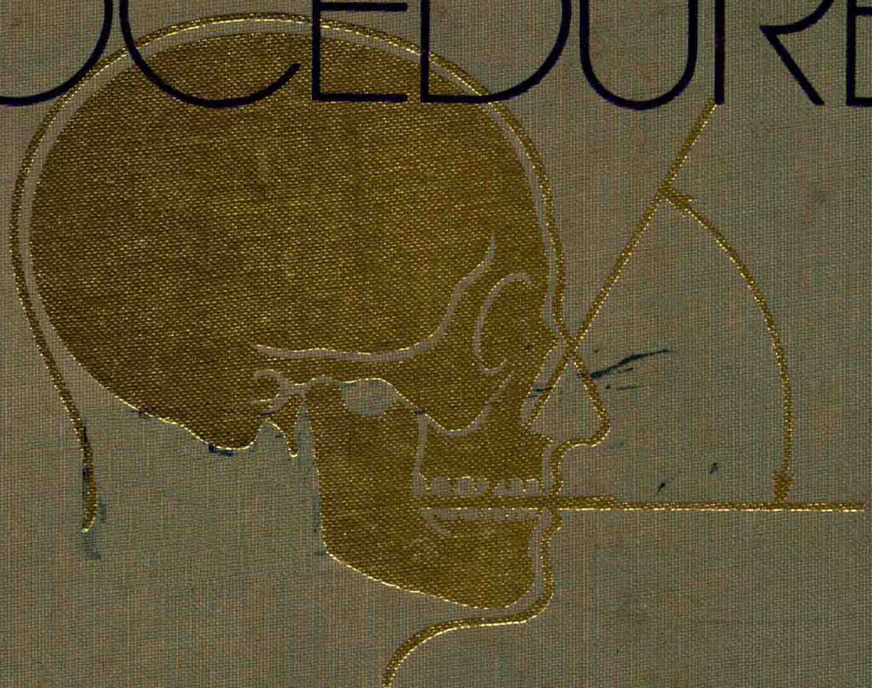
VOLUME TWO

MERRILL'S ATLAS OF

RADIOGRAPHIC POSITIONS and RADIOLOGIC PROCEDURES



Philip W. Ballinger

FIFTH EDITION

VOLUME TWO

MERRILL'S ATLAS OF RADIOGRAPHIC POSITIONS and RADIOLOGIC PROCEDURES

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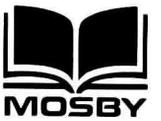

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Preface

The purpose of the fifth edition of *Merrill's Atlas of Radiographic Positions and Radiologic Procedures* remains the same as that of the first edition—to provide a current source of reference for the student, technologist, and physician. In revising this edition the attempt was made to add recently described techniques and to selectively delete obsolete examinations or to combine discussions of similar examinations. The attempt was also made to organize and present the material in a concise, readable, and easy-to-use format.

Several changes have been made in this edition, including revisions of terminology. For instance, the title has been modified to reflect the profession's changes in terminology during recent years. In addition, the new chapter on radiographic terminology defines and illustrates the patient body positions by using the currently accepted terminology and abbreviations, which are in general agreement with those used in the profession, as well as with those used by The American Registry of Radiologic Technologists.

New chapters have been added, including those on computed tomography, diagnostic medical sonography, digital radiography, nuclear magnetic resonance, radiation protection, radiation therapy, and radiographic terminology. Extensive revisions were made in the chapters on the alimentary tract, mammography, nuclear medicine, pediatrics, and tomography and the section on visceral and peripheral angiography.

Most of the photographs for the radiographic positions have been replaced with new illustrations to show both the path of the central ray and a lighted collimator field. Selected illustrations show the use of gonad shielding, where appropriate.

Selected radiographs have been anatomically labeled in this edition. In general, the AP, PA, and lateral projections were not labeled, since line drawings corresponding to the anatomic structures were included in the anatomy section of the same chapter. Most labeling is included on oblique and axial projections in which the body parts may be distorted or the radiographic location altered in relation to the surrounding structures. I hope that this labeling will satisfy the requests made by numerous users of the text.

In earlier editions of this text numerous radiographic positions involving the cranium used specifically constructed angle platforms for positioning. Because of the increasing availability of specialty head units, most of these patient positions are shown using a head unit. In most cases, however, line drawings for the patient positions are included to demonstrate proper positioning of the patient for both horizontal and upright radiography.

The bibliographies in each of the three volumes have been extensively updated. Where possible, articles that have been published in the more widely circulated journals are cited. It is my belief that if an excellent article cannot be obtained easily, the value of such an article is not as great. To assist the user of the bibliography, an index is included on the first page of each bibliography.

Several items have been deleted from this edition. The chapter on dental radiography was deleted, and several projections requiring the use of accessory positioning devices no longer commercially available (e.g., Bullitt mastoid apparatus) were also deleted. Other projections were deleted to conform to NCRP regulations.

Mention of nonshockproof equipment was deleted from this edition because very few such installations remain in operation. Where such equipment is in use, extreme caution must always be exercised to ensure that the patient does not come close to or in contact with the x-ray tube or the overhead system.

During the revision of this edition it was a pleasurable experience to have received the cooperation and assistance of so many people. On several occasions problems seemed insurmountable. It was fortunate that at such times a resource person was always available, and I was gratified with the professional effort and support received.

