-shaped, and the ulna and radius contribute equally to its formation. With the gradual development of pronation and supination, a separate joint develops between the radius and ulna the distal radioulnar joint (*art. radioulnaris distalis*). Together with the proximal radioulnar joint, it forms a single complex articulation with a vertical pivotal axis.

   The development of the distal ulnar epiphysis, in contrast, is delayed, and it becomes shorter than the radial epiphysis, but, to make up for this, a special cartilaginous disc (*discus articularis*) appears on it. In man, due to the greatest range of supination and pronation, the disc becomes highly developed and acquires the shape of a triangular fibrocartilaginous plate (*fibrocartilago triangulare*). Its apex fuses with the styloid process of the ulna, the base with the medial border of the radius, and together with the carpal articular surface of the radius, the triangular fibrocartilaginous plate forms the articular concave surface of the proximal part of the hand joints. The ulna, therefore, participates in the wrist joint only by means of this cartilaginous disc and is not directly related to it. The proximal part of the hand joints is, consequently, called the radiocarpal and not the antebrachium carpal joint.

   Accordingly, the concave articular surface of the radiocarpal joint is
formed by the carpal articular surface of the radius and the triangular disc while the articular head is formed by the proximal surface of the first row of carpals, the scaphoid and triquetral bones, which are united by inter-carpeal ligaments (ligamenta intercarpea). According to the number of bones forming it, the joint is complex, while according to the shape of the articular surfaces, it is an ellipsoid joint with two pivotal axes (sagittal and frontal).

B. The distal part, the **mediocarpal** or **midcarpal joint** (art. mediocarpea) in located between two rows of carpal bones, with the exception of the pisiform bone which is a sesamoid bone.

Both carpal joints (radiocarpal and midcarpal) possess their own articular capsules attached to the margins of the articular surfaces. Accessory ligaments reinforce the capsule of the radiocarpal joint on the radial and ulnar sides. These are the lateral ligament (lig. collaterale carpi radiale) passing from the styloid process of the radius to the scaphoid bone, and the medial ligament (lig. collaterale carpi ulnare) stretching from the styloid process of the ulna to the triquetral and pisiform, bones. On the palmar surface of the radiocarpal joint is the anterior radiocarpal ligament (lig. radiocarpeum palmare).

On the dorsal surface, the capsule of the radiocarpal joint is reinforced by the posterior radiocarpal ligament (lig. radiocarpeum dorsale) passing from the radius to the bones of the first carpal row.

Besides the midcarpal joint, there are intercarpal joints (articulationes intercarpeae), formed by some of the carpal bones interconnected by interosseous intercarpal ligaments (ligamenta intercarpea interossea) and articulating with one another by contiguous articulation surfaces.

Fibrous bands spread from the capitate bone on the palmer surface to the neighbouring bones; this is the radial carpal ligament (lig. carpi radiatum).

The flexer retinaculum (retinaculum flexorum, s. lig. carpi transversum) [BNA], bears no direct relation to the hand joints; it stretches between the eminentia carpi radialis and the eminentia carpi ulnaris and thus bridges the carpal sulcus and converts it into the carpal tunnel (canalis carpi). This canal transmits the median nerve and the tendons of the finger flexors; hence the
The **carpometacarpal joints** (*articulationes carpometacarpeae*) are formed by the second row of carpal bones and the bases of the metacarpals. With the exception of the carpometacarpal joint of the thumb, all these joints are plane articulations and are strengthened from both the dorsal and the palmar surfaces by the tightly stretched **dorsal** and **palmar carpometacarpal ligaments** (*ligamenta carpometacarpea dorsalis* and *palmaris*), as a result of which they permit a very small range of movement.

The common cavity of the carpometacarpal joints is encompassed by a capsule and is shaped like a transverse cleft communicating with the midcarpal articulation and the **intermetacarpal joints** (*articulationes intermetacarpeae*). These are unions between the adjacent bases of the last four metacarpals; the articulating surfaces of the bases of these bones are connected by means of strong ligaments, the **interosseous metacarpal ligaments** (*ligamenta metacarpea interossea*). The capsules of the intermetacarpal joints are reinforced by transversely passing **dorsal** and **palmar metacarpal ligaments** (*ligamenta metacarpea dorsalis* and *palmaris*).

The carpometacarpal joint of the thumb (**art. carpometacarpea pollicis**) is absolutely isolated from the other carpometacarpal joints and differs from them sharply in structure and movements. It is formed by the saddle-shaped articular surfaces of the trapezium bone and the base of the first metacarpal, which are invested in a wide articular capsule. Since it is an atypical joint, it permits movements on two mutually perpendicular axes.

The thumb is displaced toward the palm flexion and set in opposition to the little finger and the other fingers. This movement is called **opposition**. Movement in the opposite direction is called **reposition**. Movements on the anteroposterior axis consist in abduction and adduction of the thumb to the index finger.

The **metacarpophalangeal joints** (*articulationes metacarpophalangeae*), between the convex heads of the metacarpals and the facets on the base of the proximal phalanges, are rather ellipsoid in character. The ligament apparatus
consists of a loose capsule and two accessory collateral ligaments (*ligamenta collateralalia*) passing obliquely from the depressions on the radial and ulnar surfaces of the metacarpal heads to the sides of the base of the proximal phalanges. On the palmar aspect of the capsule is a thickening containing a fibrous cartilage, the palmar ligament (*lig. palmar*). Connected with this thickening are strong fibrous ligaments, the deep transverse metacarpal ligaments (*ligamenta metacarpea transversa profunda*), stretched between the heads of the second, to fifth metacarpals on the palmar surface. Movements at the metacarpophalangeal joints take place on two axes: flexion and extension of the whole finger with a range of movements of 90-100 degrees occur on the transverse axis, abduction and adduction of the finger (a range of 45-50 degrees) occur on the anteroposterior axis.

The interphalangeal joints (*articulationes interphalangeae manus*) between the head and base of the adjoining phalanges are typical hinge joints allowing flexion and extension on a transverse (frontal) axis. The range of movements is 110-112 degrees at the proximal interphalangeal joints and 80-90 degrees at the distal joints. Accessory collateral ligaments (*ligamenta collateralalia*) pass on the sides of the joints.

JOINTS OF THE PELVIC BONES

All types of joints reflecting the successive developmental stages of the skeleton are encountered in the human pelvis: synarthroses in the form of syndesmoses (ligaments); synchondroses (between the separate parts of the hip bone) and synostoses (after their fusion to form the hip bone); hemiarthroses (the pubic symphysis) and diarthroses (the sacro-iliac joint). The total range of movements between the pelvic bones is very small (4 to 10 degrees).

1. The sacro-iliac joint (*art. sacroiliaca*) is formed by the contiguous auricular surfaces of the sacrum and ilium. These surfaces are congruous and covered by a thin layer of fibrous cartilage. The sacrum is wedged between the two iliac bones, as a result of which it cannot be displaced anteriorly and downward by the weight of the trunk until the bracings of the pelvic vault are separated; the sacrum is therefore the *key of the pelvis* (Lesgaft). This key is
strengthened by the **interosseous sacro-iliac ligaments** (*ligamenta sacroiliaca interossea*) stretching in the form of short bundles between the iliac tuberosity and the sacrum.

The joint, is strengthened also by other ligaments connecting the sacrum to the ilium: anteriorly by the anterior sacro-iliac ligaments (*ligamenta sacroiliaca ventralia*) (which are tightly fused with the capsule) and posteriorly by the posterior sacro-iliac ligaments (*ligamenta sacroiliaca dorsalia*) running downward from the superior and inferior posterior iliac spine, to the sacral vertebrae, and by the iliolumbar ligament (*lig. iliolumbale*) stretched between the transverse process of the fifth lumbar vertebra and the iliac crest.

2. The **pubic symphysis (symphysis pubica)** is on the midline and joins the pubic bones. A fibrocartilaginous plate, the interpubic disc (*discus interpubicus*) is lodged between the facies symphysialis of these bones, which face each other and are covered with hyaline cartilage. A narrow synovial slit-like cavity is seen in this disc nearer to its posterior surface (hemiarthrosis) usually from the age of 7 years. The pubic symphysis is strengthened by thick periosteum and ligaments, above by the superior pubic ligament (*lig. pubicum superius*) and below by the arcuate ligament (*lig. arcuatum pubis*), which rounds off the subpubic angle (*angulus subpubicus*).

3. The sacrotuberal and sacrospinal ligaments are two strong interosseous ligaments connecting on each side the hip bone with the sacrum. The ligaments described contribute to the formation of the bony framework of the pelvis in the posteroinferior segment and transform the greater and lesser sciatic notches to the greater and lesser sciatic foramina (*foramen ischiadicum majus* and *minus*).

4. The **obturator membrane (membrana obturatoria)** is a fibrous plate closing the obturator foramen of the pelvis except in its superolateral part.

It is attached to the edges of the obturator sulcus of the pubis found here and thus converts this sulcus to the **obturator canal (canalis obturatorius)** transmitting the obturator vessels and nerves.

**THE PELVIS AS A WHOLE**

Both hip bones unite with each other and with the sacrum to form a bony
ring, the **pelvis** (Fig. 96), which connects the trunk with the free lower limbs and at the same time, encloses a cavity containing the viscera. The bony ring is divided into two parts: a wider upper part, the **greater, false pelvis** (*pelvis major*) and a narrower lower part the **lesser, true pelvis** (*pelvis minor*). The greater pelvis is bounded only laterally by ilia, which are rather widely spread out. It has no bony walls in front and the deficiency in its posterior boundary is filled by the lumbar vertebrae. The superior boundary of the lesser pelvis, separating it from the greater pelvis is the **terminal line** (*linea terminalis*) formed by the promontorium, arcuate line of the ilia, the pectines of the pubic bones, and the superior border of the pubic symphysis. The opening thus hounded is called the **pelvic inlet** (*apertura pelvis superior*). The **cavity of the true pelvis** (*cavum pelvis*) is below the inlet. Anteriorly, the wall of the pelvic cavity, formed by the pubic bones and their articulation, is very short. In contrast, posteriorly the wall is long and is formed by the sacrum and coccyx. The lateral walls of the true pelvis are formed by areas of the hip bones corresponding to the acetabuli and by the ischiac bones together with the ligaments reaching them from the sacrum. Below the pelvic cavity ends as the **pelvic outlet** (*apertura pelvis inferior*).

1. The distance between the two superior anterior iliac spines, the interspinos diameter (*distantia spinarum*), measuring 25-27 cm.
2. The distance between the two cristae iliaca, the intercristal diameter (*distantia cristarum*), measuring 28-29 cm.
3. The distance between the two greater trochanters, intertrochanteric diameter (*distantia trochanterica*), measuring 30-32 cm.
4. The distance from the symphysis to the depression between the last lumbar and first sacral vertebrae (20-21 cm). To determine the true anteroposterior diameter of the pelvis (*conjugata vera*), 9,5-10 cm are subtracted from the value of the external anteroposterior diameter. The result will be the obstetric conjugate diameter (*conjugata vera s. gynecologica*), which is usually 11 cm.

Finally, the external oblique diameter is measured.

5. The distance between the anterior and postero-superior spinae of the iliac
bones (lateral conjugate); it measures 14.5-15 cm.

6. To determine the transverse diameter of the pelvic inlet (13.5-15 cm), the intercristal diameter (29 cm) is divided by 2 or 14-15 cm are subtracted from its value.

7. To measure the transverse diameter of the pelvic outlet (11 cm), the compasses are set on the medial borders of the ischial tuberosities, and 1.0-1.5 cm are added to the value obtained (9.5 cm) for the thickness of the soft tissues.

8. To measure the anteroposterior diameter of the pelvic outlet (9-11 cm), the compasses are set on the apex of the coccyx and the inferior border of the symphysis. From the value obtained (12-12.5 cm), we subtract 1.5 cm to compensate for the thickness of the sacrum and soft tissues.

By connecting the central points of the anteroposterior diameters of the pelvis, including the outlet and inlet, the axis of the pelvis is drawn in the form of an anteriorly concave line passing through the centre of the pelvic cavity. In its natural position, the pelvis is markedly inclined anteriorly (inclinatio pelvis) so that the plane of the pelvic inlet, or the anatomical conjugate, meets the horizontal plane at an angle which is larger in females than in males. Inclination of the pelvis is due to the upright position of the human body.

Sex differences begin to be manifested most sharply with the onset of puberty. They consist in the following. The bones of the female pelvis are generally thinner and smoother than those of the male pelvis. The iliac wings are spread out more widely in females as a result of which the distance between the spines and crests is greater. The inlet of the pelvis is transversely oval in females and rather longitudinally oval in males. The promontory projects farther forward in a male pelvis. The male sacrum is relatively narrow and more concave; the female sacrum, in contrast, is relatively wider but at the same time flatter. The outlet of the pelvis is much narrower in males. In females the ischial tuberosities are further apart, and the protrusion of the coccyx to the front is less. The junction of the inferior pubic rami has the shape of an arc (arcus pubis) in a well-developed female pelvis but forms an acute angle (angulus subpubicus) in a male pelvis. The cavity of the true pelvis is definitely funnel-shaped in males but
less funnel-shaped and more cylindrical in females. In general the male pelvis is higher and narrower, while the female pelvis is shorter, wider, and roomier.

**The Hip Joint**

The hip joint (art. coxae) is formed by the cup-like acetabulum of the hip bone, by its facies lunata to be more precise, and the femoral head fitting into it. A fibrocartilaginous ring (labrum acetabulare) is attached to the whole rim of the acetabulum and makes the cavity deeper so that its depth is more that half a spheroid. The fibrocartilaginous rim bridges the acetabular notch and forms the **transverse ligament of the acetabulum** (*lig. transversum acetabuli*).

The articular capsule of the hip joint is attached along the whole rim of the acetabulum. In the region of the acetabular notch it fuses with the transverse ligament of the acetabulum, leaving a free opening between this ligament and the edges of the notch. Air-tightness of the joint here is provided by the synovial membrane covering the ligament of the head. The articular capsule is attached to the femur in front along the entire distance of the intertrochanteric line and behind to the femoral neck parallel to and medial of the intertrochanteric crest.

The hip joint has two other intra-articular ligaments, the above mentioned transverse ligament of the acetabulum and the ligament of the head (*lig. capitis femoris*) whose base is attached to the edges of the acetabular notch and to the transverse ligament of the acetabulum. The apex is attached to the fovea capitis femoris. The ligament of the head is covered by a synovial sheath rising over it from the floor of the acetabulum. It is an elastic padding which absorbs the shocks experienced by the joint and transmits the vessels to the femoral head. That is why the head does not necrotize in fractures of the femoral neck if the synovial sheath remains intact, and vice versa.

The hip joint is a ball-and-socket joint of the limited type (cotyloid joint) and therefore permits **movement**, though not as freely as a free ball-and-socket joint, on three main axes: frontal, sagittal, and vertical. Circumduction is also possible.

The external ligaments of the joint are arranged in accordance with the three main pivotal axes: three longitudinal ligaments (ligamenta iliofemorale,
pubofemorale and ischiofemorale), which pass perpendicular to the horizontal axes (frontal and sagittal), and one circular (zona orbicularis), which is perpendicular to the vertical axis.

