The variations of the accesory sinuses of the nose

John B. Gregg  
State University of Iowa

Sumner B. Chase

Thomas R. Gittins

This work has been identified with a Creative Commons Public Domain Mark 1.0. Material in the public domain. No restrictions on use.

This thesis is available at Iowa Research Online: https://ir.uiowa.edu/etd/3974

Recommended Citation
https://doi.org/10.17077/etd.aqmdegtp
THE VARIATIONS OF THE ACCESSORY SINUSES OF THE NOSE

A THESIS
PRESENTED TO THE GRADUATE FACULTY
OF
THE STATE UNIVERSITY OF IOWA
IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE
DEGREE OF
MASTER OF SCIENCE

BY

JOHN B. GREGG B. A., M. D.
SUMNER B. CHASE M. D.
THOMAS R. GITTINS B. S., M. D.

DEPARTMENT OF
ANATOMY

IOWA CITY, IOWA

JUNE 1916.
I Introduction

II Anatomy of the Frontal Bone
   A. Frontal Sinus.

III Anatomy of the Ethmoid Bone
   A. Ethmoidal Labyrinth

IV Sketches Showing Variations in Frontal Sinus and Ethmoidal Cells

V Anatomy of the Sphenoid Bone
   A. Sphenoidal Sinus
   B. Sketches Showing Variations of the Sphenoidal Sinus

VI Anatomy of Superior Maxilla
   A. Maxillary Sinus
   B. Sketches Showing Variations of Maxillary Sinus
In the following paper we have attempted to report no original work or theories. The variations of the accessory sinuses have been very thoroughly studied and worked out by Doctor H. J. Prentiss in the Anatomical Laboratories of the State University of Iowa, and it is our purpose simply to correlate this work in a way which we hope may be helpful. We wish to express our appreciation to Doctor Prentiss for the opportunity afforded to study these variations of the sinuses and thereby profit by his original and painstaking work. It is entirely the result of his work, as our part has been simply to collect and correlate what he already has carefully worked out.

Before taking up the variations we have chosen to go into the anatomy of the head, which harbor the sinuses, so as to have a clearer understanding of the normal relations of these sinuses to the bones, as well as of the variations themselves.
4.

Anatomy of the Frontal Bone.

The Frontal Bone:

This bone is developed from a membrane. It is shaped like a quadrant of an ovoid. It presents a vertical plate and two horizontal plates.

Developmentally we have two frontals, usually the vertical portions fuse; but the horizontal portions are separated by the trabeculae of the ethmoids. The vertical part presents (a) an equatorial or horizontal border; and (b) a peripheral or longitudinal border.

The horizontal border. Beginning in the median line we have the nasal notch filled in by the nasal process. The nasal notch is limited laterally by the internal angular process from which laterally we have the orbital arches, which terminate in the external angular process from which springs the temporal ridge. The horizontal border is continued laterally to where it meets the peripheral border.

Projecting down from the nasal process in the median line is the nasal spine. At birth the supraorbital notch is midway between the external and internal angles; at maturity the notch is placed at the junction of the inner one third and outer two thirds. Directly above the nasal notch is a slight projection, called the glabella. At the point of articulation between the nasal bones and frontal bone we have the "nasion". From this nasion, running laterally, we have the superciliary ridge; for the attachment of the superciliary muscle. This ridge has no bearing on the frontal sinus. Above are the frontal eminences, the centres for ossification in that region. Lateral to the
temporal ridge is a part of the temporal fossa for the attachment of the temporal muscle.

The inner view of the vertical plate of the frontal bone presents in the median line, the beginning of the crest for the superior longitudinal sinus. Where the crest joins the horizontal portion, we sometimes find a foramen entering the nose, called the foramen caecum; and for an emissary vein from the nose. The ridge gives attachment for the falx cerebri.

On each side of the ridge are depressions for the Pacchionian bodies. The Pacchionian bodies parallel the longitudinal sinus and their significance is to drain the accessory cerebrospinal fluid into the venous channels. The dura and arachnoid mater alone enter the Pacchionian depressions. The subarachnoid space connects by the foramen of Majendi with the general cerebrospinal fluid. Thus there is drainage from the subarachnoid space into the outpushings from the superior longitudinal sinus.

The horizontal plates of the frontal bone or orbital plates are two in number. In shape they are triangular; convex on the brain side and concave on the eye side. The inner borders of the plates are parallel, forming the boundaries of the ethmoid notch. The lateral borders form angles of 45 degrees with the median borders. The cranial surface extends from the ethmoid notch to the lateral border.

The orbital surface extends from the lateral border to
where it articulates with the lateral mass of the ethmoid. The cranial surface is a larger surface than the orbital.

The inferior surface. The ethmoid notch is surrounded by an articular surface. Anteriorly this articular surface is the nasal notch filled in with the nasal process for articulation with the nasal bones and the nasal processes of the superior maxillae. Laterally it presents a series of partial cells except directly behind the nasal process of the frontal bone. The one just behind the nasal process is for entrance directly into the frontal sinus, for here is the vertical plate of the frontal bone. Behind this the partial cells, form complete cells by articulation with the lateral masses of the ethmoids, and these small plates are called frontal turbinates.

Directly under the orbital arch and 2 mm to the inner side of the supraorbital foramen is the pulley for the superior oblique muscle.

Frontal Sinus:

This cavity is not present in the newly-born, but makes its appearance in the orbital plate between the end of the first and the beginning of the third year, and up to the sixth or seventh year reaches only the size of a pea. It does not commence by direct reabsorption of the frontal bone, but by an upward expansion of an air passage from the anterior ethmoidal labyrinth, which gradually forces its way into the diploe of the squamous portion of this bone. At the end of
the seventh or ninth year the sinus may be recognized as a
distinct separate cavity above the root of the nose internal to
the supraorbital ridge.

In the adult the frontal sinuses are made up of two irregular
cavities, lying in the ascending ramus of the frontal bone just
posterior to the nasal process, and pass upwards and outwards
between the two plates of this portion of the frontal sinus. The
sinus assumes the shape of a pyramid and has three walls, an
interior, a posterior and an anterior.

The communication between the frontal sinus and the nose
is formed by frontal ostium, which lies at the posterior inferior
portion of the inferior triangle, in a position almost correspond­
ing to the posterior or cerebral wall of the sinus (Skillern).