For reviewing certain sections of the text and offering constructive criticism and thoughtful suggestions, I gratefully acknowledge my indebtedness to James Bland, C.N.M.T., Mary Pat Borgess, M.D., Steven K. Cho, M.D., Betsy A. Delzeith, R.T.(R), J. David Dunbar, M.D., Thomas R. Frye, M.D., Lawrence R. Fulmer, M.D., Howard D. Klosterman, M.D., Roscoe E. Miller, M.D., Charles F. Mueller, M.D., Jean R. Pacquelet, M.D., David J. Paul, M.D., Robert J. Ragosin, M.D., and Alfred E. Stockum, M.D.

My most sincere appreciation is extended to Picker International and specifically to Mr. Ron Ratliff for the prompt attention and action in loaning the radiographic unit used in photographing most of the patient positions. Without the unit the task of taking the hundreds of photographs would have been much more difficult and time consuming. Thanks are also extended to James W. Miller, R.T.(R), of E.G. Baldwin and Associates for the loan of the accessory equipment used in the photographs.

I owe special thanks to William F. Finney, R.T.(R), and Jeffrey L. Rowe, R.T.(R), for reviewing and offering valuable suggestions for selected specialty chapters and to J. James Jerele, D.O., for his time and effort in reviewing the manuscript on the alimentary tract.

For the careful reading of the manuscript to double-check for accuracy and clarity I thank Janie Moore, R.T.(R). I appreciate Ms. Sarah Mignery's secretarial assistance and responses to my many requests that the material was "needed yesterday."

To Elyse T. Massey, R.T.(R), I extend my sincere appreciation for her valuable assistance in updating the bibliography in all three volumes. Her competent and organized effort was indeed appreciated, and it was a pleasure to work with her.

I gratefully extend special thanks to Mr. Michael J. Keating and Mr. E. Brent Turner, who photographed and printed most of the new illustrations. During the shooting sessions many problems were overcome by their expertise and creativity. I truly appreciate their cooperation, support, and ability to meet almost impossible deadlines. Grateful appreciation is also extended to the staff of the Medical Illustration and Photography Department of The Ohio State University Hospitals for support provided in producing many new illustrations.

To Nina Massuros Kowalczyk, R.T.(R), and Alan J. Orth, R.T.(R), I extend my deepest appreciation and thanks for the more than full-time effort and competent assistance in planning, initiating, and seeing through to completion the changes in this edition. During our months of work I developed a greater respect for their abilities and for their dedication to accomplishing the objectives within the time allotted.

To the professional staff members of The C.V. Mosby Company I extend my deepest appreciation for all their help and assistance. It was indeed a pleasure to work with them and to learn of their sincere desire to produce a book of utmost quality.

Loving appreciation is given to my parents, D.W. and Mildred Ballinger, for encouraging me to pursue a career in radiography. Following my registration as an R.T., they encouraged me to pursue an undergraduate and graduate education for which I am profoundly grateful. I also extend my thanks to J. Robert Bullock, R.T.(R), for his valued support. I will always remember him as a teacher, supervisor, mentor, colleague, and friend. His valued opinions were often the basis for decisions affecting my career.

To my wife, Nancy, my thanks for her support and assistance in serving as chief errand runner, proofreader, clerk, bookkeeper, and general home manager during the time of my preoccupation with the text. I hope that my son, Eric, and my daughter, Monica, understand why I was not always available to them. Their often-asked question "Are you done with the book?" can now be answered, "Yes."

Philip W. Ballinger

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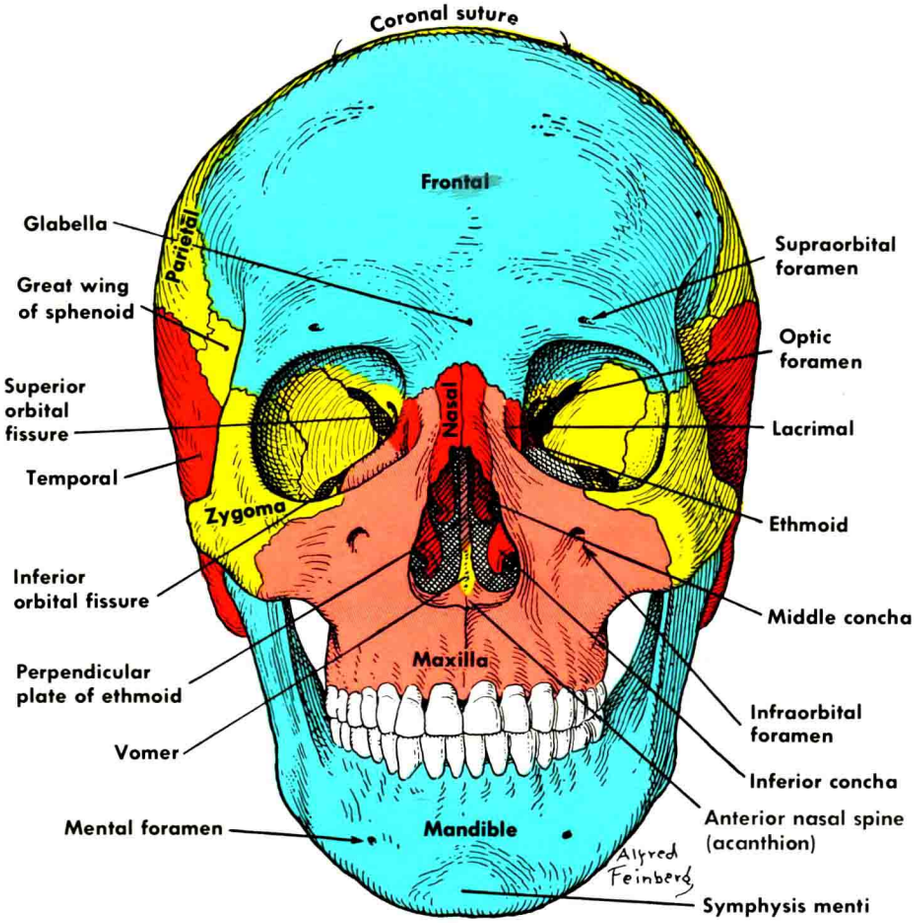
ANATOMY