1. The **iliofemoral (Bertin's) ligament** (*lig. iliofemorale*) is on the anterior aspect of the joint. Its apex is attached to the anterior inferior iliac spine and its widened base to the trochanteric line. The **pubofemoral ligament** (*lig. pubofemorale*) is on the inferomedial aspect of the joint; it stretches from the pubis to the lesser trochanter and blends with the capsule rotation.

2. The **ischiofemoral ligament** (*lig. ischiofemorale*) begins on the posterior aspect, of the joint at the acetabular rim in the region of the ischium passes laterally and upward over the femoral neck, blends with the capsule, and attaches to the anterior edge of the greater trochanter.

3. The **orbicular zone** (*zona orbicularis*) consists of circular fibres in the deep layers of the articular capsule under the longitudinal ligaments described above. These fibres embrace the femoral neck like a loop and attach above to the bone under the anterior inferior iliac spine the circular arrangement of the orbicular zone corresponds to the rotational movements of the thigh.

**The Knee Joint**

The **knee joint** (*art. genus*) is the largest and, at the same time, the most structurally complicated joint in the body.

Three bones form the knee joint: the lower end of the femur, the upper end of the tibia, and the patella. The articular surfaces of the femoral condyles, uniting with the tibia, are convex in the transverse and sagittal directions and are segments of an ellipsoid. The tibial facies articularis superior articulating with the femoral condyles consists of two shallow facets covered with hyaline cartilage; these facets are complemented by two intra-articular cartilages, **lateral and medial semilunar cartilages** (*menisci lateralis* and *medialis*) interposed between the femoral condyles and the articular surfaces of the tibia.

Each meniscus is a trihedral plate bent along the edge; the thickened peripheral edge is attached to the articular capsule, while the sharpened edge
directed into the joint is free.

The ends of both menisci are attached anteriorly and posteriorly to the intercondylar eminence. A fibrous bundle, the transverse ligament of the knee (*lig. transversum genus*) stretches in front between the menisci.

The **articulare capsule** is attached at some distance from the edges of the femoral, tibial and patellar articular surfaces.

In front the synovial membrane forms a large recess, the **suprapatellar bursa** (*bursa suprapatellaris*), extending rather high between the femur and the quadriceps muscle of the thigh. Sometimes the suprapatellar bursa may not communicate with the knee joint and may be separated from it. On the tibia the capsule is attached to the edges of the articular surfaces of the condyles. On the patella it is attached to the edges of the cartilaginous surface, and as a result seems to be inserted into a "frame" formed by the anterior part of the capsule.

The **medial and lateral ligaments** stretch on the sides of the joint perpendicular to their frontal axis: *ligamentum collaterale tibiale* stretches on the medial side from the medial epicondyle of the femur to the edge of the fibia and fuses with the capsule and the medial meniscus; *ligamentum collaterale fibulare* passes on the lateral side between the lateral epicondyle and the fibular head.

On the posterior aspect of the knee-joint capsule are two ligaments merging with its posterior wall, the **arcuate ligament of the knee** (*lig. popliteum arcuatum*) and the **oblique ligament of the knee** (*lig. popliteum obliquum*) (one of the three end bundles of the tendon of the semimembranous muscle).

The tendon of the quadriceps muscle of the thigh is on the anterior aspect of the knee joint. It encloses the patella as a sesamoid bone and is then continuous with a thick and strong **patellar ligament** (*lig. patellae*).

On the sides of the patella, expansions of the tendon of the quadriceps muscle form the **lateral and medial patellar retinacula** (*retinacula patellae laterale* and *mediale*) made up of vertical and horizontal bundles; the vertical bundles are attached to the tibial condyles, the horizontal to both femoral epicondyles. These bundles hold the patella in place during movement.

Besides the extra-articular ligaments described above, the knee joint has
two infra-articular ligaments called cruciate ligaments (*ligamenta cruciata genus*). One of them, the anterior ligament (*lig. cruciatum anterius*), connects the medial surface of the lateral condyle of the femur with the area intercondylaris anterior tibiae. The other, the posterior ligament (*lig. cruciatum posterius*) passes from the lateral surface of the medial femoral condyle to the area intercondylaris posterior of the tibia. The synovial membrane lining the capsule covers the cruciate ligaments projecting into the joint and forms two fat-containing alar folds (*plicae alares*) on the anterior wall of the joint below the patella. These folds become adjusted to the articular surfaces with each position of the knee joint by filling the spaces between them. Converging below they are continuous with the unpaired infrapatellar synovial fold (*plica synovialis infrapatellaris*).

In the vicinity of the joint are numerous synovial bursae, some of which communicate with it. Up to three bursae are found on the anterior surface of the patella: these are the subcutaneous prepatellar bursa (*bursa subcutanea prepatellaris*); the subfascial prepatellar bursa (*bursa prepatellaris subfascialis*), located deeper under the fascia and, finally, the subtendineous prepatellar bursa (*bursa subtendinea prepatellaris*), under the aponeurotic expansion of the quadriceps muscle. The deep infrapatellar bursa (*bursa infrapatellaris profunda*) which does not communicate with the joint is always found at the lower attachment of the patellar ligament between this ligament and the tibia. In the posterior region of the joint, bursae are encountered under the sites of attachment of almost all muscles.

Two types of movement occur at the knee joint: flexion and extension and then rotation. The knee is a typical condylar joint. Flexion and extension take place on the frontal axis passing through the femoral condyles.

In flexion the menisci straighten out, while the collateral ligaments relax because the points of their attachment come closer to each other; as a consequence, rotation on the longitudinal axis becomes possible when the knee is flexed.

**Joints between the Leg Bones**

The proximal union of the tibia and fibula, the superior tibiofibular joint (*art. tibiofibularis*) is formed by the flat articular facet on the head of the fibula
and a similar facet on the surface of the lateral tibial condyle (art. plana). The tightly stretched articular capsule attached to the edges of both articular facets is strengthened by dense *anterior* and *posterior ligaments of the superior tibiofibular joint* (*ligamenta capitis fibulae anterius* and *posterius*). The joint cavity communicates with the knee joint in almost 20 per cent of all cases.

The *interosseous membrane* of the leg (*membrana interossea cruris*) is stretched between the interosseous borders of both bones.

The *distal union* of the ends of the tibia and fibula is formed by syndesmosis or by a joint, *syndesmosis* (*articulatio*) *tibiofibularis*. This articulation is strengthened by *anterior* and *posterior tibiofibular ligaments* (*ligamenta tibiofibularis anterius* and *posterius*) passing from the lateral malleolus to the distal end of the tibia.

One difference between the joints of the forearm bones and those between the leg bones is striking. The mobility of the leg bones is extremely limited because the lower limb is concerned with the function of weight-bearing and is a strong support for the body.

**Joints of the Bones of the Foot**

According to the union of the foot with the leg bones and the union of its parts, all joints of the foot may be separated into four groups:

1. The *talocrural* or *ankle joint* (*art. talocruralis*) is formed by the articular surfaces of the distal ends of both leg bones, which fit over the trochlea of the talus like a fork; the lower articular surface of the tibia articulates with the facies articularis superior of the trochlea, while the articular surface of the malleoli articulate with the articular surfaces on the sides of the talus. The articular capsule is attached to the cartilaginous margin of the articular surfaces and covers part of the neck of the talus in front. Accessory ligaments run on the sides of the
joint from the malleoli to the adjacent tarsal bones. The medial (deltoid) ligament (lig. mediate deltoideum) has the appearance of a plate resembling the Greek letter delta in shape; the lateral ligament is formed by three bundles passing from the lateral malleolus into three different directions: forward, the anterior talofibular ligament (lig. talofibulare anterius), downward, the calcaneofibular ligament (lig. calcaneofibulare), and backward, the posterior talofibular ligament (lig. talofibulare posterius). In the character of its structure, the ankle joint is a hinge joint. Movement takes place on the frontal axis passing through the trochlea of the talus, during which the foot is now raised with the toes upward (dorsiflexion), now lowered (plantar flexion).

2. The following four joints are distinguished in the articulations between the tarsal bones, the intertarsal joints (art. intertarseae): (a) the subtalar (talocalcanean) joint (art. subtalaris); (b) the talocalcaneonavicular joint (art. talocalcaneonavicularis); (c) the calcaneocuboid joint (art. calcaneocuboidea), and (d) the cuneonavicular joint (art. cuneonaviculare).

A. The subtalar joint (art. subtalaris) is formed by the posterior articular facets of the talus and calcaneus which represent segments of a cylindrical surface. They are surrounded by an articular capsule strengthened on the sides by accessory ligaments. The cavity does not communicate with any other joint.

B. The talocalcaneonavicular joint (art. talocalcaneonavicularis) is to the front of the subtalar joint and is formed by an almost spherical talus and a corresponding articular socket formed by the navicular bone, the articular facet on the sustenaculum tali of the calcaneus, and the plantar calcaneonavicular ligament (lig. calcaneonaviculare plantare) filling the space between the sustenaculum and the posterior margin of the navicular bone.

The articular capsule is attached directly to the edge of the articular surfaces and is strengthened on the dorsal surface by the talonavicular ligament (lig. talonaviculare). The plantar calcaneonavicular ligament mentioned above serves as an accessory ligament on the plantar aspect.

Between the two joints mentioned, there is a bony canal, sinus tarsi, which lodges a strong interosseous talocalcaneal ligament (lig. talocalcaneum
C. The calcaneocuboid joint (art. calcaneocuboidea) is formed by the articular facets on the opposed surfaces of the calcaneus and the cuboid bone. It has a tightly stretched capsule strengthened by ligaments binding the articulating bones on the dorsal and plantar aspects.

The calcaneocuboid joint together with the talonavicular joint are often described under the common name transverse tarsal joint (art. tarsi transversa) or Chopart's joint. An examination of a section of the common line of Chopart's joint shows it to resemble a Latin letter S placed transversely. In addition to ligaments strengthening the calcaneocuboid and talonavicular joints separately, Chopart's joint has a ligament common to both these joints which is of great practical importance. This is the bifurcate ligament (lig. bifurcalum), which arises posteriorly on the superior border of the calcaneus and then separates into two parts one of which, the calcaneonavicular ligament (lig. calcaneonaviculare), is attached to the posterolateral border of the navicular bone, while the other, the calcaneocuboid ligament (lig. calcaneocuboideum), is attached to the dorsal surface of the cuboid bone. This short but strong ligament is the "key" to Chopart's joint since only when this ligament has been cut can the articular surfaces be drawn widely apart in an operation for the exarticulation of the foot at this joint.

D. The cuneonavicular joint (art. cuneonavicularis) is formed by articulation of the posterior articular surfaces of the cuneiform bones with the three facets on the distal articular surface of the navicular bone. All these articular surfaces are enclosed in a single common capsule, and the joint cavity extends between the opposed surfaces of the cuneiform bones.

Movements at the intertarsal joints consist firstly in rotation of the calcaneus together with the navicular bone and the anterior (distal) end of the foot on the sagittal axis within a range of 55 degrees.

In medial rotation of the foot (pronation), its lateral border is raised, while the dorsal surface faces medially; in contrast, in lateral rotation (supination) the medial border is raised, and the dorsal surface of the foot faces laterally. In addition, abduction and adduction on the vertical axis can take place, with the
tip of the foot displaced medially or laterally from the midline. Finally, dorsal and plantar flexion can occur on the frontal axis. Movement on all the axes also takes place at the talocalcaneonavicular joint, which is a complex spheroid.

3. The **tarsometatarsal joints** (articulationes tarsometatarseae), known in the aggregate as **Lisfranc's joint**, unite the second row of the tarsal bones with the metatarsals. They are formed by the articular surfaces on the distal aspect of the three cuneiform bones and the cuboid bone, with which the corresponding articular surfaces of the bases of the five metatarsal bones articulate. The tarsometatarsal joints are typical tight joints, the slight movement at which lends elasticity to the arch of the foot. Articulations of the first metatarsal with the medial cuneiform bone, articulations of the second and third metatarsals with the corresponding cuneiform bones, and articulation of the fourth and fifth metatarsals with the cuboid have their own articular capsules. In general, the line of the articulations composing Lisfranc’s joint forms an arch with a quadrangular projection to the back corresponding to the base of the second metatarsal bone. The tarsometatarsal joints are strengthened by **dorsal, plantar, and interosseous ligaments** (ligamenta tarsometatarsea dorsalia, plantaria and cuneometatarsea interossea).

   The **intermetatarsal joints** (articulationes intermetatarseae) are formed by the opposed surfaces of the metatarsal bones; their joint cavities often communicate with the cavity of the tarsometatarsal joints. The joints are strengthened by transverse **ligamenta metatarsea dorsalia, plantaria and interossea**.

4. **Joints of the toe bones. A. Metatarsophalangeal joints** (articulationes metatarsophalangeae) between the heads of the metatarsals and the basis of the proximal phalanges resemble the analogous joints of the hand in their structure and in the ligamentous apparatus. **Movements** at the joints are in general the same as those at the corresponding joints of the hand, but they are limited.

   **B. The interphalangeal joints** (articulationes inter phalangeae pedis) do not differ in structure from the similar joints on the hands.

   **The foot as a whole.** The foot is constructed and functions as a resilient mobile arch. The foot of all animals, including anthropoids, is devoid of the arched structure that characterizes man as a result of his erect position.
Among the ligaments, the long plantar ligament (*lig. plantare longurn*) plays the decisive role in strengthening the arch of the foot. It arises from the inferior surface of the calcaneus, stretches forward, and attaches by its deep fibres to the tuberosity of the cuboid bone and by superficial fibres to the base of the metacarpals.

Five *longitudinal arches* and one *transverse arch* are distinguished in the whole arched structure of the foot. The longitudinal arches begin from one point on the calcaneus and diverge anteriorly along the upwardly convex rays corresponding to the five rays of the foot. Each longitudinal arch is therefore made up of one metatarsal bone (the first in the first arch, the second in the second arch, etc.) and parts of the carpal bones located between it and the tuberosity of the calcaneus. The sustentaculum tali plays an important role in the formation of the first (medial) arch. The second arch is the longest, and highest of all the longitudinal arches. The longitudinal arches, joined in the anterior part in the form of a parabola, form the *transverse arch* of the foot. The bony arches are maintained by the shape of the bones forming them and by the muscles and fasciae. The muscles are active "tightening devices" holding the arches. The transverse arch is held, in particular, by the transverse ligaments of the sole, the obliquely stretched tendons of the long peroneal and posterior tibial muscles, and the transverse head of the adductor muscle of the, great toe.

When the apparatus described loses its strength, the foot becomes flat. The resulting faulty structure called flat-foot is painful. According to some data, the role of the passive factors (bones and ligaments) in maintaining the arch is no less and may even be greater than the role of the active factors (muscles).