This ostium may empty directly into the nose or into an
enclosed duct which leads into the nose — naso-frontal duct.
The naso-frontal duct is not present in every instance, but
is formed as follows: The anterior superior nasal spine,
which helps to form the frontal sinus. The bulla is usually
situated several mm posterior to this structure, thus allow­
ing the infundibulum to expand, but when the bulla lies anterior
to the normal position, instead of the infundibulum being wide
it is narrowed into a duct which is closed laterally by the
anterior attachment of the middle turbinate. In fact, the
naso-frontal duct is simply a continuation of the hiatus semi­
lunar is into the frontal sinus. Its length varies from 1/8
to 1/2 inch, depending upon the encroachment of the ethmoid
bulla. The boundaries of this structure would then be anterior­
ly, the uncinate process, agger nasi, and superior nasal spine;
posteriorly, lamella of the ethmoid bulla; internally, the anterior attachment, of the middle turbinate; externally, by the thin lacrymal bone.
Anatomy of the Ethmoid Bone.

The Ethmoid Bone:

This bone forms the olfactory portion of the nose. It is placed in the upper portion of the nose and is removed from the direct air currents. It forms the roof and lateral walls of this portion of the nose, and also the septum. It is composed of (a) a vertical plate; (b) two horizontal plates, or two cribriform plates; and (c) two lateral masses.

The vertical plate. This helps form the septum. It presents five borders and two surfaces. The borders are: (a) superior, (b) posterio-superior, (c) posterio-inferior, (d) anterior inferior, (e) anterior superior. The vertical diameter of this bone reaches from the cranial cavity to almost the hard palate.

The superior border presents in front the cristi galli which runs back diminishing in prominence as a free edge. The cristi galli gives attachment to thr falx cerebri.

The posterior superior border articulates with the anterior border of the sphenoid (with sphenoid crest).

The postero-inferior border articulates with the vomer practically its whole length.

The antero-inferior border articulates with the cartilage of the nose.

The antero-superior border articulates with the spine of the frontal bone and with the crest of the nasal bones.

The horizontal plates. (Called cribriform plates). They are two in number, and form the roof of the olfactory part of the nasal cavity. They are very thin with the concave surface superiorly in which rests the olfactory bulb. Medially they fuse
with the vertical plate, laterally being attached to the superior medial border of the lateral mass.

These bones present (15-20) foramina for the olfactory nerves. The wall between vertical plate and the lateral mass is about 1/8 inch; that being the width of the cribriform plate one side.

The nasion is the external land mark for the cribriform plate. From the nasion back to the external occipital protuberance gives the plane of the cribriform plate. Some variations are found; the cribriform plate may be below this line.

The nasion is the junction of the frontal with the nasal bones; is at the crease.

The lateral masses of the ethmoid bone:
Each is made up of the body and the anterior thin lamella. The body occupies the posterior 2/3 and the anterior thin lamella the anterior 1/3.

The body is an irregular parallelopipedon and presents (a) a superior surface which is cellular to articulate with the frontal turbinates, (b) a lateral surface which runs down and anteriorly forming the os planum, (c) an inferior surface, with a lateral articular surface for the superior maxilla and a medial free surface free in the roof of the middle meatus, (d) a medial surface forming the lateral wall of the nose cavity, (e) an anterior surface (cellular) which helps to form the posterior boundary of the naso-frontal duct, (f) a posterior surface; cellular, to articulate with the anterior surface of the sphenoid and the orbital process of the palate bone.

The os planum is oblique from above down running down and laterally. The posterior diameter of the ethmoid mass is
broader than the anterior diameter.
The inferior surface is broader than the superior surface.
The mesial surfaces parallel each other.
The sphenoidal opening is hidden by the lateral mass of the ethmoid; thus the foramen (sphenoidal) is behind the lateral mass of the ethmoid.

The external surface is smooth and forms the os planum of the inner wall of the orbital cavity. Anteriorly, this surface articulates with the lacrymal bone; posteriorly it articulates with the sphenoid and the lower portion with the orbital process of the palate bone.

Superiorly it articulates with the medial border of the orbital table of the frontal bone.

The medial surface of the body is directly continuous with the anterior thin lamella, and helps form the lateral wall of the nose. These surfaces parallel each other.

This surface presents the superior meatus placed posteriorly. The superior turbinate or concha overhangs the superior meatus. The superior meatus drains the posterior ethmoidal cells.

The superior surface presents incomplete cells which are completed by articulation with the frontal turbinates.

The inferior surface has articulation surface laterally placed for articulation with the oblique medial articular surface of the superior maxilla; and a medial, free cellular mass in the roof of the middle meatus called the bulla.

The posterior surface swings laterally to form the articular portion, articulating with the sphenoid. The sphenoid
foramen is overlapped by the free posterior portion of the body of the ethmoid. The body of the ethmoid is made up of cells separated by thin lamellae.

The anterior thin lamella is a direct forward continuation of the inner surface of the body. The lamella extends as far forward as the nasal bone, and articulating with it. It presents two surfaces on the lateral aspect; an anterior portion for articulation with the nasal process of the superior maxilla; and a posterior portion free, which forms the inner boundary of the naso-frontal duct. The articular portion articulates with the upper portion of the superior maxilla which is terminated below by the sharp process called superior turbinated crest. The middle turbinate springs from the lower edge of the anterior thin lamella at the level of the superior turbinated crest.

From the lateral articular surface of the anterior thin lamella at its lower limit, springs the uncinate process, which passes downward and backward beneath the bulla to form the infundibulum. This process is ribbon-like, varying in width considerably. As it passes beneath the bulla, it takes the horizontal position. It is really obliquely placed, so the shelf leads into the upper limit of the antrum.

The anterior articular portion of the thin lamella may be thin or thick; when thin the frontal sinus secretions pass down into the naso-frontal duct, then into the infundibulum before entering the middle meatus. The secretions are directed backward toward the naso-pharynx; the pus may be directed into the maxillary sinus.
When the articular process is thick, the uncinate process is thrown laterally and drainage from the frontal sinus can be directed into the anterior portion of the middle meatus.

When the uncinate process springs laterally, the lateral displacement is usually due to a cell or cells developing between the nasal process of superior maxilla and the anterior thin lamella. The middle turbinate swings from the lower border of the anterior thin lamella and the body of ethmoid.