The skeleton of the head is divided into two parts: (1) the *cranium*, or *calvaria*, which is composed of eight bones, and (2) the *face*, which is composed of 14 bones. The cranial bones are rigidly jointed together by articulations called sutures, and they form the protective housing for the brain. These bones are as follows: one *frontal*, one *ethmoid*, two *parietal*, one *sphenoid*, two *temporal*, which contain the organs of hearing, and one *occipital*. The facial bones, with the exception of the mandible, are also rigidly jointed together by sutures. These bones form the protective housing for the upper ends of the respiratory and digestive tracts and, with several of the cranial bones, form the orbital sockets for the protection of the organs of sight. The facial bones are as follows: two *nasal bones*, two *lacrimal bones*, two *maxillae*, two *malar bones*, or *zygomas*, two *palatine bones*, two *inferior nasal conchae*, or *turbinates*, one *vomer*, and one *mandible*. The *hyoid bone* is commonly included with this group of bones; it will be considered later.

The bones of the cranial vault are composed of two plates of compact tissue separated by an inner layer of spongy tissue called diploë. The outer plate, or table, is thicker than the inner table over most of the vault, and the thickness of the layer of spongy tissue varies considerably. The internal surfaces of the bones forming the vault of the cranium are marked with narrow, branchlike grooves (the *meningeal grooves*), and with relatively larger channels (called *sulci*), which lodge blood vessels of various sizes.

In the newborn infant the bones are thin and incompletely developed. They contain a small amount of calcium, are indistinctly marked, and present six areas of incomplete ossification called *fontanels*. Two of the fontanels are situated in the midsagittal plane at the superior angles of the parietal bones, and two on each side at the inferior angles of the parietal bones. The posterior and anterolateral fontanels normally close at the first and third months, respectively, and the anterior and posterolateral fontanels close during the second year. The cranium develops rapidly in size and density during the first 5 or 6 years, after which time there is a gradual increase to adult size and density, usually reached by the age of 12 years. The thickness and degree of mineralization in normal adult craniums show comparatively little difference in radiopacity from subject to subject, and the atrophy of old age is less marked than in other regions of the body.

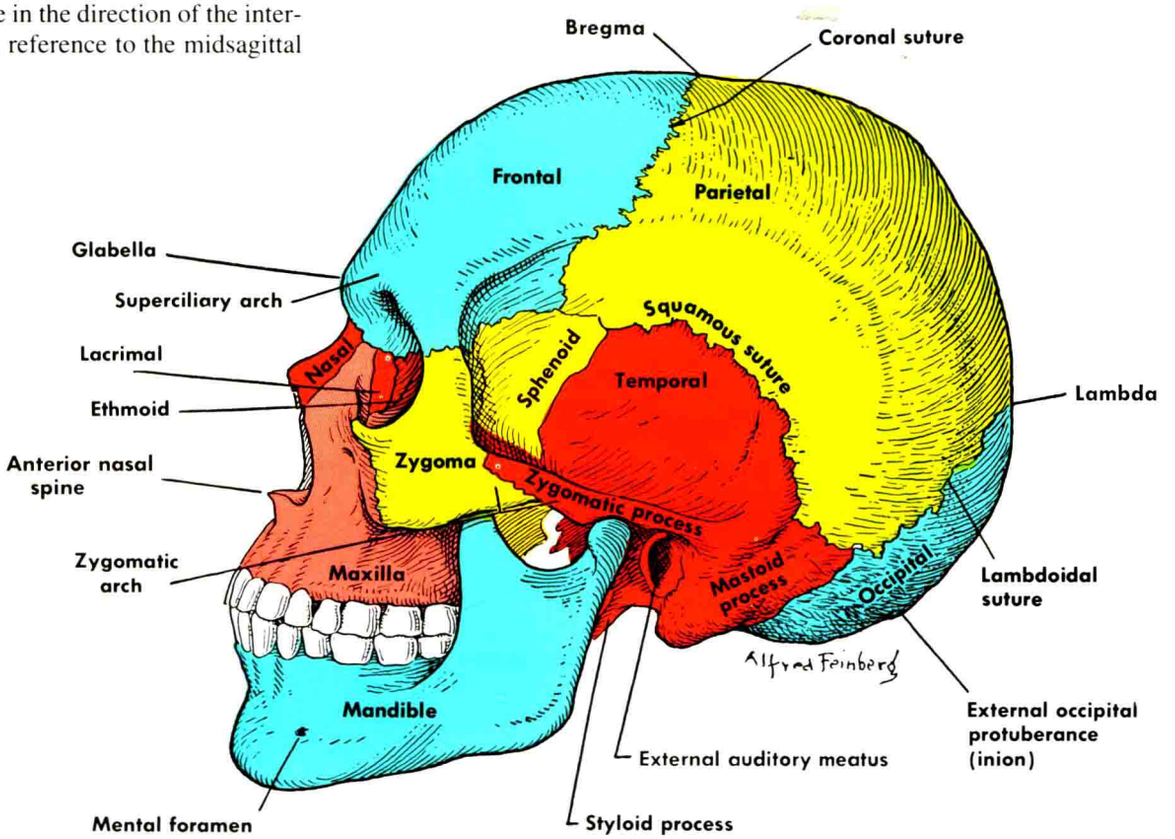


ANTERIOR ASPECT OF SKULL

The average, or so-called normal, cranium is more or less oval in shape, being wider behind than in front. It measures approximately 15 cm at its widest point from side to side, 18 cm at its longest point from front to back, and 22 cm at its deepest point from the vertex to the submental region. Craniums vary in size and shape, resulting in a variation in the position and relationship of internal parts.