**THE ACTIVE LOCOMOTOR APPARATUS MYOLOGY**

**MUSCLE DEVELOPMENT**

The muscles of the trunk develop from the dorsal part of the mesoderm found on the sides of the notochord and neural tube; this part of the mesoderm is divided into primary segments, or somites. After the *sclerotome*, which gives rise to the spinal column, is separated, the remaining laterodorsal part of the somite forms the *myotome* whose cells (myoblasts) become, elongated in the longitudinal direction and transform
later into symplasts of the muscle fibres. Some myoblasts differentiate into special cells, 
myosattelites, located next to the symplasts. The myotomes grow ventrally and are 
divided into the dorsal and ventral parts. The dorsal part gives rise to the dorsal 
musculature (on the back of the trunk), the ventral part to the ventral musculature on 
the anterior and lateral surfaces of the trunk. The myotomes on each side are primarily 
separated one from the other by transverse connective-tissue septa, myocepta.

Some of the muscles remain in the place of their formation on the trunk and 
form the local, native, autochthonous musculature (Gk. autos self, chthon earth). Others 
move from the trunk to the limbs in the process of development. These muscles are 
called truncifugal (trunc +L fugero flee). Finally, a third group of muscles arises on the 
limbs and migrates to the trunk; these are trunci petal muscles (L petere to go, to seek).

The musculature of the limbs is a derivative of the ventral trunk musculature.

THE MUSCLE AS AN ORGAN

A muscle is formed of bundles of striated fibres. These fibres run parallel to each 
other and are bound by loose connective tissue (endomysium) into bundles of the first 
order. Several such primary bundles unite and in turn form bundles of the second 
order, and so on. The muscle bundles of all orders are united by a connective-tissue 
sheath, perimyseum, to form the muscle belly. The connective-tissue layers between the 
muscle bundles are continuous at the ends of the belly with the tendon of the muscle.

Since a muscle contracts when it receives an impulse from the central nervous 
system, each muscle must be connected to it via a set of nerves. There are two types 
of these: afferent nerves which convey impulses from the muscles to the nervous system 
and thus conduct "muscle perceptions" (Pavlov called them motor analysers); and 
efferent nerves which convey impulses to the muscles and thus conduct the excitations 
to the muscle. Besides, the muscle receives sympathetic nerves, which keep the muscle 
in a living organism in a constant state of constriction called tone or tonus. Vigorous 
metabolism takes place in the muscles, and they are consequently supplied richly with 
vessels. According to the law of the shortest distance, the muscles are supplied with 
arteries from the nearest vessels, which give off muscle branches, rami musculares. The 
accompanying veins drain into analogous venous trunks. The intervascular veins 
anastomose extensively and each artery is attended by two veins.
Each muscle has an actively contracting part, i.e. the fleshy central part or belly (body), and a passive part, the tendon, by which it is attached to a bone. A tendon consists of dense connective tissue and is a shiny, light gold colour, sharply differing from the reddish-brown colour of the belly. A tendon is usually found on both ends of a muscle, but when the tendon is very short, the muscle seems to arise from the bone or to be attached to it directly by the belly.

Each muscle is a separate organ, i.e. an integral structure with its own distinctive shape, structure, function, development, and location in the body.

**THE WORK OF MUSCLES (ELEMENTS OF BIOMECHANICS)**

*Contractility* is the principal property of muscular tissue on which the work of the muscles is based.

When the muscle contracts the two points of its attachment are drawn closer together. The *mobile point* of attachment (*punctum mobile*) is pulled toward the fixed point (*punctum fixum*) and as a result a movement occurs in that part of the body.

In this manner, the muscle exerts traction of a certain force and moving a load (e.g. the weight of a bone), accomplishes a definite, mechanical, task. The force of the muscle depends on the number of muscle fibres composing it and is determined by the size of the physiological cross-section, i.e. the size of the section at the site through which all the fibres of the muscle pass. The range of the contraction depends on the length of the muscle. The bones moving at the joints under the effect of the muscle form levers, from the mechanical standpoint, i.e. the simplest machine, as it were, for moving weights.

Since movement occurs in two opposite directions (flexion-extension; adduction-abduction, etc.), at least two muscles located on opposing sides are needed to accomplish rotation on any one axis. Muscles acting in mutually opposed directions are called *antagonists*.

As distinct from antagonists, muscles whose resultant passes in one direction are called *agonists* or *synergists*.

The resultant of a muscle is a straight line connecting the centre of its origin with the centre of its insertion.

Exact information on the functional state of the separate muscles of a living
organism is obtained by means of electromuography.

**REGULARITIES IN THE DISTRIBUTION OF THE MUSCLES**

1. According to the principle of bilateral symmetry of the body structure, the muscles are *paired* or consist of two symmetric halves (*e.g.* the trapezius muscle).

2. In the segmented trunk many muscles are *segmental* (the intercostal muscles, the short muscles of the spine) or retain signs of metamerism (the rectus abdominis muscle). The wide muscles of the abdomen were formed from the merger of segmental intercostal muscles due to reduction of the bone segments, the ribs.

3. Since movement accomplished by a muscle occurs on a straight line which is the shortest distance between two points (the fixed point and the mobile point), the muscles themselves lie on the *shortest distance* between these points. That is why, knowledge of the sites of muscle attachment and the fact that the mobile point is pulled toward the fixed point during a muscle contraction, enables one to know beforehand to which side the muscle will move a bone and to define the muscle's function.

4. Muscles passing over a joint have a definite relationship to the pivotal axes, which determines their function.

**CLASSIFICATION OF MUSCLES**

The numerous muscles (their number is nearly 400) differ in shape, structure, function, and development.

*Long, short, and broad muscles* are classified by their *form*. The long muscles correspond to long levers of movement and are therefore mainly encountered on the limbs. They are spindle-shaped; their middle portion is called the *belly* (*venter*), the end at the origin of the muscle the *head* (*caput*) and the other end the *tail* (*cauda*). The tendons of long muscles resemble narrow bands.

Some of the long muscles originate with more than one head *on* different bones, strengthening their support. Muscles with *two* (*biceps*), *three* (*triceps*), and *four heads* (*quadriceps*) are encountered. In fusion of muscles that differ in origin or develop from several myotomes, *tendinous intersections* (*intersectiones tendineae*) remain between them. Such muscles (multigastricus, for example) have two bellies (*e.g.* the digastric muscle) or more (*e.g.* the rectus abdominis muscle). The number of tendons also varies (multicaudal muscles). The common flexors and extensors of the fingers and toes, for
instance, each have more than one tendon (up to four) so that the contraction of one belly of the muscle effects movement of several fingers (toes) simultaneously, and the work of the muscle is, therefore, economized.

The broad muscles are found mainly on the trunk and have an expanded tendon called *aponeurosis*.

Other shapes of muscles are also encountered: quadrate (m. quadratus), triangular (m. triangularis), pyramidal (m. pyramidalis), cylindrical (m. teres), deltoid (m. deltoideus), serrate (m. serratus), and those the shape of the flatfish plaice (m. soleus), etc.

According to the direction of the fibres, which is functionally determined, muscles with straight parallel fibres (m. rectus), oblique fibres (m. obliquus), transverse fibres (m. transversus), and circular fibres (m. orbicularis) are distinguished. The circular fibres form ring-like muscles, or sphincters, around the body's orifices. A muscle whose oblique fibres approach the tendon from only one side is called unipennate; a bipennate muscle is one in which the fibres approach the tendon from two sides. A peculiar relation of fibres to the tendon is encountered in the semitendinous (m. semitendinosus) and semimembranous (m. semimembranosus) muscles.

According to function, the muscles are classified as flexors (flexores), extensors (extensores), adductors (adductores), abductors (abductores), rotators (rotatores), effecting medial rotation or pronation, pronators (pronatores) *and* lateral rotation, supinators (supinatores).

According to their relation to the joints, over which they extend (one, two, or more), the muscles are called uniarticular, biarticular, or multiarticular. Multiarticular muscles are longer and closer to the surface than the uniarticular muscles. According to position, superficial and deep, internal and external and lateral and medial muscles are distinguished.

**THE AUXILIARY APPARATUS OF MUSCLES**

In addition to the main parts of a muscle, the belly and the tendon, there are auxiliary structures which in one way or other make the work of the muscle easier. A group of muscles (or all the musculature of a given part of the body) are invested into
membranes of fibrous connective tissue called fasciae (L. *fascia* band). The fasciae increase the side resistance during muscular contraction and prevent displacement of the muscle to the side. At the site of damage to the fascia, the muscle forms a protrusion, like a muscular hernia. By surrounding the muscles and separating one muscle from another, the fasciae promote their isolated contraction. Fasciae, therefore, cover either one muscle (fascia proper of the given muscle) or a group of synergic muscles, i.e. muscles performing a similar function (deep fascia or *fascia proper* of a region, *fascia propria*). Fasciae separating one group of muscles from another give off processes, *intermuscular septa* (*septa intermuscularia*), which penetrate between the neighbouring groups of muscles and attach to the bones. Above the deep fasciae there are also superficial fasciae which invest all the muscles of a given region and are found under the skin; these are the *subcutaneous*, or superficial, *fasciae* (*fascia subcutanea s. superficialis*) (thickened subcutaneous fat). Thus, the fasciae not only separate the muscles but also join them.

**THE SOFT FRAMEWORK OF THE HUMAN BODY**

Fasciae, intermuscular septa, coverings of organs, and the sheaths of vessels and nerves are the most important components of this framework. As pointed out above, superficial and deep fasciae are distinguished. The fasciae propria of muscles and the sheaths of muscles, vessels, nerves and lymph nodes are the coverings of the organs.

Thickenings in the form of ligaments are found in the fasciae in the region of some limb joints. They are made up of dense fibres running over the tendons which pass here. *Fibrous* and *osteofibrous canals*, or *sheaths* (*vaginae fibrosae tendinum*) transmitting tendons form under these, fascial ligaments. The ligaments and the fibrous sheaths located below them hold the tendons in place on the bone. They also prevent their displacement to the sides and as a result help direct the muscle traction more exactly. Gliding of the tendons in the fibrous sheaths is made easier because the walls of the sheaths are lined with a fine synovial membrane which at both ends of the sheath folds over on the tendon and forms a closed *synovial sheath* (*vagina synovialis tendinis*) around it. Part of the synovial membrane, enclosing the tendon directly and fusing with it forms the *visceral layer*, while the other part, lining the fibrous sheath and fusing with its wall, forms the *parietal layer*. Duplication of the synovial membrane, called
the *mesentery of the tendon (mesotendineum)*, forms about the tendon where the visceral layer is continuous with the parietal layer. A few drops of fluid resembling synovia are found in the cavity of the synovial sheath between the visceral and parietal layers of the synovial membrane. The fluid lubricates and facilitates movement of the tendon in the sheath.

**Synovial bursae (bursae synoviales)** are of similar significance. They are found in different parts under the muscles and tendons, mainly near the sites of attachment. Some bursae, as is pointed out in the chapter dealing with syndesmology, communicate with the joint cavity. A *pulley-shaped structure (trochlea)* is usually formed in places where the tendon of a muscle changes its direction; the tendon passes over the trochleae like a belt over a pulley. They are bony and fibrous trochlea.

*Sesamoid bones (ossa sesamoidea)* are also related to the auxiliary structures of a muscle. They occur in the thickness of a tendon at the site of their attachment to the bone, in places where it is necessary to increase the angle of attachment of the muscle to the bone in order to increase its force.

**SPECIAL MYOLOGY**

**MUSCLES OF THE BACK**

The muscles of the back are arranged in two layers, the superficial and the deep layers.

**SUPERFICIAL MUSCLES OF THE BACK**

The *trapezius muscle (m. trapezius)*. This is a triangular muscle occupying the upper part of the back to the occiput. The trapezius muscles together form a trapezium, hence the name. Contraction of all the fibres of the muscle pulls the shoulders to the back. On contraction of both muscles the shoulder-blades are drawn toward each other.

The *latissimus dorsi muscle (m. latissimus dorsi)* (L *latissimus widest*) occupies the whole lower part of the back and its upper portion is covered by the lower end of the trapezius muscle.

Contraction of the muscle pulls the upper limb to the back and downward and at the same time rotates it medially, as it happens, for instance when a conductor of an orchestra takes a handkerchief out of the pocket of his tial-coat.

The *romboid major and minor muscles (mm. rhomboideus major and minor)* closely
adjoin one another under the trapezius muscle and have the shape of a rhomboid plate.

Contraction of the rhomboid muscles pulls the shoulder blade to the spine and upward.

The levator scapulae muscle (m. levator scapulae). Its action is implied by its name.

The **serratus posterior superior muscle** (*m. serratus posterior superior*) lies in the upper part of the back under the rhomboid muscle.

Action. Raises the ribs.

The **serratus posterior inferior muscle** (*m. serratus posterior inferior*) lies in the same plane as the superior muscle, but its fibres run in the opposite direction.

Action. Pulls the lower ribs downwards.

**DEEP MUSCLES OF THE BACK**

**AUTOCHTHONOUS MUSCLES OF THE BACK**

The autochthonous muscles of the back form on each side two longitudinal (lateral and medial) muscular tracts which are lodged in the groove between the vertebral spinous and transverse processes and the angles of the ribs. In the deep parts, nearest to the skeleton, they are made up of short muscles arranged in segments between the vertebrae (medial tract); the long muscles are closer to the surface (lateral tract). In addition the splenius muscle covers both tracts in the posterior cervical region.

The action of the complex of the autochthonous muscles of the back consists in holding the trunk erect.

**MUSCLES OF THE CHEST**

The musculature of the chest is divided into the muscles that originate from the surface of the thoracic cage and stretch from it to the shoulder girdle and upper limb and the muscles-proper (autochthonous) of the chest, which are components of the thoracic wall.

**CHEST MUSCLES RELATED TO THE UPPER LIMB**

The **pectoralis major muscle** (*m. pectoralis major*) originates from the medial half of the clavicle (*pars clavicularis*), the anterior surface of the sternum and cartilages of the second to seventh ribs (*pars sternocostalis*) and, finally, from the anterior wall of the sheath of the rectus abdominis muscle (*pars abdominalis*). The fibres of the muscle
stretch laterally where they converge and are attached by a short tendon to the crista tuberculi majoris of the humerus.

Action. This muscle draws the arm to the trunk and rotates it medially; the pars clavicularis lifts the arm forward. The muscle can raise the ribs with the sternum when the upper limbs are held fast and in this way help inspiration.

The pectoralis minor muscle (m. pectoralis minor) is under the greater pectoral muscle.

Action. On contraction this muscle pulls the shoulder blade forward and downward. When the arms are held fast, it acts as a muscle of inspiration.

The subclavius muscle (m. subclavius) is very small and stretches from the clavicle to the first rib.

Action. The muscle strengthens the sternoclavicular articulation by pulling the clavicle down and medially.

The serratus anterior muscle (m. serratus anterior) is on the surface of the lateral, chest wall.

Action. Together with the rhomboid muscle, which is also attached to the medial border of the scapula, it forms a wide muscular loop embracing the trunk and pressing the scapula to it.

AUTOCHTHONOUS MUSCLES OF THE CHEST

The external intercostal muscles (mm. intercostales externi) fill the intercostal spaces from the spine to the costal cartilages.