Ethmoidal Labyrinth:

These cells are also present at birth, being hollowed out in the fetus at the third embryonal month and develop simultaneously with the frontal sinus. Curran has shown that all the cells are present at birth as well as those which afterward go to form the sphenoid and ethmoid. He dissected fetuses from three and one-months until birth, and was able to form a continuous picture, thus drawing reliable conclusions. In fourteen heads about the same number of cells were present that are found in the adult, (nine to fourteen). According to Broeslin only four ethmoid cells are present at birth, two anterior and two posterior.

The key to an understanding of the ethmoid labyrinth is found not in the cadaver, but in the development, through resorptive processes, from the lateral masses of the ethmoid bone. Such resorptive processes being due to the osteoclasts and osteoblasts, the osteoclasts tearing down, the osteoblasts building up. This resorption is not a haphazard affair but proceeds along very definite lines, though there are certain
exceptions.

The processes on the medial wall of the sphenoid bone, known as turbinates, are extensions medially of lamellae which cross-sect the whole lateral mass, extending outward to the thin lamina or external surface and upward to the frontal turbinates.

It is clear, then, that a fully developed labyrinth consists of four or five stages or lamellae. The first and lowest, incomplete, makes the uncinate process. The second, complete, makes the bulla ethmoidalis, and, in typical cases, reaches from the external thin wall of the lateral mass to the frontal turbinates. Comparing the first and second stages it is seen that the former is only developed in its lower part, and does not cross-sect the labyrinth as does the second.

The second stage, known as the bulla lamellae, forms the boundary between the nasal part of the frontal sinus and the ethmoid labyrinth. If it tends to lie somewhat posteriorly the frontal sinus is enlarged at the expense of the labyrinth. If anteriorly, the reverse is true, that is, the frontal sinus suffers and the labyrinth is enlarged. If it lies excessively anterior it may lead to an ethmoid cell being pushed toward the frontal sinus. Such a cell is called "bulla frontalis" (Zuchesk).

The third stage forms the middle turbinate and is complete through the labyrinth upwards and outwards. Between the third and second stage lies the anterior ethmoid labyrinth, its size depending upon the distance between these.
two stages. In typical cases, all cells lying anterior to the third stage empty into the middle meatus. The fourth and fifth stages make the superior and supreme turbinates. All cells posterior to the third stage form the posterior labyrinth and empty into the fissure olfactoria. The spaces between the stages or lamellae are known as inter-turbinate passages.

The Ethmoidal Cells:

These are caused, as first mentioned, by the work of the osteoclast and osteoblast of the periosteum beneath the mucous membrane of the lateral wall of the nasal cavity. As a result of their activities we have developed in the inter-turbinate passages, septa, complete or incomplete, making sometimes real cells, and at others, only partial ones.

It can thus be seen that the hiatus semilunaris represents the inter-turbinal passage between the first and second stages, and is not fully developed. But in common with the other passages, it develops cells which are apt to be incomplete, and when present are known as infundibular cells. These will be spoken of later.

The number of cells presents the greatest variety. The anterior and posterior labyrinth can consist of one large cell in a non-pathological bone. On the other hand, the number of cells may be limited only by space. The whole question depends upon the existence of lamellae and the activity of the osteoclasts and osteoblasts. In one case the anterior cells predominate, in another, the posterior. For all
clinical purposes we speak of the ethmoid cells of the middle meatus as anterior, and the cells of the olfactory fissure as posterior cells. But it must be borne in mind that an anterior ethmoid cell can extend backward to the body of the sphenoid, and that a posterior is sometimes found as far anterior as the anterior insertion of the middle turbinate or in it.

It is important that the typography of the ethmoid labyrinth be understood, because the effectiveness in the diagnosis and therapeutic of ethmoid labyrinthitis stands in direct proportion to our knowledge of anatomical conditions.

The Anterior Ethmoid Labyrinth:

Its border is a thin plate of bone, the external surface of the body of the lateral mass, often spoken of as the lamina papyracea. This boundary may be altered by the resorption process extending through it and beyond into the cancellous bone between the two thin plates of bone, forming the roof of the orbit which is a part of the horizontal portion of the frontal bone. This resorption may be slight or involve the whole of the orbital roof. It may form a cell independent of the frontal sinus or be connected with it. The number of these outpushings into the roof of the orbit varies. One specimen illustrated here shows four cells formed, each having its own ostium into the ethmoid labyrinth proper and thence into the nasal cavity. Such suprachinoidal cells are given the name of "orbital sinuses" (Prentiss).
They may be entirely independent from each other, separated by bony septa, or they may communicate with two or more cells. If they communicate with the frontal sinus they are called "orbital-frontal sinuses" (Prentiss).

As a rule the upper border of the anterior labyrinth is formed by the frontal turbinates, a portion of the horizontal portion of the frontal bone. But here again the work of the bone cells may cause resorption and a cell is formed which protrudes upward into the anterior cerebral fossa.

The nasal limits of the anterior ethmoidal labyrinth can best be considered under four heads.

1. The anterior boundary toward the frontal sinus. It has been already stated that the lamella forms the boundary between the frontal sinus and the anterior ethmoid. Therefore, anterior to this lamella lies the hiatus semilunarlis and the naso-frontal duct. Posterior to it lies the ethmoidal labyrinth. There are exceptions to this rule due to anomalies or defects in the bulla lamella.

The lamella can be placed out of position either forward or backward. In the first case the hiatus semilunaris or infundibulum are not a slit-shaped passage, but becomes a sort of vestibule to the frontal sinus, and bears a striking similarity to an ethmoidal cell.

The bulla lamella may lie far forward. Thus the frontal sinus is diminished in size before the advance march of the labyrinth and there may be formed a cell which protrudes up
into the frontal sinus known as the bulla frontalis.

As was said before, normally a bulla lamella crosses the entire labyrinth externally to the outer wall and upwards to the superior wall of the ethmoidal labyrinth. But there may be a defect in this defense, partial or complete. Depending upon its extent this defect may put any or all of the cells lying between the second or bulla lamella, and the third or middle turbinate lamella, in direct communication with the infundibulum, making in some cases a single large cell of the whole anterior labyrinth.

2. The Relation of the Anterior Labyrinth to the Naso-Frontal Duct:

In typical cases the medial wall of the hiatus semilunaris is covered by, and only by, the solid anterior end of the middle turbinate. But in many cases the labyrinth pushes ahead of the bulla lamella and forms the medial wall of the hiatus. In this manner it can happen that the naso-frontal duct lies in the middle of the anterior ethmoidal cells. Also, these cells, in combination with the frontal process of the superior maxilla and the lacrimal bone, can form a cell known as the cellula lacrimalis, which lies on the orbital side and directly posterior to the naso-lacrimal duct. The cells covering the medial wall of the hiatus are generally complete, but they may be defective, once more causing a single opening into the hiatus.