Internal deviations from the normal are usually indicated by the external deviations and thus can be estimated with a reasonable degree of accuracy. There is a 3-cm difference between the width and length of the normally shaped head. Any deviation from this relationship indicates a comparable change in relationship of the internal structures, which, if it is more than a 5-degree change, must be compensated for either by a change in part rotation or by the central ray angulation for all projections except direct lateral views. A 1-cm change in the 3-cm width-to-length measurement indicates an approximate 5-degree change in the direction of the internal parts with reference to the midsagittal plane.

Although it is not necessary for the technologist to know the minute details of the complex structure of the cranium, it is necessary for him to know its anatomy from the standpoint of size and shape, and the position and relationship of its component parts, so that he can estimate and compensate for deviations from the normal.



LATERAL ASPECT OF SKULL

CRANIAL BONES

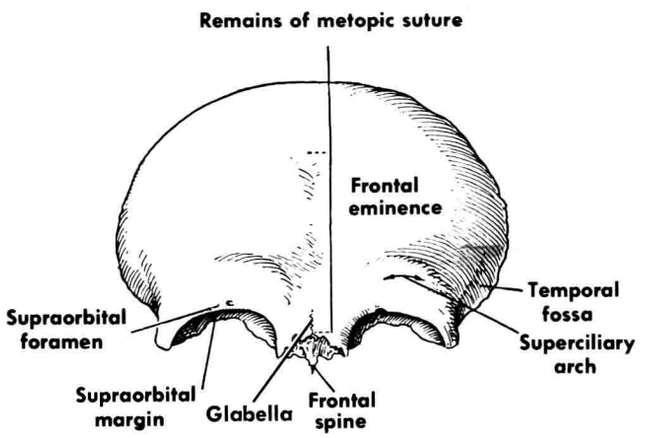
Frontal bone. The frontal bone consists of a vertical portion, called the squama, which forms the forehead and the anterior part of the vault, and a horizontal portion, which forms the roofs of the orbits, part of the roof of the nasal cavity, and the greater part of the anterior cranial fossa.

On each side of the midsagittal plane of the upper portion of the squama is a rounded elevation called the frontal eminence. Below the frontal eminences, just above the supraorbital margins, are two arched ridges that correspond in position to the eyebrows. These ridges are called the *superciliary arches*. The smooth elevation between the superciliary arches is termed the *glabella*.

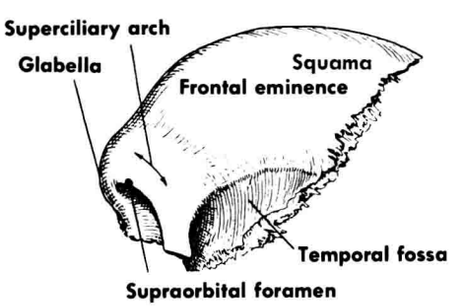
The frontal air sinuses are situated between the two tables of the squama on each side of the midsagittal plane, and from the lower margin they extend superiorly, laterally, and posteriorly. These sinuses are separated by a thin, bony wall, the intersinus septum, which may be incomplete and usually deviates from the midline. The frontal sinuses vary greatly in size, and they are frequently divided into a number of loculi by the presence of other septa.

The squama articulates with the parietal bones and with the greater wings of the sphenoid bone at the coronal suture. The midpoint of the frontonasal suture is termed the *nasion*.

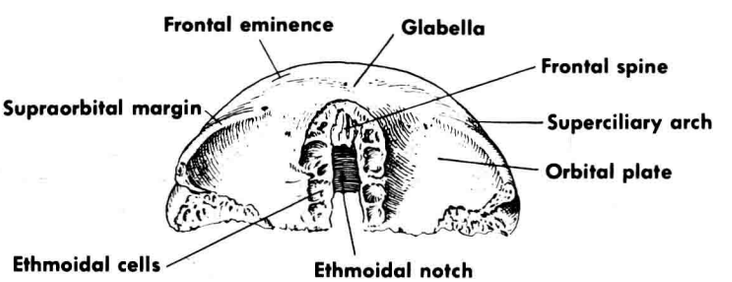
The orbital plates of the horizontal portion of the frontal bone are separated by a notch, called the ethmoid notch, that receives the cribriform plate of the ethmoid bone. The orbital plates articulate with the lesser wings of the sphenoid bone at their posterior margins.



ANTERIOR ASPECT OF FRONTAL BONE



LATERAL ASPECT OF FRONTAL BONE



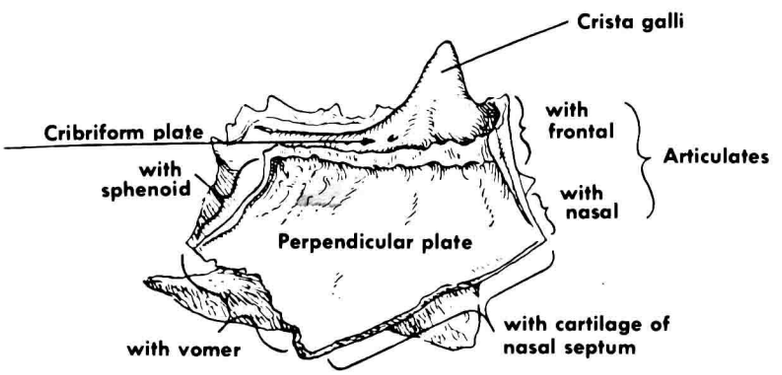
INFERIOR ASPECT OF FRONTAL BONE

Ethmoid bone. The ethmoid bone is a small, cube-shaped bone. It consists of a horizontal plate, a vertical plate, and two light, spongy lateral masses. It is situated between the orbits and forms part of the anterior cranial fossa and part of the nasal and orbital walls.