Between the costal cartilages the muscles are replaced by a fibrous band with fibres lying in the same direction (membrana intercostalis externa).

The internal intercostal muscles (mm. intercostales interni) are under the external muscles, and the direction of their fibres is opposite to that of the fibres of the latter, which they intersect at an angle.

Posteriorly, the internal intercostal muscles reach only the costal angles and are further replaced by the posterior intercostal membrane (membrana intercostales interna) stretching between the posterior ends of the ribs.

The subcostal muscles (mm. subcostales) are thin muscular bundles found on the inner surface of the lower part of the thoracic cage in the region of the costal angles.
Their fibres are directed like the fibres of the internal intercostal muscles, but the muscles overlap one or two ribs.

The transversus thoracis muscle (m. transversus thoracis) is also on the inner surface of the thoracic cage, on its anterior surface, and is a continuation of the transverse muscle of the abdomen.

**Action.** The external costal muscles raise the ribs and expand the thoracic cage in the anteroposterior and transverse directions and are, consequently, muscles of inspiration during normal quiet breathing.

Some authors claim that the internal intercostal muscles also contribute to quiet expiration. The subcostal muscles, the transverse muscle of the thorax, and other muscles which draw the ribs downward (the abdominal muscles) also act in forced expiration.

**THE THORACOABDOMINAL DIAPHRAGM**

The thoracoabdominal diaphragm forms the partition between the thoracic and abdominal cavities. It is a flat thin dome-shaped muscle, covered above and below with fasciae and serous membranes. The muscle fibres arise from the whole circumference of the inferior thoracic aperture, run upwards, and are contiguous with an aponeurotic tendon occupying the centre of the diaphragm and called the central tendon (centrum tendineum). According to the origin of the fibres, the lumbar, costal, and sternal parts are distinguished in the muscular part of the diaphragm.

The lumbar part (pars lumbalis) is the strongest and consists of two crura, right and left (crus dextrum and sinistrum). Both crura originate by means of a long tendon from the anterior surface of the bodies of the first to fourth lumbar vertebrae (the left crus arises at a higher level than the right) and from two tendinous ligaments which are thickenings of the thoracolumbar fascia. One of these ligaments, the medial arcuate ligament (lig. arcuatum mediate) passes above the psoas major muscle and stretches between the body of the first or second lumbar vertebra and its transverse process; the second, lateral arcuate ligament (lig. arcuatum laterale) runs above the quadrate muscle of the loins from the transverse process of the first lumbar vertebra to the free border of the twelfth rib.

A triangular space (hiatus aorticus) is left between both crura and the spine; it
transmits the aorta and the thoracic duct stretching behind it. The edge of this opening is bordered with a tendinous band as a result of which contraction of the diaphragm does not affect the lumen of the aorta. Ascending, the crura converge in front of the aortic hiatus, but somewhat to the left and above it they separate again to form, an opening the oesophageal hiatus (hiatus esophageus), through which the oesophagus and both vagus nerves attendant to it pass. The oesophageal hiatus is bordered with muscle bundles which act as a sphincter regulating the movement of food. Narrow openings form between the muscle bundles of each crus. They transmit the splanchnic nerves, the azygos vein (hemiazygos vein on the left), and the sympathetic trunk.

The costal part (pars costalis) originates by separate slips from the inner surface of the cartilages of the seventh to twelfth ribs.

The sternal part (pars sternalis), the smallest of all the parts of the diaphragm, is made up of several short slips arising from the posterior surface of the sternal xiphoid process and stretching to the tendinous centre. A paired triangular opening, the sternocostal triangle (trigonum sternocostale) is left between the sternal part and the costal part of the diaphragm near the sternum; the internal thoracic artery (superior epigastric artery) passes in it. Another, larger, paired space, the lumbocostal triangle (trigonum lumbocostale), lies between the costal and lumbar parts. It corresponds to the communication existing between the thoracic and abdominal cavities in embryonal life. It is covered by the pleura and endothoracic fascia above and by the subperitoneal fascia, retroperitoneal fat and peritoneum below. Diaphragmatic hernias may protrude through it.

The central tendon of the diaphragm (centrum tendineum) has a trifoliate shape. Its surface shines like a mirror, and it was formerly called Helmont's mirror or speculum. A little to the back and to the right of the midline is a quadrangular opening in the central tendon (foramen venae cavae), which transmits the inferior vena cava. As pointed out above, the diaphragm is dome-shaped, but it is asymmetrical in height: its right part, abutting inferiorly on the voluminous liver, stands higher than the left part.

Action. During inspiration the diaphragm contracts, its dome flattens out, and its height decreases. With the descent of the diaphragm the thoracic cavity grows larger
in the vertical direction, which is what occurs during inspiration.

**MUSCLES OF THE ABDOMEN**

**THE LATERAL MUSCLES**

These are three broad muscular sheets, one overlapping the other. Their tendinous aponeuroses, after forming the sheath of the rectus abdominis muscle, join on the anterior aspect of the abdomen at the linea alba.

The external oblique muscle (\textit{m. obliquus externus abdominis}) is the outermost of the three broad abdominal muscles. It arises from the lower eight ribs by eight slips on the lateral surface of the thoracic cage; the muscular fibres run downward and forward.

The fibres of the muscle are continuous with an extensive aponeurosis, which passes in front of the rectus muscle and joins the contra-lateral aponeurosis on the midline along the linea alba.

The free inferior border of the aponeurosis of the external oblique muscle spans the gap between the anterior superior iliac spine folding back on itself to form a groove. This border, artificially separated from the rest of the aponeurosis, is called the inguinal or Poupart's ligament (\textit{lig. inguinale Pouparti}).

At the medial attachment of the inguinal ligament its fibrous fibres pass backward to the pubic crest and form the lacunar, or Gimbernat's ligament (\textit{lig. lacunare Gimbernati}). Above the medial part of the inguinal ligament in the aponeurosis of the external oblique muscle is a triangular cleft, the superficial (subcutaneous) ring of the inguinal canal, anulus inguinalis superficialis. It is discussed in detail below. To the back of the posterior border of the fleshy part of the external oblique muscle, between it and the origin of the latissimus dorsi muscle, is a small triangular space, the lumbar or Petit's triangle (\textit{trigonum lumbale Petiti}). The floor of the triangle is formed by the internal oblique muscle of the abdomen.

The internal oblique muscle of the abdomen (\textit{m. obliquus internus abdominis}) is found under, the external oblique muscle.

Its fibres run on the whole, upward or to be more precise they fan out.

The anterior bundles of the muscle are continuous with a broad aponeurosis which on the lateral border of the rectus abdominis muscle splits into two layers contributing to the formation of the sheath of this muscle. The aponeurosis meets the
contralateral aponeurosis medially to the rectus muscle, on the linea alba.

The transversus abdominis muscle (m. transversus abdominis) is the deepest and thinnest of the broad abdominal muscles.

From the sites of origin the fibres of the muscle run horizontally forward and medially and end in a wide aponeurosis, which passes to linea alba behind the rectus abdominis in the upper part and in front of this muscle in the lower part.

**THE ANTERIOR MUSCLES**

The rectus abdominis muscle (m. rectus abdominis) stretches on both sides lateral of the midline and consists of longitudinal muscle bundles running vertically.

Along its length the muscle is interrupted by transverse (three or four) tendinous intersections (intersectiones tendineae), which fuse with the anterior wall of the sheath in which the rectus abdominis is enclosed. The tendinous intersections are traces of the former segmental development of the ventral musculature.

The pyramidalis muscle (m. pyramidalis) is a small triangular muscle under the anterior wall of the sheath of the rectus abdominis, above the symphysis pubis. It is attached to the linea alba, which it tenses on contraction. This is a rudiment of a muscle that in monotremes and marsupials surrounds the pouch in which they carry their young.

The sheath of the rectus abdominis muscle.

Each rectus abdominis muscle is enclosed in a sheath (vagina m. recti abdominis') formed by the aponeuroses of the three lateral abdominal muscles. In the upper part, above the umbilicus, the sheath is so formed that the aponeurosis of the external oblique muscle passes in front of the rectus muscle, while the aponeurosis of the transversus abdominis muscle passes behind it; the aponeurosis of the internal oblique muscle splits into two laminae, which encompass the rectus muscle anteriorly and posteriorly, fuse with the aponeuroses of the external oblique and transverse muscles, and with them form the anterior and posterior walls of the sheath. In the lower part, 4-5 cm below the umbilicus, the structure of the sheath is different: the aponeuroses of the three abdominal muscles pass in front of the rectus muscle as the anterior wall of its sheath, while the posterior wall is replaced by fascia transversalis that lines the inner surface of the abdominal wall. The posterior aponeurotic wall of the sheath terminates here as a
rather sharp crescentic margin called the **arcuate line** (*linea arcuata*). The absence of the posterior wall of the sheath facilitates the filling of the urinary bladder, which, on rising above the edge of the symphysis pubis, is displaced to this site. The thickening of the anterior wall of the lower part of the sheath is associated with the upright position of the human body, in which the lower part of the abdominal wall experiences the most pressure.

**Linea alba.** The aponeuroses of the broad muscles of the abdomen meet and fuse on the midline and form a tendinous band, **linea alba**, between the rectus abdominis muscles. This line stretches from the sternal xiphoid process to the symphysis pubis. It is quite wide in the upper part (2.0-2.5 cm at the level of the umbilicus), narrows quickly at some distance below the umbilicus, and to compensate thickens in the anteroposterior direction. Almost in the middle of the linea alba is the **umbilical ring** (*anulus umbilicalis*) filled with cicatricial tissue, which fuses with the skin of the umbilicus. The light colour of the linea alba is due to the decussation of the tendinous fibres in the frontal plane (in passing from one side to the other) and sagittal plane (in passing from the surface to greater depth) and its poverty of vessels. Surgeons make use of this circumstance when the abdominal cavity must be opened widely during operation (e.g. in caesarian section).

**Action, of the abdominal muscles.** The muscles of the abdomen narrow the abdominal cavity and exert pressure on the viscera enclosed in it, thus forming the abdominal press (*prelum abdominale*), whose action is manifested in expelling the contents of the abdominal organs in defaecation micturition and labour, as well as in coughing and vomiting.

The abdominal muscles also assist in respiratory excursions; since they are attached to the ribs, they pull them downward and help in expiration. Their participation in this act consists also in exerting pressure on the viscera and thus raising the relaxed diaphragm to the position it holds in expiration.

**THE POSTERIOR MUSCLES**

The **quadrate muscle of the loins** (*m. quadratus lumborum*) is a quadrangular muscular plate located in front of erector spinae muscle and separated from it by the deep layer of the thoracolumbar fascia.
**Action.** In unilateral contraction with the other abdominal muscles and the erector spinae muscle, the quadratus lumborum muscle flexes the spine and the chest laterally. In bilateral tonic contraction with the same muscles, it holds the spine in a vertical position. It can also act as a respiratory muscle the 12th rib downward.

**THE INGUINAL CANAL**

The inguinal canal (*canalis inguinalis*) is a passage transmitting the spermatic cord (*funiculus spermaticus*) in the male and the round ligament of the uterus in the female. The inguinal canal is located in the lower part of the abdominal wall, on each side of the abdomen, immediately above Poupart’s ligament, and descends medially and forward. The canal is 4.5 cm long. It forms as follows: the internal oblique and the transversus abdominis muscles are fused with the lateral two thirds of the groove of the inguinal ligament (but not with the medial one third of the ligament) and pass freely over the spermatic cord or the round ligament. Thus, a triangular or oval passage forms between the inferior border of the internal oblique and the transverse muscles above and the medial part of the inguinal ligament below. *This passage is the inguinal canal.*

Four walls can be distinguished in the inguinal canal. The **anterior wall** is formed by the aponeurosis of the external oblique muscle, the **posterior wall** by the transversal fascia. The superior wall, or roof, is formed by the inferior border of the internal oblique and transverse muscles, and the **inferior wall**, or **floor**, is formed by the inguinal ligament. The anterior and posterior walls each have an opening, called the inguinal ring, and the deep ring, respectively.

The **superficial inguinal ring** (*anulus inguinalis superficialis*) (in the anterior wall), is formed by the separation of the fibres of the aponeurosis of the external oblique muscle into two crura, one of which (*crus laterale*) is attached to the tuberculum pubicum, and the other (*crus mediale*) to the symphysis pubis. Besides these two crura, a third (posterior) crus of the superficial ring is described (*ligamentum reflexum*) located within the inguinal canal itself behind the spermatic cord. This crus is formed by the inferior fibres of the aponeurosis of the contralateral external oblique muscle; these fibres cross the midline, pass behind the crus mediale, and fuse with the fibres of the inguinal ligament. The superficial inguinal ring demarcated by the medial and lateral crura is an oblique triangular slit. The sharp lateral angle of the slit is rounded by
arcuate tendinous fibres (*fibrae intercrurales*).

The deep **inguinal ring** (*anulus inguinalis profundus*) is in the posterior wall of the inguinal canal formed by the fascia transversalis.

The peritoneum covering this wall forms two inguinal (fossae inguinale) separated from each other by two vertical folds of the peritoneum called umbilical folds. These are as follows: a **lateral fold** (*plica umbicalis lateral*), a fold of peritoneum elevated by the underlying inferior epigastric artery; a **medial fold** (*plica umbicalis medialis*) containing the medial umbilical ligament, i.e. the obliterated umbilical artery of the embryo; and a **median fold** (*plica umbicalis mediana*) covering the median umbilical ligament, the obliterated urachus of the embryo.

The **lateral inguinal fossa** (*fossa inguinalis lateralis*) located laterally of the lateral umbilical fold corresponds to the deep inguinal ring; the **medial fossa** (*fossa inguinalis medialis*) located between the lateral and medial umbilical folds corresponds to the weaker part of the posterior wall of the inguinal canal and is situated exactly opposite the superficial inguinal ring. Inguinal hernia may emerge into the inguinal canal through the fossae described and form a protrusion on the abdominal wall. A lateral (external) oblique inguinal hernia protrudes through the lateral fossa; a medial (internal) direct hernia emerges through the medial fossa. The origin of the inguinal canal is linked with the descent of the testis, descensus testis, and the formation of the peritoneal processus vaginalis in embryonic life. The fossa nearest the midline, the **supravesical fossa** (*fossa supravesicalis*) situated between the medical and median umbilical folds, is in no direct relation to the posterior wall of the canal, and most of it is located behind the rectus abdominis.

**MUSCLES OF THE NECK**

The muscles of the neck are grouped as follows.

1. Superficial muscles (platysma, *m. sternocleidomastoideus*).
2. Medial muscles, or muscles of the hyoid bone: (a) muscles located above the hyoid bone (*mm. mylohyoideus, digastricus, stylohyoideus, geniohyoideus*); (b) muscles located below the hyoid bone (*mm. sternohyoideus, sternothyroideus, thyrohyoideus, omohyoideus*).
3. Deep muscles: (a) lateral, attached to the ribs (*mm. scaleni anterior, medius*
and posterior); (c) prevertebral muscles (m. longus colli, m. longus capitis, m. rectus capitis anterior and lateralis).