3. Extension of the Anterior Ethmoidal Cells into the Middle Turbinate:

In certain cases the labyrinth hardly reaches the anterior
end of the middle turbinate, but in others it attacks it so severely that many ethmoid cells are found in its substance, so that the middle turbinate, instead of being a solid bone, takes on the character of a puff-ball.

4. The Infundibular Cells:

As was shown, the hiatus semilunaris presents an inter-turbinal passage and as much is liable to cell formation. There are a number of possibilities: (a) The infundibulum, instead of following the usual rule of leading into the frontal sinus can end in an ethmoid cell. In this case, the frontal sinus has a separate opening. This blind cell can remain small, or being larger, pushes forward on the frontal sinus, making a cell called the bulla frontalis: (b) The infundibulum can have two openings; one leading into the frontal sinus, the other into an ethmoidal cell, far forward, which may have varied positions in relation to the frontal sinus. It may be medial, laterally or behind the frontal sinus. (c) The formation of the agger-nasal cell. The cells arising from the infundibulum may develop in such a manner as to actually excavate the processus uncinatus and the agger nasi, the elevation caused by the attachment of the middle turbinate to the cristi ethmoidalis of the frontal process of the superior maxilla. In this case, the uncinate process and agger nasi can bulge prominently into the nasal cavity: (d) Besides these, there may be a few ethmoid cells opening into any part of the infundibulum. The ostia of the anterior labyrinth. Every cell empties into a nasal passage by an ostium of its own through a cell which is in possession of such. The number
of ostia depend upon such circumstances.

The cells empty into the middle meatus in these places: (1) the most constant location is the angle between the bulla ethmoidalis and the middle turbinate where there may be one or several openings. (2) Infundibular cells may open backward and laterally into the anterior part of the infundibulum - a fact to be remembered in probing the frontal sinus. (3) The cells can empty into the posterior part of the infundibulum just in front of the ostium maxillae, explaining under certain circumstances how pus can flow from the ethmoid to antrum, making the latter a reservoir.

The Posterior Ethmoid Labyrinth:

For practical purposes all cells lying behind the lamella of the middle turbinate are posterior ethmoid cells and empty into the olfactory fissure. This posterior labyrinth is developed from the remaining lamella, which are subject to considerable variety. It is bounded in front by the lamella of the middle turbinate and behind by the posterior ethmoid wall, which is nothing but the lamella of the supreme turbinate. This last lamella does not always close the labyrinth. If it lies somewhat anterior, it may divide the posterior ethmoid cell into two halves, of which the posterior is open, lying on a disarticulated ethmoid bone. This open cell is closed by the anterior wall of the sphenoid bone. If the lamella of the superior turbinate, instead of being vertical, lies horizontal, the cell is again divided into an upper and lower chamber. This upper cell or chamber can push back into the
sphenoid body, making two cavities in it, of which the lower is the sphenoid sinus, the upper an ethmoid cell. Like the anterior labyrinth there may be a resorption externally into the roof of the orbit, forming the orbital sinus mentioned above, their number and size varying. Also there may be the development of a cell through the upper border at the expense of the anterior cerebral fossa. The posterior ostia are usually three in number and empty into the olfactory fissure. A secretion from them would, therefore, pour anteriorly over the middle turbinate or posteriorly into the nasopharynx. As a general rule, the anterior cells outnumber the posterior ones. The communication of the anterior cells with the middle meatus is through several small ostia. The ostia of the anterior cells empty into the infundibulum, and drain into the hiatus semilunaris, which is below the bulla. The ostia of the posterior cells open directly into the superior meatus. The posterior cells extend downward from the attachment of the middle turbinate to the thin wall separating the sphenoid cells. As a rule there is no communication between the ethmoid cells and the sphenoid cells.

The blood supply of these bones is from the superior nasal branch of the sphenopalatine, as well as the anterior and posterior ethmoidalis, which spring from the ophthalmic artery. None of the arteries are of any considerable size.
Variations found in the Ethmoidal Labyrinth.

Plate I

Fig. A. This figure shows the cell development into the crista galli from the frontal sinus.

Fig. B. This shows the extension of the frontal sinus back into the orbital plate of the frontal bone.
Plate II

This figure is a sketch of condition in Plate I Fig. B looking down from above. Shows extension of frontal sinus into orbital plate of frontal bone.
Plate II
Plate III Variations in the upward extent of the frontal sinus.

Fig. A. No frontal sinus whatever.
Fig. B. Frontal sinus of about normal dimensions.
Fig. C. Extreme upward extension of frontal sinus.
Plate III

Fig. A

Fig. B

Fig. C
Plate IV

Fig. A. Showing practically no sinus on either side, yet very prominent frontal eminences.

Fig. B. Each sinus slightly over developed but varying in position.

Fig. C. Extreme development of right sinus with a very small left frontal sinus.
Plate V

Fig. A. This figure shows the left frontal sinus excessively developed, especially to the right, taking up a position normally occupied by the right sinus, while on the right side the sinus is present only as a small up-pushing posterior to the left sinus.

Fig. B. In this sketch the left frontal sinus is overdeveloped and misplaced, while the right sinus is also out of its normal position, being posterior to the left sinus and extending to the left of the midline.
Plate VI

Fig. A. Showing an extreme variation in the development and extent of each frontal sinus.

Fig. B. Small sinus on left side; blind end of naso-frontal duct on right side.
Plate VI

Fig. A

Fig. B
Plate VII

Fig. A. This sketch shows a downward pushing of the frontal sinus between the nasal process of superior maxilla and anterior portion of anterior thin lamella of ethmoid, thus forming a blind cell.

Fig. B. This figure shows naso-frontal duct sending upwards and forwards a blind cell between the nasal process of the superior maxilla and anterior portion of anterior thin lamella of ethmoid.
Plate VII

Fig. A.

Fig. B
Plate VIII

Fig. A. Showing frontal sinus distinct, with the presence of two independent orbital sinuses, each having its own orifice.

Fig. B. Section to show above condition,
Plate VIII

Fig. A

Fig. B
Plate IX

Fig. A. Showing a distinct fronto-orbital sinus and two separate orbital sinuses.

Fig. B. View from above of upper figure.
Plate X

Fig. A. Showing extension of ethmoidal cell upward into brain cavity and posteriorly into body of sphenoid, lateral to sphenoidal sinus.