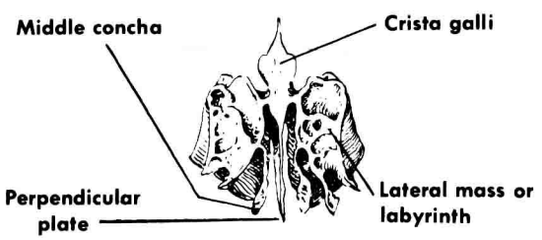
The horizontal portion, called the *cribriform plate,* is received into the ethmoid notch of the frontal bone. It is perforated by many foramina for the transmission of the olfactory nerves and has a thick, conical process, called the *crista galli,* projecting upward from its anterior midline.

The vertical portion is called the *perpendicular plate*. This plate is a thin, flat bone that projects inferiorly from the inferior surface of the cribriform plate and forms the upper portion of the bony septum of the nose.

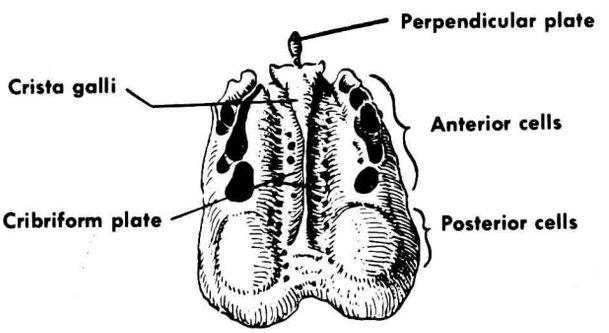
The *lateral masses* contain the ethmoid air sinuses, which are composed of numerous cells. The cells of each side are arbitrarily divided into two groups, called the anterior and the posterior ethmoid cells. The walls of the lateral masses form a part of the medial walls of the orbits and a part of the lateral walls of the nasal cavity. Projecting inferiorly from each medial wall of the masses are two thin, scroll-shaped processes called the *superior* and *middle nasal conchae,* or *turbinates.*



LATERAL ASPECT OF ETHMOID BONE WITH LABYRINTH REMOVED



ANTERIOR ASPECT OF ETHMOID BONE

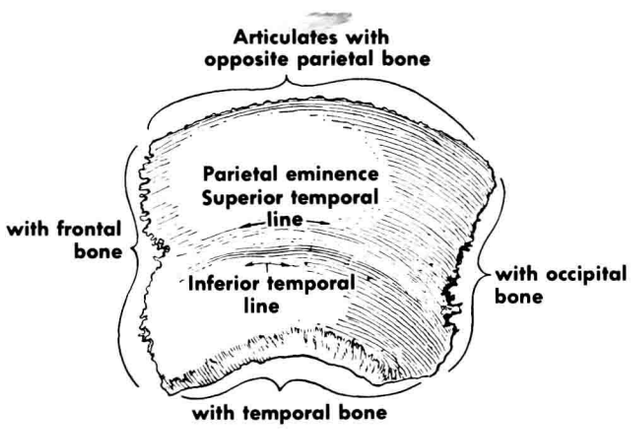


SUPERIOR ASPECT OF ETHMOID BONE

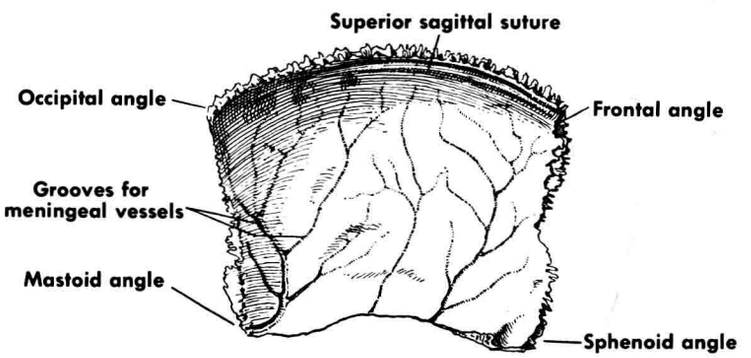
Parietal bones. The parietal bones are more or less square in shape and have a convex external surface and a concave internal surface. They form a large portion of the sides of the cranium, and by their articulation with each other at the sagittal suture in the midsagittal plane, they form the posterior portion of its roof.

The parietal bones articulate with the frontal bone at the coronal suture, with the occipital bone at the lambdoidal suture, and with the greater wings of the sphenoid and the temporal bones at the sphenoparietal, the squamosal, and the parietomastoid sutures. The point where the sagittal suture meets the coronal suture is called the *bregma*, and the point where the sagittal and lambdoidal sutures meet is called the *lambda*.

Each parietal bone presents a prominent bulge, called the *parietal eminence*, near the central portion of its external surface. In radiography the width of the head should be measured at this point, the widest point of the head.



EXTERNAL SURFACE OF PARIETAL BONE



INTERNAL SURFACE OF PARIETAL BONE

Sphenoid bone. The sphenoid bone is an irregularly wedge-shaped bone situated at the base of the cranium between the horizontal portion of the frontal bone and the basilar portion of the occipital bone. It consists of a *body*, two *lesser wings*, and two *greater wings*, which project laterally from the sides of the body, and two *pterygoid processes*, which project inferiorly from each side of the inferior surface of the body.