**SUPERFICIAL MUSCLES**

1. **Platysma** is a subcutaneous muscle of the neck lying directly under the fascia thin sheet.

   **Action.** Pulling the skin of the neck, the muscle protects the subcutaneous veins from compression; it can also depress the angle of the mouth, which is important for facial expression.

   The **sternocleidomastoid muscle** (*m. sternocleidomastoideus*) lies immediately under the platysma and is separated from it by the cervical fascia.

   **Action.** In unilateral contraction, the muscle flexes the cervical segment of the spine to the same side; the head is raised at the same time, and the face turned to the opposite side.

   In bilateral contraction, the muscles hold the head in a vertical position (head-holder); that is why the muscle itself and the place of its attachment (the mastoid process) are most developed in man, who walks erect.

**THE MIDDLE MUSCLES, OR MUSCLES OF THE HYOID BONE**

These muscles of suprahyoid localization lie between the mandible and the hyoid bone.

The **mylohyoid muscle** (*m. mylohyoideus*) is a flat muscle with parallel fibres that arise from the mandibular mylohyoid line.

Both mylohyoid muscles meet and form the floor of the mouth (*diaphragma oris*) which closes the bottom of the oral cavity.

The **digastric muscle** (*m. digastricus*) consists of two bellies connected by a round intermediate tendon.

The **stylohyoid muscle** (*m. stylohyoideus*) descends obliquely from the styloid process of the temporal bone.

The **geniohyoid muscle** (*m. geniohyoideus*) lies above the mylohyoid muscle laterally of the raphe. It stretches from the spina mentalis of the mandible to the body of the hyoid bone.

**Action.** All the four muscles described above raise the hyoid bone. When the
Bone is steadied, three muscles (mylohyoid, geniohyoid, and digastric) lower the mandible and thus are antagonists of the muscles of mastication.

**Muscles Located below the Hyoid Bone.**

The *sternohyoid muscle* (*m. sternohyoideus*) originates from the posterior surface of the sternal manubrium. Between the medial borders of both sternohyoid muscles is a narrow vertical space closed by fascia; this is the *linea alba cervicalis*.

*Action.* Pulls the hyoid bone downward.

The *sternothyroid muscle* (*m. sternothyroideus*) lies under the sternohyoid muscle and is broader.

It then ascends and *attaches to* the lateral surface of the thyroid cartilage (to its *linea obliqua*).

*Action.* Lowers the larynx.

The *thyrohyoid muscle* (*m. thyrohyoideus*) seems to be a continuation of the sternothyroid muscle from which it is separated by a tendinous intersection. It stretches from the oblique line of the thyroid cartilage to the body and greater horn of the hyoid bone.

*Action.* Pulls the larynx upwards when the hyoid bone is steadied.

The *omohyoid muscle* (*m. ornohyoideus*) is a long narrow muscle consisting of two bellies joined almost at a right angle by an intermediate tendon.

*Action.* The omohyoid muscle lies in the thickness of the cervical fascia which it tightens on contraction and thus aids in dilation of the large veins situated under the fascia. It also pulls the hyoid bone downwards.

**THE DEEP MUSCLES**

**Lateral Muscles Attached to the Ribs, the Scalene Muscles**

The three scalene muscles are altered intercostal muscles, which explains their attachment to the ribs.

The *scalenus anterior muscle* (*m. scalenus anterior*).

The *scalenus medius muscle* (*m. scalenus rnedius*).

The *scalenus posterior muscle* (*rn. scalenus posterior*).

*Action.* The scalene muscles raise the upper ribs and act as muscles of inspiration. When the ribs are steadied, bilateral contraction of the muscles accomplish forward
flexion of the cervical spine; in unilateral contraction, they flex and rotate this segment of the spine to their side.

Prevertebral Muscles

The **longus cervicis muscle** (*m. longus colli*) is triangular and lies on the anterior surface of the spine, on both sides of it.

The **longus capitis muscle** (*m. longus capitis*) overlaps the upper part of longus colli.

The **rectus capitis anterior** and **lateralis muscles** (*mm. recti capitis anterior and lateralis*) stretch from the lateral mass of the atlas (anterior muscle) and its transverse process (lateral muscle) to the occipital bone.

Action. Rectus capitis anterior and longus capitis flex the head forward. Longus colli flexes the cervical spine on bilateral contraction of all its fibres; in unilateral contraction the spine is flexed laterally; the oblique portions take part in rotation and flexion of the head to the side; rectus capitis lateralis helps this muscle.

TOPOGRAPHY OF THE NECK

The **neck** (*collum*) is divided into four regions: posterior, lateral, the region of the sternocleidomastoid muscle, and the anterior region.

The **posterior region** (*regio colli posterior*) is behind the lateral border of the trapezius muscle and is the nape, or nucha.

The **lateral region** (*region colli lateralis*) is behind the sternocleidumastoid muscle and is bounded in front by this muscle, below by the clavicle, and behind by the trapezius muscle.

The sternocleidomastoid region (*regio stemocleidomastoidea*) corresponds to the projection of this muscle.

The anterior region (*regio colli anterior*) is in front of the sternocleidomastoid muscle and is bounded posteriorly by this muscle, in front by the midline of the neck, and above by the border of the mandible. A small area behind the mandibular angle and in front of the mastoid process is called the fossa retromandibularis. It lodges the posterior part of the parotid gland, nerves, and vessels.

The anterior and lateral regions are divided into a number of triangles by the omohyoid muscle descending obliquely from front to back and crossing the
sternocleidomastoid muscle.

The *omoclavicular trigone* or *subclavian triangle* (*trigonum omoclaviculare*) is distinguished in the lateral region of the neck; it is bounded by the sternocleidomastoid muscle in front, the inferior belly of the omohyoid muscle above, and the clavicle below.

Two triangles are distinguished in the anterior region of the neck: (1) the *fossa carotica*, or *carotis trigone* (*trigonum caroticum*) (transmitting the carotid artery), formed by the sternocleidomastoid muscle posteriorly, the posterior belly of the digastric muscle in front and above, and the superior belly of the omohyoid muscle in front and below and (2) the *submandibular trigone* (*trigonum submandibulare*) (lodging the submaxillary gland), formed by the inferior border of the mandible above and the two bellies of the digastric muscle.

Triangular slits or spaces form between the scalene muscles; they transmit nerves and vessels of the upper limb.

1. Between the anterior and middle scalene muscles is *spatium interscalenum*, bounded by the first rib below (it transmits the subclavian artery and the brachial plexus).

2. In front of the anterior scalene muscle is *spatium antescalenum* covered in front by the sternothyroid and sternohyoid muscles (it transmits the subclavian vein, the suprascapular artery, and the omohyoid muscle.

**FASCIAE OF THE NECK**

The first fascia, or the *superficial cervical fascia* (*fascia colli superficialis*) is part of the common superficial (subcutaneous) fascia of the body and is continuous with the fasciae of the neighbouring areas. It is distinguished from the superficial fascia of the other parts of the body in that it contains the platysma muscle for which it is the perimysium.

The second fascia, or the *superficial layer of the cervical fascia proper* (*lamina superficialis fasciae colli propriae*) encloses the whole neck like a collar and covers the suprahyoid and infrahyoid group of muscles, the salivary glands, the vessels, and the nerves. It is attached above to the mandible and the mastoid process and is continuous on the face with the parotid and masseteric fasciae which cover the parotid gland and
the masseter muscle. Below, the superficial layer is attached to the anterior border of the manubrium sterni and the clavicle. In front, on the midline, it fuses with the deep layer of the cervical fascia proper to form the *linea alba cervicalis* (2-3 mm in width). On each side of the neck, the superficial layer passes from the linea alba posteriorly to the spinous processes of the cervical vertebrae. On reaching the sternocleidomastoid and the trapezins muscles it separates into two lamellae, encloses the muscles and again fuses, thus forming fascial sheaths for each of these muscles separately.

The third fascia, or the **deep layer of the cervical fascia proper** (*lamina profunda fasciae colli propriae*) is manifest only in the middle part of the neck behind the sternocleidomastoid muscle where it is stretched like a trapezium over a triangular space bounded above by the hyoid bone, on both sides by the omohyoid muscles, and below by the clavicles and the sternum. Since the deep layer of the cervical fascia proper is attached below to the posterior border of the manubrium sterni and the clavicles, while the superficial layer is attached to the anterior border of these bones, a narrow space is left between these layers; this is spatium interaponeuroticum suprasternale containing loose fatty tissue and the superficial veins of the neck, the jugular venous arch (arcus venosus juguli), injury to which is fraught with danger.

The deep layer, separating and again fusing, forms fascial sheaths for the infrahyoid muscles (the sternohyoid, sternothyroid, and thyrohyoid muscles). It unites these muscles to form a thick connective-tissue muscular expansion, like their aponeurosis (aponeurosis omoclavicularis), which tenses when the omohyoid muscles contract and thus facilitates the flow of blood in the cervical veins perforating it and fusing with it. This tension and the triangular shape suggested the image-bearing name of the aponeurosis, the "cervical sail".

The fourth fascia, or the endocervical fascia (*fascia endocervicalis*) encloses the organs located in the neck (larynx, trachea, thyroid gland, pharynx, oesophagus, and the large vessels). It consists of two layers, a visceral layer which invests each of these organs and forms a capsule for them, and a parietal layer which encloses all these organs in the aggregate and forms a sheath for the important vessels, the common carotid artery and the internal jugular vein.

The space between the parietal and visceral layers of the endocervical fascia lies
in front of the viscera and is therefore called previsceral space \((spatium \text{ previscerale})\), that in front of the trachea, in particular, is called pretracheal space \((spatium \text{ pretracheale})\). The latter contain, in addition to fatty tissue and lymph nodes, the isthmus of the thyroid gland and blood vessels (arteria thyroidea ima and plexus thyroideus impar) which can be injured during tracheotomy. Spatium pretracheale extends into the anterior mediastinum.

The fifth, prevertebral fascia \((fascia \text{ prevertebralis})\) covers anteriorly the prevertebral and scalene muscles stretching on the spine; and by fusing with the transverse processes of the vertebrae forms sheaths for these muscles.

Between the fourth and fifth fasciae, behind the pharynx and oesophagus, is a narrow space filled with loose fatty tissue; this is retrovisceral space \((spatium \text{ retroviscerale})\), which is continuous downwards with the posterior mediastinum.

According to the Paris Nomina Anatomica, all fasciae of the neck are embraced under the term fascia cervicalis, which is divided into three layers as follows.

1. The superficial layer (fascia) \((lamina \text{ superficialis})\) corresponding to the first fascia, fascia colli superficialis.

2. The pretracheal layer (fascia) \((lamina \text{ pretrachealis})\) covering the salivary glands, muscles, and other structures located in front of the trachea, hence its name. It corresponds to the second and third fasciae (after Shevkunenko), i.e. the superficial and deep layers of fascia colli propriae.

3. The prevertebral layer (fascia) \((lamina \text{ prevertebralis})\) corresponding to the fifth fascia, i.e. fascia prevertebralis (ater Shevkunenko).

The fourth fascia \((fascia \text{ endocervicalis})\) is omitted in PNA.

**THE MUSCLES OF THE HEAD**

All the muscles of the head can be divided into the following two groups:

1. Muscles of mastication
2. Muscles of facial expression

**MUSCLES OF MASTICATION**

The four muscles of mastication on each side are related morphologically (they are all attached to the mandible which they move when they contract), and functionally
(they accomplish the chewing movements of the mandible, which determines their location).

The **masseter muscle** (*m. masseter*) is thick and quadrangular.

The **temporal muscle** (*m. temporalis*) is wide at its origin and occupies the whole temporal fossa of the skull up to the temporal line.

The **lateral pterygoid muscle** (*m. pterygoideus lateralis*) and the **medial pterygoid muscle** (*m. pterygoideus lateralis*).

**Action.** The temporal, masseter, and medial pterygoid muscles pull the mandible to the maxilla when the mouth is open and thus close the mouth. On simultaneous contraction of both lateral pterygoid muscle the mandible protrudes forward. Movement in the opposite direction is accomplished by the posterior fibres of the temporal muscle which pass almost horizontally forward. Unilateral contraction of the lateral pterygoid muscle displaces the mandible to the contralateral side of the mouth. The temporal muscle is associated with articulate speech; it sets the mandible in a definite position when a person speaks.

**MUSCLES OF FACIAL EXPRESSION**

The muscles of facial expression, as distinct from the skeletal muscles, are not doubly attached to the bones but always interlace at one or both ends with the skin or mucous membrane. As a result they are devoid of fasciae and move the skin upon contraction. When they relax, the skin returns to its former state due to its elasticity.

The muscles of facial expression are small, thin muscle bundles grouped around the natural orifices (the mouth, nose, palpebral fissure, and ear). These muscles take part in closing or widening, the orifices.

*Sphincters* are usually arranged annularly around the orifices they close, while the *dilators* which widen the orifices, are arranged radially.

**MUSCLES OF THE SCALP**

Almost the whole skull cap is covered by a thin **epicranius muscle** (*m. epicranius*), which has a wide tendinous part, the epicranial aponeurosis (*galea aponeurotica*) (aponeurosis epicranialis) and a muscular part separating into three bellies: (1) the anterior, or frontal, belly (*venter frontalis*) arises from the skin of the eyebrows and interlaces with the aponeurosis in front; (2) the posterior, or occipital, belly (*venter
occipitalis) originates from the superior nuchal line and interlaces with the aponeurosis posteriorly, and (3) the lateral belly separates into three small muscles approaching the auricle anteriorly (m. auricularis anterior), superiorly (m. auricularis superior), and posteriorly (m. auricularis posterior). The three auricular muscles interlace with the aponeurosis laterally. The galea aponeurotica invests the middle part of the dome of the skull to form the central part of the epicranial muscle.

Action. Loosely connected to the periosteum of the skull bones, the epicranial aponeurosis fuses closely with the skin, which can, therefore, move with it during contraction of the frontal and occipital bellies. When the epicranial aponeurosis is steadied by the occipital belly of the muscle, the frontal belly raises the eyebrow (arches it) and wrinkles the skin of the forehead transversely.

MUSCLES SURROUNDING THE EYES

The procerus muscle (m. procerus) is inserted into the skin of the glabella where it interlaces with the frontal belly of the epicranius. By drawing down the skin of this region, it causes transverse wrinkling of the skin above the bridge of the nose.

The orbicularis oculi muscle (m. orbicularis oculi) surrounds the eyelids; its wide peripheral orbital part (pars orbitalis) is on the bony margin of the orbit, while the central palpebral part (pars palpebralis) is on the eyelids. A small third, lacrimal, part (pars lacrimalis) can also be distinguished. It is apart of the pars palpebralis, which arises from the wall of the lacrimal sac and, by dilating the sac, contributes to the absorption of the tears through the lacrimal canaliculi. The palpebral part closes the lids gently, while strong contraction of the orbital part closes them tightly. Isolated contraction of the upper fibres of this part draws the skin of the forehead and the eyebrow downward; as a result the eyebrow is straightened out, and the transverse wrinkles on the forehead are smoothed out. In this respect it is an antagonist of the venter frontalis.