Fig. B. View of above condition from above. The extension backward of the ethmoidal cells is at the expense of the right sphenoidal sinus.
Plate X

Fig. A

Fig. B
Plate XI

Fig. A. Right frontal sinus invading cristi galli and extending downwards into the vertical plate of the ethmoid.

Fig. B. Section to show above condition of frontal sinus extension.
Plate XII

Extensions from naso-frontal duct (anterior ethmoidal cells) behind infraorbital arch to the infraorbital foramen forming a tunnel in the antero-superior portion of the antrum but not connected with the maxillary sinus.
Plate XIII

Showing frontal sinus extending down and directly communicating with the maxillary sinus (Skillern).
Plate XIII
Plate XIV

The naso-frontal duct forms a Y division and in this case the posterior compartment on the left side does not connect with the anterior compartment except in the naso-frontal duct. Certain ethmoidal cells push into the orbital plate especially beneath the great orbital sinuses.
Plate XIV
Plate XV

To show a posterior compartment connecting with posterior ethmoidal cells. The naso-frontal duct has a Y shape division to lead to anterior and middle compartments.
Plate XVI

To show that the orbital and frontal sinuses connect on the left by a small foramen; having a common on connection with the naso-frontal duct.
Plate XVII

Fig. A. To show a distinct frontal sinus, with an orbital sinus taking up nearly the whole of the orbital plate.

Fig. B. A section showing the above condition.
Plate XVIII

Fig. A. Showing distinct frontal sinuses, with orbital sinuses taking up nearly the whole orbital plate. Note two independent orbital sinuses on left side.

Fig. B. Extensive frontal sinuses accompanying the extensive orbital sinuses as shown above. The frontal sinus on each side gives off a lateral diverticulum.
Plate XVIII

Fig. A

Fig. B
Plate XIX

Fig. A. Showing relatively large frontal sinuses on each side, with independent orbital sinuses; one large one on the left; two smaller ones on the right side.

Fig. B. Frontal view of above condition.
Plate XIX
Plate XX

To show the frontal sinus extending posteriorly into the great wing of the sphenoid. It might be mistaken for a sphenoidal cell.
Plate XX
Plate XXI and XXII

To show uncinate process swinging down medially or from the nasal side. In this case the naso-frontal passes into infundibulum before reaching the middle meatus. The nasal frontal duct send directly forward a large cell between the anterior thin lamella of the ethmoid and the nasal process. A part of this thin place has been cut away and an arrow drawn to show the course (in second plate).
Plate XXI

ant. cell from no. frontal duct. (see following plate)
Plate XXII

cell - anterior out -
pushing of naso-buccal
duct - medial wall
out away.
Plate XXIII

Extension of frontal on both sides into middle turbinate, developing a cell in each turbinate occupying the anterior portion of the bone.
Plate XXIV

This plate shows an extension into the middle turbinate of a cell from the superior meatus.
Plate XXIV

...cell hum superior
meatus in middle turbinate...
Plate XXV

To show the naso-frontal duct forming a huge extension forward between the anterior thin lamella and nasal process of the superior maxilla.
Plate XXVI

The middle turbinate has been removed to show the uncinate process articulating laterally with the lacrimal bone. One spinule attached develops a foramen above leading from the naso-frontal duct anteriorly.
Plate XXVI

Spinous of uncinate articulating laterally & lacrimal bone.

Poramen leading from naso frontal duct anteriorly.
Plate XXVII

Downward projection from the frontal sinus of a large cell, which is between the nasal process of the superior maxilla and the anterior thin lamella. The plate has been opened to show the cell, the middle turbinate having been removed.
Plate XXVII

Mesial wall of cell cut away, showing large cell pushed down from naso frontal duct.
Plate XXVIII

Showing frontal sinus passing into middle meatus with no relation to infundibulum. Observe the large extension medially of a blind cell from the upper limit of the infundibulum, which partially protrudes the naso-frontal duct.
Plate XXVIII

large cell-ant. out pushing...
of infundibulum, partially occluding naso-frontal duct.
Plate XXIX

Lateral placement of uncinate process with articulation along its lateral edge with the lacrymal bone.
Anatomy of the Sphenoid Bone.

The Sphenoid Bone:

The sphenoid bone connects the cranial bones with most of the facial bones. It extends from temporal fossa to temporal fossa. It helps from the walls of the eye cavities and nasal cavity. Above it forms the floor of the cerebral fossa. Below, through the hamular process, it projects into the mouth cavity.

It is composed of a body, two lesser and two greater wings, and two pterygoid processes.

Developmentally it has no sphenoidal sinus. This sinus develops considerably after birth. Developmentally the body develops in two portions (a) the alar sphenoid anteriorly and (b) the basi sphenoid posteriorly. Between develops the pituitary gland or hypophysis which is an uppushing mainly from the buccal epithelium, called Rathke's pouch. The lesser wings (developed-cartilage) develop separately but fuse with the body before term. The greater wings develop separately and do not fuse with the body until after birth.

The pterygoid processes develop separately in two plates; the outer one develops in cartilage and fuses with the greater wing before birth. The inner plate develops in membrane and begins to fuse with the outer plate at birth.

We have the sphenoidal turbinates or bones of Torini which develop on the anterior aspect of the body. Doctor Prentiss presumes these turbinates develop the sphenoid sinus. These bones are not what are called the sphenoidal turbinates in adult life.
The body of the sphenoid is centrally placed, irregularly cuboidal in shape, presenting

(a) An anterior surface.
(b) A posterior surface fused with the occipital bone.
(c) Two lateral surfaces.
(d) A superior surface.
(e) An inferior surface.

The anterior surface: The lateral borders diverge from above downward. The anterior surface presents medially the ethmoid ridge to articulate with the vertical plate of the ethmoid. Lateral to crest is a smooth surface helping to form the olfactory portion of the nose. This nasal surface is greater than the transverse diameter of the cribiform plate. Lateral to this surface are the adult sphenoidal turbinates which articulate with the body of ethmoid above, and orbital process of palate below, and complete these posterior ethmoidal cells. Under cover of the body of the ethmoid are the sphenoidal foramina, leading into the sphenoidal sinuses. The foramina are therefore placed lateral and usually nearer the upper limit of the sinus. The

The superior surface of body presents in front the large sphenoidal spine projecting into the notch in the cribiform plate. Behind this is a smooth surface which terminates in the optic groove which is bounded posteriorly indefinitely by the olivary eminence. Behind this eminence is the deep pituitary fossa. The (sella turcica or pituitary fossa) is bounded posteriorly by the (dorsum sella or clavis Blumenbachii). The clavis Blumenbachii
presents at its anterior border and lateral limits the posterior clinoid processes which are for the attachment of the tentorium cerebelli. On the lateral edge of the clavis is a groove for the sixth cranial nerve.