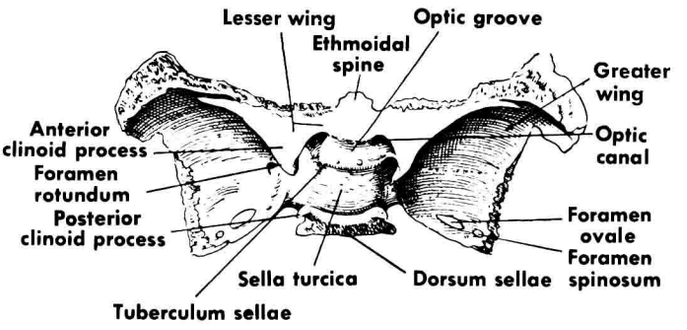
The *body* of the sphenoid bone contains the two sphenoid air sinuses, which are separated by a median septum. The anterior surface of the body forms the posterior bony wall of the nasal cavity. The superior surface presents a deep depression that is called the *sella turcica* and that lodges a gland known as the *hypophysis*, or *pituitary body*. The sella turcica is bounded anteriorly by the *tuberculum sellae* and posteriorly by the *dorsum sellae*, which bears the *posterior clinoid processes*. The sella turcica lies in the midsagittal plane of the cranium at a point ¾ inch anterior to and ¾ inch superior to the level of the external auditory meatus.

The *optic groove* extends across the anterior portion of the superior surface of the body of the sphenoid bone. This groove accommodates the *optic chiasm*, which is the structure formed by the approach and crossing of the two optic nerves. The groove is bounded anteriorly by a ridge called the limbus sphenoidalis and posteriorly by the tuberculum sellae. It ends on each side at the optic canal, the passage opening into the apex of the orbit for the transmission of the optic nerve and ophthalmic artery.

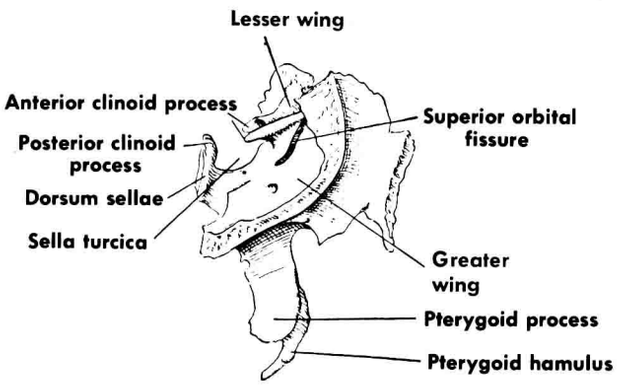
The *lesser wings* are triangular in shape and nearly horizontal in position. They arise, one on each side, from the anterosuperior portion of the body of the sphenoid bone and project laterally, where they end in sharp points. The lesser wings form the posteromedial portion of the roofs of the orbits, the posterior portion of the anterior cranial fossa, the upper margin of the *superior orbital fissures*, and the *optic canals*. The medial ends of their posterior borders form the *anterior clinoid processes*. Each arises from two roots. The upper root is thin and flat, and the lower root, referred to as the *sphenoid strut*, is thick and rounded. The circular opening between the two roots is known as the optic foramen or, because of its length, as the optic canal. The canals measure from 4 to 9 mm in length and about 5.5 mm in diameter.

The *greater wings* arise from the sides of the body and curve laterally, posteriorly, anteriorly and superiorly. The greater wings form a part of the middle fossa of the cranium, the posterolateral walls of the orbits, the lower margin of the superior orbital fissures, and the greater part of the posterior margin of the inferior orbital fissures. The foramina rotundum, ovale, and spinosum are paired and are situated in the greater wings. These foramina transmit nerves and blood vessels, so that they are subject to radiologic investigation for the detection of erosion disclosing lesions of neurogenic or blood-vascular origin. The foramen rotundum is a round aperture and is horizontally placed in the anteromedial portion of the greater wing adjacent to the lateral wall of the sphenoid sinus. The foramen ovale is the largest of these foramina, is usually oval in shape, and is situated lateral and posterior to the foramen rotundum. The foramen spinosum is the smallest of these foramina and is situated near the posterior angle of the greater wing, just lateral and posterior to the foramen ovale.

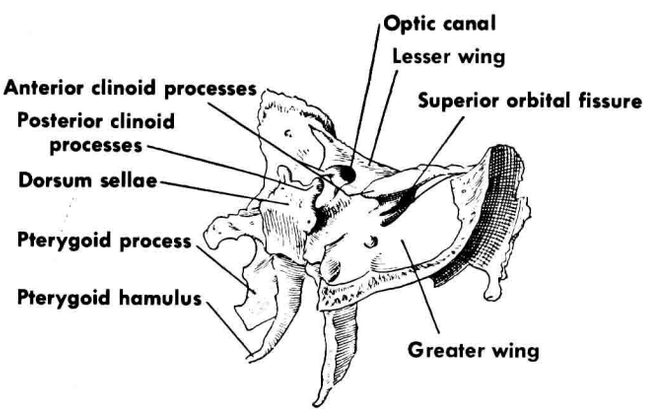
The *pterygoid processes* arise from the lateral portions of the inferior surface of the body and the medial portions of the inferior surfaces of the greater wings, project inferiorly, and curve laterally. Each pterygoid consists of two plates of bone, one lateral and one medial, that are fused at their upper anterior parts. The medial process, called the pterygoid hamulus, is longer and narrower than the lateral process. The pterygoid processes articulate with the palatine bones anteriorly and with the alae of the vomer where they enter into the formation of the nasal cavity.