Still another small part of the orbicular muscle of the eye lodged under the pars orbitalis can be distinguished; this is the corrugator muscle of the eyebrow (m. corrugator supercilii), which draws the eyebrows toward each other and causes the formation of vertical wrinkles in the space between the eyebrows above the bridge of the nose.
MUSCLES AROUND THE MOUTH

The **levator labii superions muscle** (*m. levator labii superioris*) raises the upper lip and thus makes the nasolabial sulcus deeper; it pulls the ala of the nose upward and dilates the nares.

The **zygomatic minor muscle** (*m. zygomaticus minor*) is inserted into the nasolabial fold which it deepens during contraction.

The **zygomatic major muscle** (*m. zygomaticus major*).

It pulls the angle of the mouth upward and laterally, as a result of which nasolabial sulcus becomes much deeper.

The **risorius myscle** (*m. risorius*) is another muscle important in the expression of laughter (*L. risus* laughter). This small transverse slip arises from the parotid and maseteric fasciae and passes to the angle of the mouth. It is often absent. It stretches the mouth in laughing; in some persons it is attached to the skin of the cheeks and when it contracts, a small depression (dimple) forms laterally to the angle of the mouth.

The **depressor anguli oris muscle** (*m. depressor anguli oris*).

It pulls down the angle of the mouth and straightens out the nasolabial fold. Depression of the angles of the mouth produces the expression of grief.

The **levator anguli oris muscle** (*m. levator anguli oris*).

It raises the angle of the mouth.

The **depressor labii inferioris muscle** (*m. depressor labii inferioris*).

It pulls the lip down and a little laterally, as occurs, for example, in expressions of disgust.

The **mentalis muscle** (*m. mentalis*) is one of the strongest in the group of muscles of facial expression.

It raises the skin of the chin (with the formation of small dimples in it) and pushes the lower lip upward, pressing it to the upper lip.

The **buccinator muscle** (*rn. buccinator*).

The action of this muscle consists in the expulsion of the contents of the vestibule of the mouth, as, for example, the expulsion of air when playing a trumpet; hence the name of the muscle, buccinator (*L. trumpeter*).
The orbicularis oris muscle \((m. orbicularis oris)\) lies in the thickness of the lips around the rima oris. In both the upper and lower lips the fibres of the muscle pass from the angle of the mouth to the midline and interlace with the contralateral fibres. Numerous slips from the adjoining muscles join them. Contraction of the peripheral part of the orbicularis oris purses the lips and pushes them forward, as in kissing. During contraction of the part under the vermilion border, the lips are drawn tightly together and inverted; as a result the vermilion border is hidden. The orbicularis oris, which is arranged around the mouth, functions as a sphincter, i.e. a muscle that closes the mouth. This action is antagonistic to the action of the radial muscles of the mouth, i.e. muscles which radiate from it and open it (mm. levator labii superioris and levator anguli oris, depressor labii inferioris and depressor anguli oris, etc.).

**MUSCLES SURROUNDING THE NOSE**

The nasal muscle \((m. nasalis)\) separates into three parts: pars transversa, pars alaris, and m. depressor septi \((nasi)\).

**THE MUSCLES OF THE UPPER LIMB**

The hand, as an organ of labour, performs certain necessary movements with the help of the muscles of the upper limb.

**MUSCLES OF THE REGION OF THE SHOULDER JOINT**

They are divided topographically into dorsal and ventral groups.

* **A. THE DORSAL GROUP**

* 1. The deltoid muscle \((m. deltoideus)\) covers the proximal end of the humerus.

   **Action.** Contraction of the anterior (clavicular) part of the deltoid muscle raises the arm forward (anteflexio); contraction of the posterior (scapular) part causes the opposite movement (rotroflexio). Contraction of either the middle acromial part or of the whole deltoid muscle abducts the arm from the trunk to the horizontal level.

   The supraspinatus muscle \((m. supraspinatus)\) lies in the supraspinal fossa of the scapula.

   **Action.** Adducts the arm and is a synergist of the deltoid muscle.

   The infraspinatus muscle \((m. infraspinatus)\) occupies most of the (infraspinous fossa).
The teres minor muscle (m. teres minor).
Action. Rotates the humerus laterally.
Action. The same as that of the infraspinous muscle.

The teres major muscle (m. teres major).
Action. Pulls the arm to the back and downward and thus adducts it and also rotates the arm medially.

B. THE VENTRAL GROUP
The subscapularis muscle (m. subscapularis) at its origin occupies the entire costal surface of the scapula.
Action. Rotates the arm medially and can also pull the joint capsule tight and thus prevent it from incarceration.

The coracobrachialis muscle (m. coracobrachialis).
Action. Elevates forward and adducts the arm.

MUSCLES OF THE UPPER ARM
The muscles of the upper arm retain the extremely simple form characteristic of the initial arrangement of the limb musculature and are traditionally divided into two flexors (m. biceps and m. brachialis) on the anterior surface (anterior group) and two extensors (m. triceps and m. anconeus) on the posterior surface (posterior group).

ANTERIOR MUSCLES OF THE UPPER ARM
The biceps brachii muscle (m. biceps brachii) is a large muscle that is clearly visible under the skin when contracted and is, therefore, recognizable even to people unfamiliar with the study of anatomy. Proximally, the muscle consists of two heads: one long head (caput longum) arises from the supraglenoid tubercle of the scapula by a long tendon, which passes through the cavity of the shoulder joint and then occupies the intertubercular groove of the humerus where it is surrounded by the vagina synovialis intertubercularis; the other head is short (caput breve) and arises from the coracoid process of the scapula. Both heads unite and form an oblong, spindle-shaped belly, which terminates as a tendon attached to the tuberosity of the radius.
Action. Flexes the forearm at the elbow joint; because it is attached to the radius, it also acts as a supinator when the forearm has been pronated.

The brachialis muscle (m. brachialis) lies deeper than the biceps muscle, and
arises from the anterior surface of the humerus and attaches to the tuberosity of the ulna. *Action.* The brachial muscle is a pure flexor of the elbow.

**POSTERIOR MUSCLES OF THE UPPER ARM**

The *triceps brachii muscle* (*m. triceps brachii*) (see Fig. 146) occupies the entire posterior surface of the upper arm and consists of three heads, which meet to form a single common tendon. The *long head* (*caput longum*) *arises from* the infraglenoid tubercle of the scapula and then descends between the teres major and teres minor muscles. The *lateral head* (*caput laterale*) *arises from* the posterior surface of the humerus above and laterally of the sulcus nervi radialis and, lower, from the septum intermusculare brachii laterale. The *medial head* (*caput mediale*) *arises from* the posterior surface of the humerus distal of the sulcus of the radial nerve and from both intermuscular septa. The wide common tendon is *attached* to the olecranon.

*Action.* Extends the forearm at the elbow joint.

The *anconeus muscle*, (*m. anconeus*) is small and triangular; its proximal border adjoins the triceps muscle.

**MUSCLES OF THE FOREARM**

These muscles are separated into two groups according to position: the anterior group is composed of flexors and pronators, the posterior group of extensors and supinators.

Each group consists of a superficial and a deep layer. The superficial layer of the anterior group of muscles arises from the medial epicondyle of the humerus, the similar layer of the posterior group from the lateral epicondyle. The deep layer of both groups has no place for attachment on the epicondyles and so originates on the bones of the forearm and on the interosseous membrane. The terminal insertions of the flexors and extensors of the wrist are on the bases of the metacarpal bones, muscles stretching to the fingers are inserted into the phalanges.

**THE ANTERIOR GROUP.**

The *superficial layer is* formed of the following muscles. The *pronator teres muscle* (*m. pronator teres*).

*Action.* Pronates the forearm and participates in its flexion.

The *flexor carpi radialis muscle* (*m. flexor carpi radialis*) is a fusiform bipennate
muscle lying on the medial border of the pronator teres muscle.

*Action.* Accomplishes plantar flexion of the wrist and can also abduct the hand radially in combination with other muscles.

The **palmaris longus muscle** (*m. palmaris longus*) runs medial to flexor carpi radialis.

This muscle is often absent.

*Action.* Tenses the palmar aponeurosis and accomplishes plantar flexion of the wrist.

The **flexor carpi ulnaris** (*m. flexor carpi ulnaris*) is on the ulnar border of the forearm.

*Action.* Together with the flexor carpi radialis accomplishes plantar flexion of the wrist. It also abducts the wrist in the ulnar direction together with the extensor carpi ulnaris.

The **flexor digitorum sublimis** muscle (*m. flexor digitorum superficialis*) lies deeper than the four muscles described above.

The muscle separates into four long tendons, which descend from the forearm to the palm through the canalis carpalis and then pass to the index, middle, ring, and little fingers.

At the level of the body of the proximal phalanx, each tendon splits into two parts which separate to form a gap called the **hiatus tendineus**. The tendon of the deep flexor passes through the gap and crosses the other tendons (*chiasma tendinum*), which then *attach* to the palmar surface of the base of the middle phalanx.

*Action.* Flexes the proximal and middle phalanges of the fingers (except for the thumb) and the wrist.

The **flexor pollicis longus** muscle (*m. flexor pollicis longus*)

*Action.* Flexes the distal phalanx of the thumb and also the wrist.

The **flexor digitorum profundus muscle** (*m. flexor digitorum profundus*).

Each of these tendons enters the hiatus tendineus between the two parts of the tendon of the flexor digitorum superficialis, crosses it, and *attaches* to the distal phalanx.

*Action.* Flexes the middle and distal phalanges of the index, middle, ring, and little fingers, and also assists in flexion of the wrist.
The pronator quadratus muscle (*m. pronator quadratus*) is a flat quadrangular muscle lying directly on both forearm bones and on the interosseous membrane immediately above the wrist joints.

*Action.* This muscle is the main pronator of the forearm while the pronator teres is an auxiliary pronator.

**THE POSTERIOR GROUP**

The superficial layer of the posterior muscles can be divided into two subgroups, radial and ulnar. The first occupies the anterolateral surface of the forearm, while the second occupies the posterior surface.

**The Radial Group of the Superficial Layer.**

The brachioradialis muscle (*w. brachioradialis*) lies on the lateral border of the forearm.

*Action.* Flexes the forearm at the elbow joint and sets the radius in a position intermediate between pronation and supination (the forearm and hand are usually held in this position when the limb is hanging limp).

The extensor carpi radialis longus (*m. extensor carpi radialis longus*) is lateral to and behind the brachioradialis muscle.

*Action.* Flexes the forearm and accomplishes dorsal flexion and radial abduction of the wrist joint (the last action is performed together with the flexor carpi radialis).

The extensor carpi radialis brevis muscle (*m. extensor carpi radialis brevis*) lies behind the long radial extensor of the wrist.

*Action.* The same as that of the extensor carpi radialis longus.

**The Ulnar Group of the Superficial Layer**

4. The extensor digitorum muscle (*m. extensor digitorum*) stretches on the posterior surface of the forearm. It *arises* with the extensor carpi radialis brevis from the lateral epicondyle. In the middle of the forearm, the muscle separates into four bellies, each ending in a long tendon. The tendons descend to the dorsal surface of the hand, pass under the retinaculum extensor through the fourth canal and then diverge toward the four fingers (with the exception of the thumb). On the dorsal surface of the hand near the metacarpophalangeal joints, the tendons are joined by means of oblique fibrous bands, *intertendinous connexion (conexus intertendineus)*, with the result that the
middle and ring fingers can be extended only jointly; the index finger and partly the little finger retain their independence because they have their own extensors).

**Action.** Extends the index, middle, ring, and little fingers and accomplishes dorsal flexion of the wrist.

The **extensor digiti minimi muscle** (*m. extensor digiti minimi*) branches off common extensor of the fingers on its ulnar side.

Action. Extends the little finger. The extensor carpi ulnaris muscle (*m. extensor carpi ulnaris*), whose lateral border adjoins the common extensor and the extensor of the little finger.

**Action.** Accomplishes dorsal flexion of the wrist and abducts in to the ulnar side; the last action is performed with the flexor carpi ulnaris.

The Ulnar Group of the Deep Layer

The supinator muscle (*m. supinator*) is in the superolateral part of the forearm. It is covered by the brachioradialis muscle and by both radial extensors of the wrist.

**Action.** The muscle is pure supinator of the forearm.

The **abductor pollicis longus muscle** (*m. abductor pollicis longus*) and the **extensor pollicis brevis muscle** (*m. extensor pollicis brevis*).

Lying together, they pass distally and laterally, emerge from under the radial border of the common extensor of the fingers, and pass through the first canal under the retinaculum extensorum to the thumb;

**Action.** The abductor pollicis longus abducts the thumb and abducts the wrist radially; the extensor pollicis brevis extends the proximal phalanx of the thumb.

The **extensor pollicis longus muscle** (*m. extensor pollicis longus*) crosses the tendons of both radial extensors of the wrist obliquely, passes under the retinaculum extensorum in the third canal and then to the dorsal surface of the thumb.

A hollow, called the **anatomical snuffbox**, forms on the radial side of the wrist joint between the tendon of the extensor pollicis longus and the tendons of the extensor pollicis brevis and abductor pollicis longus.

**Action.** Extends the thumb by pulling it dorsally.

The **extensor indicis muscle** (*m. extensor indicis*). **Action.** Extends in the index finger.
MUSCLES OF THE HAND

In addition to the tendons of the forearm muscles passing on the dorsal and palmar surfaces of the hand, there are short muscles of the hand proper, which arise and are inserted in this part of the upper limb. Three groups of these muscles can be distinguished. Two of them, located on the radial and ulnar borders of the palm, form the thenar eminence (thenar) and the hypothenar eminence (hypothenar); the third (middle) group is situated in the hollow of the hand (palma manus).

FASCIAE OF THE UPPER LIMB AND THE TENDON SHEATHS

The deltoid muscle lying in the region of the shoulder is covered by a thin deltoid fascia (fascia deltoidea).

Distally it blends with the brachial fascia. The brachial fascia (fascia brachii), which forms a tubular investment for the muscles of the upper arm, is quite thin.

On both sides the brachial fascia gives off two fibrous intermuscular septa: the septa intermuscularis brachii, which project deeply and separate the anterior muscles from the posterior. The medial septum (septum intermusculare brachii mediale) passes between the brachial and the triceps muscles and attaches to the osseous crest above the medial epicondyle of the humerus. The lateral septum (septum intermusculare brachii laterale) passes on the other border of the upper arm between the brachial and triceps muscles and distally between the triceps and the brachioradial muscles.