The posterior surface is fused with the basal process of the occipital bone.

The inferior surface presents medially a broad ridge known as the rostrum. Lateral to the rostrum is the free edge of the internal pterygoid plate called the vaginal process. This process runs from behind forward and somewhat outward and is continued by the sphenoidal process of the palate bone.

The lateral surfaces give attachment to the wings.

The inferior surface helps form the respiratory portion of the nose.

The body presents two cavities or sphenoidal sinuses which are exceedingly irregular and assymetrical, one encoraching on the other. This is a belief that the sphenoidal sinuses are developed by the bones of Torini enlarging and the mucosa lining the same. Bones of Torin\textsuperscript{V} shaped with apex looking back, base open looking anteriorly.

The inferior surface of the body of the sphenoid, medially presents the rostrum which is for articulation with the spread of the ala of the vomer. The lateral edge of the ala of the vomer articulates with the vaginal process of the internal plate of the pterygoid process. The vaginal process runs forward and outwards and is continued in the
sphenoidal process of the palate bone. This vaginal process of the internal pterygoid plate shows a groove known as the pterygopalatine groove which becomes a canal when it reaches the sphenoidal process of the palate bone and leads into the sphenomaxillary fossa. There this branch of the fifth nerve posteriorly is just beneath mucous membrane while anteriorly it is in a bony canal. The under surface of the sphenoid is really separated from respiratory portion of nose by alae of vomer articulating with the vaginal processes of the internal pterygoid plates.

The lesser wing of sphenoid is a triangular flat bone and presents three borders and two surfaces. It springs from the lateral surface of the body at the junction of the anterior and superior surfaces.

The borders are:

(a) An anterior free border articulating with the orbital plate of the frontal.

(b) A posterior free border helping to form the posterior border of anterior cerebral fossa.

(c) A medial attached border, fuses with the body of the sphenoid. In this fused border is the optic foramen for the nerve. The posterior limit of the fused border develops an extension called the anterior clinoid process for the anterior attachment of the tentorium cerebelli.

The superior surface looks upwards mainly but slightly backwards and completes the anterior fossa.

The inferior surface forms the superior boundary of the
sphenoidal foramen or orbital foramen and helps form a slight part of the orbital fossa.

The greater wing of the sphenoid is a bisected parallelopipedon with the superior and posterior surfaces scooped out by the temporo-sphenoidal lobe of the brain. It presents: (a) an anterior surface, (b) a lateral surface, (c) an inferior surface and (d) a superior concave surface. It fuses with the lateral surface of the body at the junction of the posterior and inferior surfaces, and reaches forward to help form the sphenoidal foramen.

The anterior surface is divided into an upper orbital surface and a lower spheno-maxillary surface by the orbito-spheno-maxillary ridge. This ridge runs from the lateral inferior angle to the body. This ridge forms the posterior boundary of the spheno-maxillary fissure which leads into the spheno-maxillary fossa.

The orbital surface is smooth and forms an angle of forty five degrees with the lateral surface of the body.

The spheno-maxillary surface presents the foramen rotundum close to the attachment of the great wing with the body, and which is for the superior maxillary branch of the fifth nerve.

The lateral surface of the great wing helps to form the temporal fossa and gives attachment to the muscle. This surface is separated from the inferior surface by the pterygoid, or deep temporal ridge which is in the plane of the zygomatic arch.

The inferior surface is continuous with the external
surface of the external pterygoid plate, and helps to form the zygomatic fossa. This surface gives attachment to the upper head of external pterygoid muscle. This surface has the foramen ovale presenting and the foramen spinosum.

The superior or cranial surface is concave for lodgment of the temporo-sphenoidal lobe. Where this great wing joins the body, we find the cavernous groove for lodgment of the cavernous sinus and carotid artery. This cavernous groove thins out the postero-lateral angle of the body of the sphenoid so that in curettment it would be very easy to injure the cavernous sinus. In the dura mater which lines this sinus are the nerves which enter the orbit (excluding optic nerve). They are all on lateral aspect of the sinus except the sixth nerve at its beginning. Anteriorly just lateral to the cavernous sinus is the foramen rotundum. Posteriorly, near the posterior border and laterally is the foramen ovale, and lateral to this the foramen spinosum, with its groove for the middle meningeal artery. The foramen ovale is on the inferior surface directly behind the external pterygoid plate. Between the foramina rotundum and ovale sometimes is found the foramen versallius for an emissary vein.

The pterygoid processes form the lateral boundaries of the nares. They are composed of two plates; outer and inner. The outer plate is purely for the attachment of the powerful pterygoid muscles; therefore this plate is preformed in cartilage and at birth is entirely fused with the great wing of the sphenoid. The internal plate is not fused at
birth. The plane of the external plate is at an angle of about forty-five degrees with the inner plate, but this plane is determined by the position of the mandible. This outer plate is much the larger of the two because of the pterygoid muscle attachments.

The internal pterygoid plate is developed in the membrane of the submucosa of the nasal cavity. This bone is for the attachment of the pharyngeal aponeurosis primarily. At birth this plate is showing a fusion with the outer plate at the anterior border. This plate continues the plane of the lateral wall of the nose and therefore is in an antero-posterior plane.

The inner plate presents (a) an anterior border, (b) a posterior border, (c) a free upper edge, called the vaginal process, (d) a free lower limit called the hamular process, (e) an inner nasal surface, and (f) an outer pterygoid surface.

The anterior border is sharp and articulates throughout its whole length with the vertical plate and sphenoidal process of the palate bone.

The posterior border is free and gives attachment to the pharyngeal aponeurosis or submucosa of the pharynx. The lower half of this border gives attachment to the superior constrictor muscle. The posterior border as it passes upwards, splits into two ridges forming the scaphoid fossa; said to be the origin of the tensor palati muscle. Doctor Prentiss' observation is that this muscle is fan shaped and arises from the outer surface of this internal plate.
The upper limit of the internal plate is bent medially presenting a free edge for articulation with the ala of the lower vomer; and is called the vaginal process, because between the body of the sphenoid and this turn is caught the vidian nerve. This vidian canal therefore opens anteriorly into the spheno-maxillary fossa to carry the vidian nerve into Meckel's ganglion.