SUPERIOR ASPECT OF SPHENOID BONE



LATERAL ASPECT OF SPHENOID BONE



OBLIQUE VIEW OF UPPER AND LATEROPOSTERIOR ASPECTS OF SPHENOID BONE

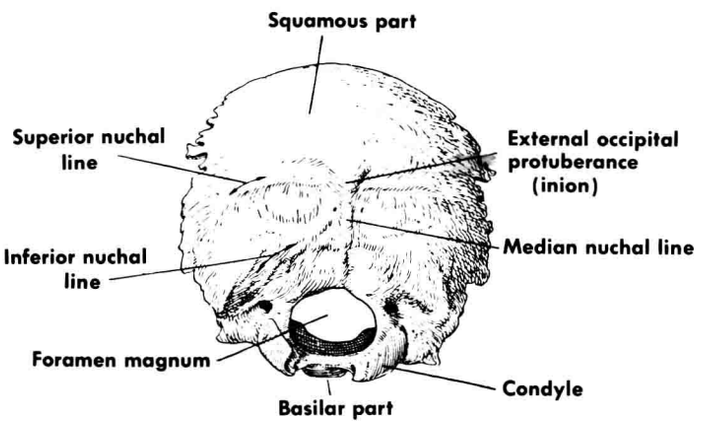
Occipital bone. The *occipital bone* is situated at the posteroinferior part of the cranium. It forms the back and almost half of the base of the cranium and the greater part of the posterior cranial fossa. It consists of four parts and has a large aperture, the *foramen magnum,* that transmits the medulla oblongata to the cranial cavity. The four parts of the occipital bone are (1) the squama, which is more or less saucer shaped, being convex externally; (2 and 3) *two lateral portions* that extend anteriorly, one on each side of the foramen magnum, from the squama to their junction with (4) the *basilar part.*

The *squama* curves posteriorly and superiorly from the foramen magnum and is also curved from side to side. It articulates with the parietal bones at the lambdoidal suture and with the mastoid portions of the temporal bones at the occipitomastoid sutures. On the external surface of the squama, midway between its summit and the foramen magnum, there is a prominent process termed the *inion,* or *external occipital protuberance,* which corresponds in position to the internal occipital protuberance. The internal surface of the squama is divided into four fossae they are separated by channels for the transverse, occipital, and sagittal blood sinuses. The two upper fossae accommodate the occipital lobes of the cerebrum, and the two lower fossae accommodate the hemispheres of the cerebellum.

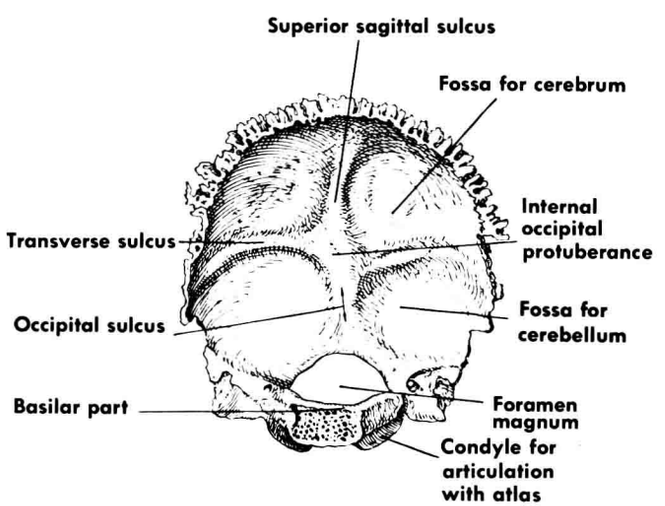
The *lateral portions* project anteriorly, one from each side of the squama. Part of each lateral portion curves medially to fuse with the basilar portion and thus to complete the foramen magnum, and part of it projects laterally to form the jugular process. On the inferior surface of the curved parts, extending from the level of the middle of the foramen magnum anteriorly to the level of its anterior margin, there are reciprocally shaped condyles for articulation with the superior facets of the atlas. These articulations are known as the *occipitoatlantal joints,* and they are the only bony articulations between the skull and the trunk.

The *jugular process* presents, on its anterior border, a deep notch that forms the posterior and medial boundary of a venous passage known as the *jugular foramen.* The extremity of the process articulates with a reciprocally shaped process on the inferior surface of the temporal petrosa beside a deep depression, the jugular fossa, that forms the anterior and lateral boundary of the jugular foramen. The right jugular foramen is normally somewhat larger than the left, and each opening is partially divided by bony projections into medial and lateral parts. The jugular foramen is situated directly below the internal auditory meatus, with its floor at the level of, and just lateral to, the anterior third of the occipital condyles.

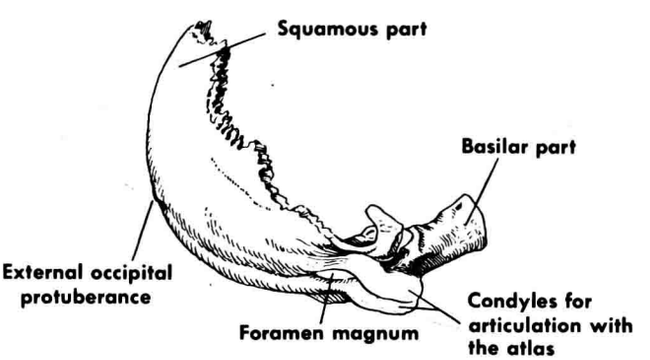
The *basilar portion* curves anteriorly and superiorly to its junction with the body of the sphenoid. In the adult the basilar part of the occipital bone fuses with the body of the sphenoid bone, with the result that they form a continuous bone.