The antebrachial fascia (fascia antebrachii) invests the forearm muscles and produces fibrous septa which project between them. It also fuses with the epicondyles of the humerus and the posterior border of the ulna. On its dorsal border with the hand, the antebrachial fascia forms a transverse thickening in the form of a ligament, which is called the extensor retinaculum (retinaculum extensorum). Processes from the retinaculum fuse with the dorsal surface of the radius and ulna. Between these processes, under the ligament, are six canals, which are partly osteofibrous and partly fibrous. These canals transmit the tendons of the finger and wrist extensors. If we count from the radial to the ulnar border the first canal transmits the tendons of the abductor pollicis longus and the extensor pollicis brevis. The second canal (sometimes a double canal) transmits the tendons of the extensors carpi radiales longus and brevis. The third, crossing the preceding canal obliquely, transmits the tendon of the extensor pollicis
longus. The fourth canal transmits the tendons of the extensor digitorum and the extensor indicis, while the fifth canal, situated more superficially, transmits the tendon of the extensor digiti minimi. Finally, the sixth canal transmits the tendon of the carpi ulnaris. The walls of the canals are lined with a synovial membrane, which, above and below the extensor, retinaculum, folds over the tendons and covers them, forming the tendon sheaths (vaginae tendinum) of the dorsal muscles. The number of sheaths corresponds to the number of canals. The sheaths protrude on the dorsal surface of the hand from under the extensor retinaculum.

The considerably thickened fascia in the middle of the palm forms a strong palmar aponeurosis (aponeurosis palmaris), which is an extension of the tendon of the long palmar muscle. The palmar aponeurosis is triangular, with the apex lying on the flexor retinaculum and the base directed to the fingers, where it separates into four flat slips between which transverse fibres (fasciculi transverse) stretch. Under the aponeurosis is a flat, fibrous ligament restraining the flexor tendons and hence called the flexor retinaculum (retinaculum flexorum).

TOPOGRAPHY OF THE UPPER LIMB

Topography of the axillary region (regio axillaris), or fossa (fossa axillaris). During abduction of the arm, the axilla, or the axillary fossa, is clearly visible. It is bounded (with the arm abducted) inferiorly by the greater pectoral muscle in front and by the latissimus dorsi and teres major muscles behind, medially by an imaginary line connecting the borders of these muscles on the chest, and laterally by a line connecting these borders on the inner surface of the upper arm. If the fascia that, together with the skin, form the floor of the axilla, is removed, access is gained into the axillary cavity (cavum axillare). Its anterior wall is formed by the greater and smaller pectoral muscles, the posterior wall by the latissimus dorsi, lores major, and subscapular muscles. The medial wall is formed by the anterior serrate muscle, and the lateral wall is formed by the humerus and the coracobrachial muscle and the short head of the biceps muscle covering it.

 Inferiorly, the axillary cavity ends in an opening. Superiorly, it narrows and communicates with the region of the neck. The cavity is filled with fatty tissue containing nerves, vessels, and lymph nodes. To facilitate more exact description of
the topography of the vessels and nerves, the anterior wall of the axillary cavity is traditionally divided into three triangles, arranged one on top of the other. The upper triangle (trigonum clavipectora) is formed by the clavicle and the superior border of the smaller pectoral muscle. The middle triangle (trigonum pectorale) corresponds to the smaller pectoral muscle. The lower triangle (trigonum subpectorale) is bounded by the inferior border of the smaller pectoral muscle, the inferior border of the greater pectoral muscle, and the deltoid muscle.

On the posterior wall of the axillary cavity is a triangular space formed by the surgical neck of the humerus (laterally), the teres major muscle (inferiorly), and the subscapular muscle (superiorly). This space is divided vertically by the long head of the triceps muscle into two openings.

1. The lateral, quadrangular opening (space) (foramen quadrilaterum) is formed by the teres major and subscapular muscles and by the bone. It transmits the posterior circumflex humeral artery and the axillary nerve.

2. The medial, triangular opening (space) (foramen trilaterum) is bounded only by the teres major and subscapular muscles. It transmits the circumflex scapular artery.

Spaces, canals, and grooves (sulci) form between the muscles, fasciae, and bones of the upper limb and lodge various vessels and nerves. Knowledge of their location is important in surgery.

The, sulcus of the radial nerve of the humerus is covered by the triceps muscle, and thus converted in a canal (canalis humeroscapularis, s. canalis n. radialis, s. canalis spiralis). It transmits the radial nerve and the attendant deep brachial artery and vein.

Two grooves, the medial bicipital groove and lateral bicipital groove (sulcus bicipitalis medialis and sulcus bicipitalis lateralis) are located on the anterior surface of the humerus, between the brachial muscle and the borders of the biceps. The deeper, medial sulcus lodges the neurovascular bundle of the arm.

In front of the elbow joint, in the bend of the arm, is the cubital fossa (fossa cubitalis), bounded by the brachioradial muscle (laterally) and the pronator teres muscle (medially). The floor and superior border of the fossa are formed by the brachial muscle.

There are three grooves between the forearm muscles.
1. The medial, **ulnar groove** (*sulcus n. ulnaris*) lies between m. flexor carpi, ulnaris (medially) and m. flexor digitorum superficialis (laterally). It transmits the ulnar nerve, artery, and veins.

2. The lateral, **radial groove** (*sulcus n. radialis*) lies between m. brachioradialis (laterally) and m. flexor carpi radialis (medially). It transmits the radial nerve, artery, and veins.

3. The **median groove** (*sulcus medianus*) lies between the flexor carpi radialis (laterally) and the flexor digitorum superficialis (medially). It transmits the median nerve.

In the region of the wrist joint, **three canals** form as a result of the flexor retitiaculum nearby. Bridging the space between the eminentia carpi ulnaris and eminentia carpi radialis, the flexor retinaculum converts the groove between these eminences, the carpal sulcus (*sulcus carpi*), into the carpal canal or tunnel (*canalis carpalis*). Then separating and running to the radial and ulnar sides, the flexor retinaculum forms, respectively, the canalis carpiradialis and canalis carpi ulnaris. The ulnar nerves and vessels that extend from the sulcus ulnaris of the forearm pass in the ulnar canal (tunnel). The tendon of the flexor carpi radialis ensheathed in a synovial sheath lies in the canalis carpi radialis. Finally, in the canalis carpalis are two separate synovial sheaths, one for the tendons of mm. flexores digitorum superficialis and profundus, the other for the tendon of m. flexoris pollicis longus. The first, the common synovial sheath of the flexor tendons (*vag. synovialis communis mm. flexorum*) is a large medially located sac enclosing eight tendons of the deep and superficial flexors of the fingers. Superiorly, it protrudes 1-2 cm proximally of the flexor retinaculum, while inferiorly it reaches the middle of the palm. The sheath continues only on the tendons of the long flexors of the little finger, surrounds them, and reaches, together with them, the base of the distal phalanx of the little finger.

The second, the synovial sheath of the long flexor muscle of the thumb (*vag. tendinis m. flexoris pollicis longi*) is situated laterally. This long, narrow canal encloses the tendon of the long flexor muscles of the thumb. Superiorly, this sheath also protrudes 1-2 cm proximally of the flexor retinaculum, while inferiorly it extends on the tendon to the base of the distal phalanx of the thumb. The remaining three fingers
have separate sheaths, synovial sheaths of the tendons of the hand, digital (vaginae synoviales tendinum digitorum [manus]), enclosing the tendons of the flexors of the corresponding finger. These sheaths stretch from the line of the metacarpophalangeal joints to the base of the distal phalanges. Consequently, the index, middle, and ring fingers have isolated sheaths for the tendons of their common flexors on the palmar surface but are devoid of these sheaths in the segment corresponding to the distal halves of the metacarpal bones.

THE MUSCLES OF THE LOWER LIMB

The muscles of the lower limb are divided into the muscles of the hip region, thigh, leg, and foot.

MUSCLES OF THE HIP REGION

They can be classified according to the location of their attachment to the femur and according to their principal action into anterior, posterior, and medial groups.

The anterior group, (flexors), is attached to the lesser trochanter;

The posterior group (extensors, rotators, and abductors) are attached to the greater trochanter or in its vicinity;

The medial group (adductors) attaches to the linea aspera femoris (the only exception is gracilis, which is attached on the leg)

THE ANTERIOR GROUP

The iliopsoas muscle (m. iliopsoas) consists of two heads described as two separate muscles. The psoas major muscle (m. psoas major) and the iliacus muscle (m. iliacus).

The fibres of the iliac muscle converge as they pass downward and join the tendon of the greater psoas, muscle to form a single iliopsoas muscle. This muscle lies on the anterior surface of the hip joint, emerges from under the inguinal ligament through the lacuna musculorum.

Action. Accomplishes flexion at the hip joint by pulling the thigh to the abdomen and slightly rotating it medially. When the lower limb is steadied, the muscle causes forward flexion of the pelvis with the trunk.

The psoas minor muscle (m. psoas minor) adjoining the greater psoas muscle is in inconstant muscle. It tenses the iliac fascia and may flex the lumbar segment of the spine.
THE POSTERIOR GROUP

The gluteus maximus muscle (*m. gluteus maximus*) is massive muscular layer lying directly under the skin and fascia in the region of the buttock.

*Action.* An antagonist of the ilipsoas muscle, the gluteus maximus muscle extends the thigh, rotating its slightly laterally. When the lower limbs are held fast it extends the anteriorly flexed trunk.

The gluteus medius muscle (*m. gluteus medius*) is covered posteriorly by the gluteus muscle.

*Action.* When contracted, this muscle abducts the thigh.

The tensor fasciae latae muscle (*m. tensor fasciae latae*) developed in the embryo separately from the gluteus medius muscle. It lies directly in front of the gluteus medius muscle on the lateral surface of the thigh between the two layers, of the fascia lata.

*Action.* It tenses the iliotibial tract and, through it, acts on the knee joint and flexes the thigh.

The gluteus minimus muscle (*m. gluteus minimis*) lies under the gluteus medius muscle.

*Action.* The same as that of the middle gluteal muscle.

The piriformis muscle (*m. piriformis*).

*Action.* Rotates the thigh laterally and assists in its abduction;

The obturator internus muscle (*m. obturatorius internus*).

The edges of the internal obturator tendon lying outside the pelvic cavity on the posterior surface of the hip joint are fused with two flat and narrow muscles, gemellus muscles (*mm. Gemelii*) (L. gemelii twins).

*Action.* Rotates the thigh laterally.

The quadrutus femoris muscle (*m. quadrutus femoris*) lies inferior to the inferior gemellus muscle under the lower border of the gluteus maximus muscle.

*Action.* Rotates the thigh laterally.

The obturator externus muscle (*m. obturatoris externus*).

*Action.* Rotates the thigh laterally.

MUSCLES OF THE THIGH

The muscles of the thigh are divided into three groups: anterior (mainly
extensors), posterior (flexors), and medial (adductors)

THE ANTERIOR GROUP

The quadriceps femoris muscle (*m. quadriceps femoris*) occupies the entire anterior and part of the lateral surface of the thigh and is formed of three heads fused to each other. These heads are as follows.

The rectus femoris muscle (*m. rectus femoris*) lies superficially an *arises* from the inferior anterior iliac spine and from the superior margin of the acetabulum. At its origin, it is covered by the tensor fasciae latae and by the sartorius. The rectus femoris muscle passes on the middle of the thigh and joins the common tendon of the whole quadriceps muscle above the patella. The vastus lateralis muscle (*m. vastus lateralis*) encircles the femur laterally and *arises* from the lateral surface of the greater trochanter, and from the lateral lip of the linea aspera femoris. The fibres of the muscle descend obliquely and end some distance above the patella. The vastus medialis muscle (*m. vastus medialis*) lies medially in relation to the femur. It *arises* from the medial lip of the linea aspera femoris. Its fibres pass obliquely from the medial side laterally and downwards. The vastus intermedius muscle (*m. vastus intermedius*) lies directly on the anterior surface of the femur from which it takes its *origin* almost reaching the intertrochanteric line proximally. Its fibres stretch vertically parallel toward the common tendon. Laterally and medially the vastus intermedius muscle is covered by the lateral and medial great muscles, with which it blends here. The rectus femoris muscle is in front of it. Under the knee joint these parts of the quadriceps muscle form a common tendon, which is attached to the base and sides of the patella and is then continuous with the patellar ligament *attached* to the tibial tuberosity. Some of the tendon fibres of the vastus lateralis and vastus medialis pass on the sides of the patella downward and obliquely to form the *retinaculum of the patella (retinacula patellae)* mentioned in the section on syndesmology. The patella, as if framed in the tendon of the quadriceps muscle, increases the angle at which the muscle meets the lever, which favourably influences the application of its force.

*Action.* Flexes the leg at the knee joint. The rectus femoris flexes the hip joint as it passes over it.

The *sartorius* or *tailor's muscle* (*m. sartorius*).
Action. Flexes the knee joint, and, when the knee is flexed, rotates the leg medially, acting with the other muscles that have attachment in common with it. It can also flex the thigh at the hip joint, thus assisting the iliopsoas and rectus femoris.

THE POSTERIOR GROUP

1. The semitendinosus muscle (*m. semitendinosus*) is called so because (of its long tendon, which makes up almost the entire distal half of the muscle.

   The semimembranosus muscle (*m. semimembranosus*) lies under the semitendinosus muscle.

   The biceps femoris muscle (*m. biceps femoris*) is located near the lateral border of the thigh and is separated from the vastus lateralis by the lateral intermuscular septum.

   The popliteus muscle (*m. popliteus*) is triangular and lies on the posterior surface of the knee joint.

   Action. Since the semitendinosus, semimembranosus, and biceps femoris muscles stretch over two joints, their simultaneous action flexes the leg at the knee joint, extends the thigh when the pelvis is steadied and assists the gluteus maximus muscle in extension of the trunk when the leg is steadied. When the knee is flexed, these muscles rotate the leg, contracting separately on either side. The leg is rotated laterally by the biceps muscle and medially by the semitendinosus and semimembranosus muscles. The popliteus muscle acts only on the knee joint; it flexes the knee and rotates the leg medially.

THE MEDIAL GROUP

The pectineus muscle (*m. pectineus*)

Its lateral border adjoins the iliopsoas muscle. Where these muscles converge they form the iliopsectineal fossa (*fossa ilipectinea*) lodging the femoral vessel at their exit from the pelvis.

The adductor longus muscle (*m. adductor longus*).

Its fibres, like the fibres of the other adductors, extend downwards and laterally.

The adductor brevis muscle (*m. adductor brevis*) lies under the preceding muscles.

The adductor magnus muscle (*m. adductor magnus*) is the strongest of the
adductor group. It is furthest to the back, and its proximal part is covered in front by the long and short adductor muscles.

The upper fibres of the muscle stretch almost transversely from the pubic bone to the site of their attachment and are classified separately as the adductor minimus muscle (*m. adductor minimus*).

The glucilis muscle (*m. gracilis*) is a long, narrow band of muscle passing superficially on the medial border of the adductor group.

*Action.* As their names indicate, all the adductor muscles adduct the thigh, slightly rotating it laterally.

**MUSCLES OF THE LEG**

To facilitate movement on the frontal axis of the ankle joint and the finger joints, most muscles are arranged on the anterior and posterior surfaces of the leg between the tibia and fibula in front (the anterior muscles) and in back (the posterior muscles). To facilitate movement of the foot on the sagittal axis, the muscles are also arranged on the lateral surface along the fibula (the lateral muscles).

**THE ANTERIOR GROUP**

The tibialis anterior muscle (*m. tibialis anterior*) lies medially to all the other muscles and is the strongest in the group described.

*Action.* Accomplishes dorsal flexion of the foot and raises its medial border (supination).