The inferior limit of the inner plate projects downward into the hamular process for the play of the tendon of the tensor palati muscle. This hook is placed behind the sulcus or groove formed by the alveolar process of superior maxilla and the hard palate, and in the plane of the posterior border of the hard palate. This is a definite landmark for cutting the pulley of the tensor palati muscle.

The outer plate of the pterygoid process.

The anterior border fuses with the lateral aspect of the anterior border of the inner plate through the upper three fourths. Below it diverges, forming the pterygoid notch which is closed by articulation with the tuberosity of the palate bone. Therefore the lower one fourth of the anterior border of the outer plate is articular to articulate with the palate bone.

This plate is entirely extra pharyngeal and gives attachment to the pterygoid muscles. Directly behind the posterior border of this plate at its attachment to the under surface of the great wing is found the foramen ovale.

The surface markings to locate this pterygoid process are as follows: The anterior border of the ramus of the
mandible parallels the anterior border of the pterygoid process. By passing a needle through the sigmoid notch of the mandible just at the posterior border of the coronoid process, one will reach the lateral surface of the external pterygoid process. This gives the depth to locate the foramen ovale and therefore the inferior maxillary division of the fifth nerve. Going in just anterior to the anterior border of the coronoid process one can reach the sphenomaxillary fossa and thus Meckel's ganglion.

Sphenoidal Sinus:

At birth this structure is but a faint depression in the cancellated tissue of the body of the sphenoid. It begins to develop about the fourth month and is fully formed about the sixteenth year. Coffin says it is a distinct cavity at the end of the first year. Braislin, however, found the sinus absent in a five-year-old child. The size of this sinus varies in different children. In some specimens between four and six months of age there is a distinct depression in the body of the sphenoid, while in others or even greater age, no such depression is present.

In the adult the sinuses vary in size, the left being the larger in the majority of cases. The sinus of either side may be very small, or large enough to hold two and a half drams of fluid; the average sinus contains one-half dram in the adult. Absence of the sinus has been reported by several observers.
Plate I

Fig. A. Sphenoidal sinus of size median between B. and C.

Fig. B. Sinus extending to foramen magnum and therefore invading basilar process of occipital bone.

Fig. A. Sinus extends only to the anterior wall of the petuitary fossa.
Plate I

Fig. A

Fig. B

Fig. C
Plate II

Variations in sphenoidal septum.

Fig. A. Straight septum is inclined to the left as it passes posteriorly, therefore the left sinus is wedge-shaped, being narrow posteriorly.

Fig. B. Septum is curvileaner, thus developing various pockets at the expense of the opposite sinus.
Plate III

Variations in sphenoidal septum.

Fig. A. Septum makes an abrupt turn to the left, so that the left sinus is only a narrow slit, though it opens into the nasal cavity by its own foramen.

Fig. B. Septum deviates markedly to the right and then veers to the left. The result is that the right sinus is made up of a wide anterior compartment connected with a wide posterior compartment by a slit-like compartment. The left sinus, therefore encroaches on the right.

This left sinus also extends laterally into the great wing, and downward into the outer plate of the pterygoid process.
Plate III

Fig. A

Fig. B
Plate IV

Great extension of the sphenoidal sinus laterally.

Fig. A. This is a sketch looking down from above, in which the roof of the lesser wing cortex has been removed showing a foramen connecting this upper compartment with the main sinus. The main sinus extends into the greater wing as far as the lateral cortex, and as is shown in the drawing, wraps around the foramina of exit of the superior and inferior maxillary nerves.

Fig. B. This figure is a vertical schematic section explaining Fig. A. It shows the cavity of the lesser wing connecting with the cavity of the body and greater wing. It also shows the main sinus extending into the outer plate of the pterygoid process. This section shows the sinus closely related to the vidian canal.
Plate V

Great extension of the sphenoidal sinus laterally.

Fig. A. This figure shows the left sphenoidal sinus extending into the greater wing as far as the lateral cortex, and therefore in close proximity to the three great trunks of the trifacial nerve.

This figure also shows an extension of the sinus ventrally at the expense of the ethmoidal cells.

Fig. B. This figure shows an extension into the orbital process of the palate bone, and therefore in close relation to the sphenopalatine foramen, or foramen of entrance of the sphenopalatine nerves from the sphenomaxillary fossa into the nasal cavity.
Plate VI

Fig. A. This figure shows an extension of the post-ethmoidal cell into the greater wing of the sphenoid, reaching to the foramen rotundum or foramen of exit of the superior maxillary nerves.

Fig. B. This sketch is a ventral view of the sphenoidal sinuses exposed. It shows the left sinus sending extensions, one into the lesser wing, and the other into the greater wing. The one into the lesser wing is in close proximity to the optic foramen. The one into the greater wing extends between the vidian foramen and the foramen rotundum.
Plate VII

Fig. A. This figure shows extension of ethmoidal cell backward into the body of the sphenoid, lateral to the sphenoidal sinus, and therefore at the expense of this sinus.

Fig. B. This sketch is looking down from above on Fig. A. It shows the ethmoidal extension encroaching on the sphenoidal sinus.
Plate VIII

This figure is to call attention to the variations in the position of the sphenoidal foramina. In this figure one is above, the other below a median line.
Plate VIII
Doctor Prentiss reports one case of a very large sinus with no sphenoidal foramina. He considers that in this case the foramina were probably closed by some inflammatory reaction. Another recent variation found is that of a middle ethmoidal cell on one side pushing across to the opposite sphenoid at the expense of the sphenoidal sinus.

He has not seen an extension into the inner pterygoid plate, but feels that this is probably due to the method of development. The outer plate fuses with and is a part of the great wing, while the inner plate never shows a perfect fusion.

The interest of these sinuses, other than the size of the extensions, is the fact that all the nerves resting on or in close proximity to the sphenoid bone including the optic nerve, in someone of these variations is in juxtaposition to the sinus extension.

Another important fact is that the canals of the nerves which pass through this bone sometimes project into the sinuses, and therefore there is then a very thin cortex separating these nerves from the sinuses.
Superior Maxilla.

The superior maxilla develops from the first visceral arch, and also from the down-pushing of the middle cartilaginous trabeculus in the floor of the anterior cerebral fossa. The malleus and incus also develop from the first visceral arch; from Meckel's cartilage. The eyes are pushing out at this time. Meckel's cartilage coming down from the region of ear, is surrounded by the mesoderm of the first arch. The mesoderm pushes up and meets the pushing down of lateral trabecula to form the lateral masses of the ethmoid.