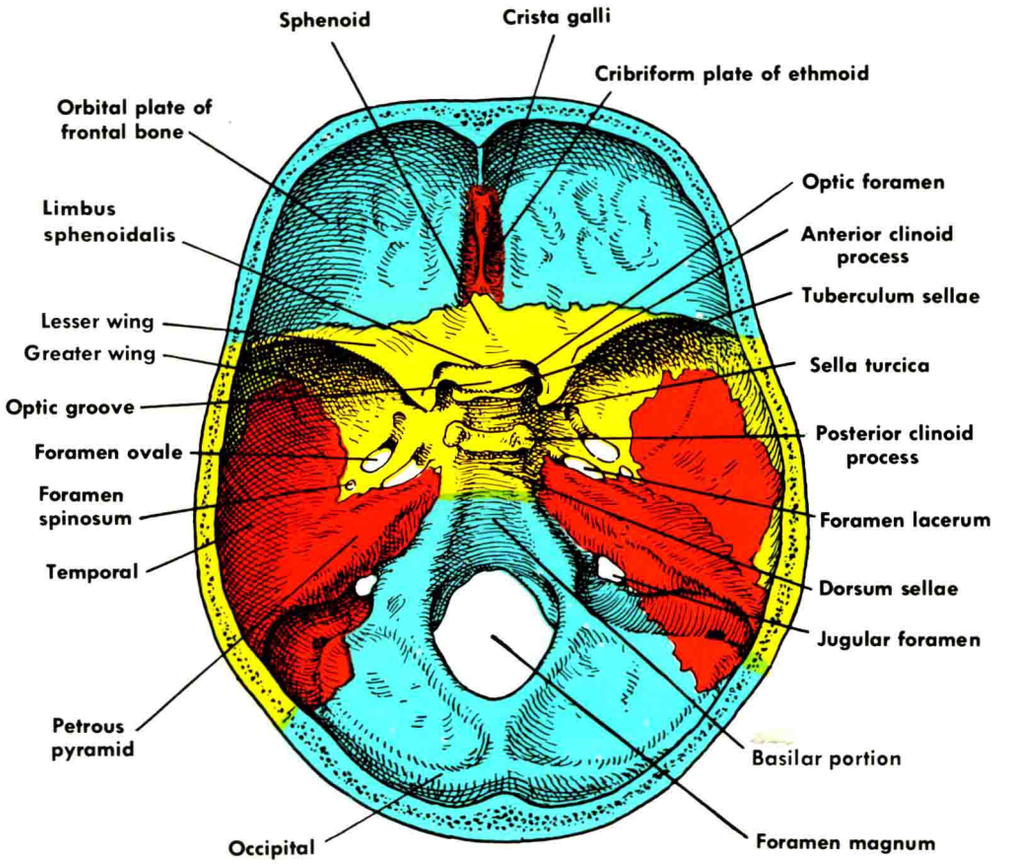
EXTERNAL SURFACE OF OCCIPITAL BONE



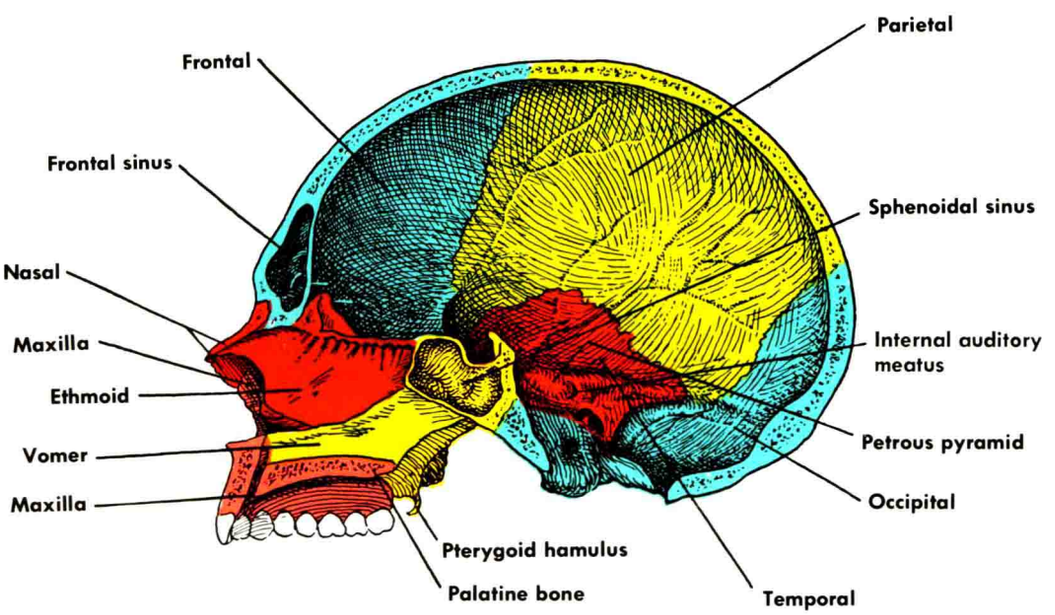
INTERNAL SURFACE OF OCCIPITAL BONE



LATEROINFERIOR ASPECT OF OCCIPITAL BONE



SUPERIOR ASPECT OF CRANIAL BASE



LATERAL ASPECT OF INTERIOR OF SKULL