The extensor digitorum longus muscle (*m. extensor digitorum longus*) originates from the lateral tibial condyle.

*Action.* The extensor longus muscle accomplishes dorsal flexion of the foot, raises the lateral border pronation, and everts the foot.

The extensor hallucis longus muscle (*m. extensor hallucis longus*) lies deeper in the space between the two muscles described above.

*Action.* Accomplishes dorsal flexion of the foot, raises its medial border, and extends the great toe.

**THE LATERAL GROUP**

The peroneus longus muscle (*m. peroneus [fibularis] longus*) lies superficially.
The **peroneus brevis muscle** (*m. peroneus [fibularis] brevis*) lies under; the long peroneal muscle.

**Action.** Both peroneal muscles pronate the foot, lowering its medial and raising its lateral borders; they also abduct the foot and assist the other muscles in its plantar flexion.

---

**THE POSTERIOR GROUP**

The *superficial layer* (muscles of the calf):

The **triceps surae muscle** (*m. triceps surae*) forms the main bulk of the calf. It is made up of two muscles, *m. gastrocnemius* lying superficially and *m. soleus* lying under it; both muscles have a tendon in common distally.

The gastrocnemius muscle (*m. gastrocnemius*) arises from the popliteal surface of the femur above both condyles by two heads whose tendons blend at their origin with the capsule of the knee joint. Uniting on the midline both heads of the muscle end almost at the middle of the crus in a tendon which fuses with the tendon of the soleus muscle to form the massive *calcaneal* (Achilles) *tendon*, *tendo, calcaneus* (*Achillis*), attached to the posterior surface of the calcanean tuber.

The **soleus muscle** (*m. soleus*) is thick and fleshy. It lies under the gastrocnemius muscle and at its origin occupies a great length of the leg bones.

Where the muscle crosses from the fibula to the tibia, the *tendinous arch of the soleus muscle* (*areas tendinous m. solei*) forms, under which the popliteal artery and the tibial nerve pass. The fibres descend and end on a wide tendinous expansion, which narrows distally and fuses with the calcaneal tendon.

The **plantaris muscle** (*m. plantaris*) originates from the popliteal surface of the femur above the lateral condyle.

**Action.** The musculature of triceps surae (including the plantar muscle) accomplishes plantar flexion at the ankle joint, both when the limb is free and when a person supports himself on the tip of the foot.

The *deep layer* is separated from the superficial layer by the deep fascia of the leg and is made up of three flexors, which are antagonists of the three extensors of the same name situated on the anterior surface of the leg.

The **flexor digitorum longus** muscle (*m. flexor digitorum longus*) is the extreme
medial muscle of the deep layer. It lies on the posterior surface of the tibia.

*Action.* The muscle is of small importance as a flexor of the toes, it mainly acts on the foot as a whole and accomplishes its plantar flexion and supination, when the limb is free.

The **tibialis posterior muscle** (*m. tibialis posterior*) occupies the space between the leg bones and is situated on the interosseous membrane and partly on the tibia and fibula.

*Action.* It adducts the foot and also accomplishes plantar flexion like the other posterior muscles.

The **flexor hallucis longus muscle** (*m. flexor hallucis longus*) is the extreme lateral muscle of the deep layer.

*Action.* Flexes the great toe.

**MUSCLES OF THE FOOT**

The foot, like the hand, in addition to tendons of the long muscles of the leg descending on it, has its own short muscles among which dorsal and plantar muscles are distinguished.

The iliopsoas muscle is covered in the region of the abdomen by the *fascia iliaca*, which is part of the common subperitoneal fascia (*fascia subperitonealis*)

Below the inguinal ligament, the fascia iliaca descend on the thigh, where it is continuous with *fascia lata* investing the muscles of the thigh. Directly below the inguinal ligament, within the boundaries of the femoral triangle (see below), the fascia divides into two layers, deep and superficial. The former passes behind the vessels of the thigh. The superficial layer extends in front of the thigh vessels and lateral of the femoral vein and terminates as a free *falciform margin (margo falciformis).*

This margin bounds a depression called the *saphenous opening (hiatus saphenus)* or *fossa ovalis* (BNA). Two "horns" are distinguished in the falciform margin. Vena saphena magna draining into the femoral vein overlaps the *inferior horn (cornu inferius)*, which blends with the deep layer of fasciae latae. The *superior horn (cornu superius)* attaches to the inguinal ligament and, curving under it, fuses with the lacunar ligament. Hiatus saphenus is covered by the *cribriform fascia (fascia cribrosa)* (the subcutaneous tissue of the thigh is pierced like a sieve by lymphatic vessels), which grows into the
falciform margin. Fascia lata, investing the muscles of the thigh, gives off processes, which pass deeply between the muscles and are attached to the bone. Some of these processes are on the lateral part of the thigh and form the lateral intermuscular septum (septum intermusculare femoris laterale). It is attached to the lateral lip of the linea aspera femoris and separates m. vastus lateralis from the posterior muscles of the thigh (m. biceps femoris in particular). The other, medial intermuscular septum (septum intermusculare femoris mediate) is on the medial aspect of the thigh and attaches on labium mediale lineae asperae in front of the adductor muscles.

Besides, fascia lata separates into two layers along the edges of some of the muscles to form a closed sheath for them. Fascia lata is very thick, particularly on the lateral surface of the thigh, where tendinous fibres blend into it. Here it forms a wide thickened band, the iliobial tract (tractus iliotibialis) extending for the entire length of the thigh. It serves as a tendon for the tensor muscle of the fascia lata and for the gluteus maximus muscle. In contrast to the tendinously thickened fascia on the gluteus medius muscle (the proximal end of the iliobial tract) the fascia covering the gluteus maximus muscle is very thin. Distally, fascia lata extends to the anterior surface of the knee and is continuous with the fascia of the leg; posteriorly it is continuous with fascia poplitea covering the popliteal fossa and representing an intermediate area between the fascia of the thigh and that of the leg. Thus, fascia lata of the thigh differs in structure in its different parts: along with very strong areas (e.g. the iliobial tract) there are also weak areas (fascia cribrosa).

The crural fascia (fascia cruris) surrounds the leg and fuses with the bones where they are uncovered by muscles. On the posterior aspect of the leg, it consists of a superficial and deep layers. The superficial layer covers the triceps surae muscle, while the deep layer lies between this muscle and the deep posterior muscles and is attached on the sides to the tibia and fibula. On the lateral side, fascia cruris gives off two intermuscular septa, which penetrate deeply and attach to the fibula. The anterior one (septum intermusculare anterius cruris) passes in front of the peroneus muscles, while the posterior septum (septum intermusculare posterius cruris) stretches behind them. On the anterior surface of the leg, above the malleoli, fibres blend with the fascia to form a transverse band between the leg bones, the superior extensor retinaculum of the foot.
This ligament presses the tendons of the anterior leg muscles to the bones. Of similar significance is the inferior extensor retinaculum (*retinaculum mm. extensorum inferius*), located distally in front of the ankle joint: it visually resembles in shape the letter Y laid on its side. This ligament originates from the lateral surface of the calcaneus, and its deep layer from the tarsal sinus, and then separates into two bands, the superior band passes to the medial malleolus while the inferior attaches to the navicular and the medial cuneiform bones.

At places this ligament splits into a superficial and deep layers investing the extensor tendons as a consequence of which four fibrous canals (three for tendons and one for vessels) are formed. The extreme lateral and the widest canal, located under the common origin of the inferior extensor retinaculum, transmits the tendons of the extensor digitorum longus and the peroneus tertius muscles. The canal next to it transmits the tendon of the extensor hallucis longus muscle, while the third, medial, canal transmits the tendon of the tibialis anterior muscle. The tendons passing through the canals are invested in synovial sheaths. The fourth canal, located behind the middle one, contains vessels (a. and v. dorsales pedis) and a nerve (n. peroneus profundus).

Thickenings of the fascia are also found behind both malleoli; they press the tendons against the bones. The medial thickening forms a ligament, the flexor retinaculum of the foot (*retinaculum mm. flexorum pedis*), which passes from the calcaneus to the medial malleolus over the tendons of the tibialis posterior, flexor digitorum longus, and flexor hallucis longus muscles. The ligament gives rise to a septum that penetrates deeper and forms three osteofibrous canals to transmit the above-named tendons and one fibrous canal that lies closer to the surface to transmit the posterior tibial artery and the tibial nerve. The tendons in the canals under the ligament are invested in three separate sheaths. Behind the lateral malleolus is a fascial thickening, the superior peroneal retinaculum (*retinaculum, mm. peroneorum superius*) stretching from the malleolus to the calcaneus over the tendons of the peroneus longus and brevis muscles, which lie under it in a common osteofibrous canal. Distally and somewhat downward both tendons pass under another ligament, the inferior peroneal retinaculum (*retinaculum mm. peroneorum inferius*) attached to the lateral surface of the calcaneus. The space under the inferior peroneal retinaculum is divided by a septum.
into two canals transmitting each tendon separately. The tendons of the peroneal muscles are invested in a common synovial sheath, which divides distally into two parts corresponding to the two canals under the inferior peroneal retinaculum.

The **dorsal fascia of the foot** (fascia dorsalis pedis) is rather thin distally from the inferior extensor retinaculum and only on the level with the base of the first metatarsal bone it has a thickening of arched fibres passing over the tendon of the extensor hallucis longus muscle.

The **fascia of the sole**, like the fascia of the palm, is greatly thickened and forms in its middle part a strong tendinous shining plantar aponeurosis (aponeurosis plantaris).

**TOPOGRAPHY OF THE LOWER LIMB**

**CANALS TRANSMITTING THE VESSELS AND NERVES**

The piriform muscle passes through the greater sciatic foramen above and below which narrow openings (foramen suprapiriforme and foramen infrapiriforme) remain and transmit the gluteal vessels and nerves.

Sulcus obturatorius of the pubic bone is supplemented below by the obturator membrane and is thus converted to a canal (canalis obturatorius) providing passage for the obturator vessels and nerves.

The inguinal ligament runs over the hip bone from the superior anterior iliac spine to the pubic tubercle of the pubic bone and in this manner bounds the space between the above-named bone and ligament. Fascia iliaca passing in this space fuses in its lateral part with the inguinal ligament while its medial portion diverges from the ligament, thickens, and attaches to the iliopubic eminence. The part of this thickened band of fascia iliaca between the inguinal ligament and the iliopubic eminence is distinguished artificially under the name of the iliopectineal arch (arcus iliopectineus).

Arcus iliopectineus divides the entire space below the inguinal ligament into two parts: a lateral, **muscular part** (lacuna musculorum) lodging the iliopsoas muscle and the femoral nerve, and a medial, **vascular part** (lacuna vasorum) for passage of the femoral artery and vein (the latter passes medially). From lacuna vasorum the vessels pass to the thigh, leg, and foot. The vessels and nerves pass in grooves, which are converted to canals and then again opened to form grooves. According to the passage of the vessels and nerves, the following grooves (sulci) and canals are distinguished.
Sulcus iliopectineus, with which lacuna vasorum is continuous, lies between the iliopsoas (laterally) and the pectineal (medially) muscles and is then in turn continuous with sulcus femorialis anterior formed by the vastus medialis (laterally) and the adductor longus and magnus (medially) muscles. Both sulci are in the femoral triangle (trigonum femorale) bounded by the inguinal ligament (superiorly, the base of the triangle), the sartorius muscle (laterally) and the adductor longus muscle (medially). The floor of the triangle, called fossa iliopectinea, is formed by the iliopsoas and pectineal muscles. At the downward-facing apex of the triangle, sulcus femorialis anterior leaves it between the muscles and transforms into a canal, canalis adductorius, passing on the lower third of the thigh into the popliteal fossa. The canal is formed by the vastus medialis muscle (laterally), the adductor magnus muscle (medially), and a tendinous lamina, lamina vastoadductoria, running over them (anteriorly); its distal foramen is called hiatus tendineus (adductorius) formed by the diverging bundles of the adductor magnus muscle.

Canalis adductorius opens distally into the popliteal fossa (fossa poplitea) shaped like a rhomb. The superior angle of the rhomb is formed by the biceps muscle laterally and by the semimembranous and semitendinous muscles medially. The inferior angle is bounded by both heads of the gastrocnemius muscle. The floor of the fossa is formed by fades poplitea femoris and the posterior wall of the knee joint. The popliteal fossa contains fatty tissue with the popliteal lymph nodes. From the superior to the inferior angle pass the sciatic nerve (or its two branches into which it divides) and the popliteal artery and vein in the following order (from the surface and deeper) nerve, vein, artery.

The popliteal fossa is continuous with canalis cruropopliteus extending between the superficial and deep layers of the posterior leg muscles and mainly formed by the tibialis posterior (anteriorly) and the soleus (posteriorly) muscles. It provides passage for the tibial nerve and the posterior tibial artery and vein. A branch of this canal which corresponds to the course of the peroneal artery is canalis musculoperoneus inferior formed by the middle third of the fibula and the flexor hallucis longus and tibialis posterior muscles. Canalis musculoperoneus superior is in the upper third of the leg, between the fibula and the peroneus longus muscle; the superficial peroneal nerve passes in it. In line with the course of the plantar vessels and nerves, two grooves are
found on the sole along the edges of the flexor digitorum brevis muscle:

(1) a **medial groove** (*sulcus plantaris medialis*) between the above-indicated muscle and the abductor hallucis muscle and (2) a **lateral groove** (*sulcus plantaris lateralis*) between the same flexor and the abductor digiti minimi muscle.

**THE FEMORAL CANAL**

Under normal conditions the femoral canal does not exist; there is a narrow opening in the medial corner of lacuna vasorum called the **femoral ring** (*anulus femoralis*). The ring is bounded laterally by the femoral vein, anteriorly and superiorly by the inguinal (Poupart's) ligament, medially from the lacunar ligament, which is a continuation of the inguinal ligament, and posteriorly by the pectineal ligament which is also a continuation, as it were, of the lacunar ligament on the pubic bone.

The anulus femoralia is filled with connective tissue (*septum femorale*), which is actually the subperitoneal fuscia loosened here, and is covered by Pirogov's lymph node from the outside and by the poritoneum from the inside; the peritoneum forms here a depression (*fossa femoralis*). Femoral hernias may form through the femoral ring, more frequently in females than in males because it is wider in the former due to the broader pelvis. With the protrusion of a hernia anulus femoralis transforms into a canal with two openings, an inlet and an outlet.

The inlet, or **internal**, opening is the femoral ring (*anulus femoralis*) described above. The outlet, or **external**, opening is the hiatus saphenus, bounded by the falciform margin and its superior and inferior horns. The space between the openings is the femoral canal (*canalis femoralis*), which has three walls: lateral, formed by the femoral vein; posterior, formed by the deep layer of fascia lata femoris; and the anterior wall, formed by the inguinal ligament and the superior horn of the crescent-shaped margin of fascia lata. The latter is loosened in the hiatus saphenus and perforated by lymph vessels and v. saphena magna as a consequence of which it resembles a lattice and is called fascia cribrosa. Loosening of fascia lata femoris in the oval fossa is responsible for the protrusion of a femoral hernia just in this place.