The superior maxilla developed from membrane, pushes up and surrounds the eyes.

The central trabecula pushes down to form premaxilla of the superior maxilla.

The superior maxilla presents a body and four processes (a) nasal process, (b) malar process, (c) palate process with premaxillary portion, and (d) alveolar process with premaxillary portion.

The maxilla at term: The body is a triangular bone, presenting two tables and cancellous tissue between. As a rule, there is no sinus. This body at this time is for the support of the first teeth, which are practically of maximum growth.

As we look down on the bone from above it is triangular; viewed from the side it is a thin plate with cancellous tissue between. The alveolus is large with thin septa.

The infraorbital canal and groove are present at term. With rapid growth of bone when the child begins to use its
muscles and gums, the alveolar cavity remains the same, but the body becomes enormously over-grown. Epithelium lines the sinus as cells proliferate to form maxillary sinus.

Adult bone: The body is paramidal in shape, with (a) (1. Facial apex, (b) base, and (c) three surfaces (2. Orbital (3. Zygomatic

The apex is laterally placed and called the malar or zygomatic process.

The base is medially placed and forms the lateral wall of the respiratory portion of the nose.

The orbital surface forms the floor of the orbit; is triangular in shape. The facial surface of the body is separated from the zygomatic surface of the malar ridge which terminates between the first and second molars.

The surfaces of the superior maxilla are as follows:

(a) The orbital surface is the thinnest portion; and presents three borders:

1. The anterior free border or infraorbital arch.
2. A posterior free border which is the anterior border of the sphenomaxillary fissure.
3. A medial border which does not join the base of the body, but joins the oblique surface connecting the orbital surface with the base. This orbital surface presents the passage for the infraorbital nerve which runs from the posterior border to the anterior border. It usually grooves the posterior portion of this surface and tunnels the anterior part, making its exit at the infraorbital foramen.
The facial surface of the superior maxilla presents the massive alveolar process, which occupies most of the facial surface, reaching usually as high as the level of the palate process. The alveolar process portion of this body is mapped off from the premaxillary portion by the canine eminence, the premaxillary alveolar portion containing the two incisors.

This facial surface presents the infraorbital foramen which is below the infraorbital arch and in the vertical plane between the two bicuspids.

The facial surface gives attachment to the small muscles of the face. At the junction of the alveolar arch and body the mucous membrane of the vestibule is reflected from the gums (gingiva) to the cheek.

The zygomatic surface presents the tuberosity at its most posterior limit. The tuberosity is where the palate articulates by its tuberosity.

The tuberosity presents one or two foramina for the postdental nerves. The tuberosity is covered by the sucking pad of fat, except for the upper attachment of the buccinator and the small head of the internal pterygoid.

The oblique surface runs from the orbital surface to the base and is for the support of the articular portion of the body of the ethmoid bone. This surface becomes wider as it goes back.

The basal surface of the body is irregularly quadrilateral, being limited in front by the lacrimal groove. This surface presents the large antral opening. This opening reaches to the lacrimal groove and backwards to where
the vertical plate of the palate articulates with the base. The opening extends from the oblique surface of the body down to the middle of the inferior meatus.

The posterior portion of the base articulates with the vertical plate of the palate bone. This presents a groove (post-palatine) which runs from above (sphenomaxillary fossa) down and forward, dividing into a posterior groove and an anterior groove; the posterior groove for the accessory artery.

The nasal process: This is a flat process, passing up, back and in from the body. It presents two surfaces; outer and inner; Two borders; anterior and posterior. The broad superior surface articulates with the nasal process of the frontal bone.

The anterior border is sharp, articulating with the nasal bone.

The posterior border is not sharp; articulates with the lacrymal bone laterally.

The external surface is divided into two portions by the anterior lacrymal crest; which is directly continuous with the infraorbital arch. This divides the external surface into (a) anterior portion (part of general facies); (b) posterior portion which helps form lacrymal groove.

The internal surface is limited by the inferior turbinated crest which is a continuation of the posterior border forward to the anterior border. This surface presents near the upper limit the articular surface for the anterior thin lamella of the ethmoid. The lower limit is known as the
superior turbinate crest, which is the level at which the middle turbinate springs inward from the lower level of the anterior thin lamella.

The posterior border articulates with the lacrimal bone above the inferior turbinate process of the lacrimal bone.

The articular portion of the nasal process above the superior turbinate crest varies with each bone; may be smooth articular surface or may present half cells which are completed cells when articulated with half cells of anterior thin lamella.

The palate process is made up of the premaxillary portion and the palate process proper. It springs from the base at the junction with the alveolar process, extending backwards between second and third molars.

The premaxillary portion is limited behind by the anterior palatine foramen, laterally between the lateral incisor and canine.

Superiorly, the premaxillary portion presents the incisor crest to which fits the vomer (anterior portion). Anteriorly the incisor crest presents the anterior nasal process.

The alveolar process is made up of the alveolar process proper and premaxillary portion. The premaxillary portion contains incisors.

From the middle of each third molar to the symphysis forms an equilateral triangle. The inner border of the
alveolar portion is a straight line; the curvature comes from the premaxilla. The alveoli may project into the antrum; this being only possible with molars and bicuspids.

Maxillary Sinus in the Adult:

In the body of the superior maxilla of the adult is a large sinus of pyramidal shape having for its base the outer wall of the nasal cavity; its base, the outer extremity of the malar bone; its floor, the alveolar process of the superior maxilla; its roof, the floor of the orbit; its outer wall, the facial surface of the superior maxilla; and its inner wall, the zygomatic surface of the superior maxilla. It varies in size and shape in different individuals, and in the sexes, being larger in the male. The two sides also vary in size and in arrangement. The floor is sometimes on a level with the floor of the nasal cavity, and again it may be above or below it. Occasionally a complete septum of bone will wall off a separate chamber and virtually form two antra upon the same side. It opens by one or more ostia into the middle meatus of the nose, over which hangs the middle turbinate, which under many conditions completely obstructs this opening. It is lined by a thin ciliated epithelium and is drained by the action of the cilia in the direction of the ostia.

Owing to the proximity of the roots of the teeth which occasionally penetrate into the antrum, caries is one source of empyema. It has been estimated by some observers to be
responsible for about 50% of antral cases of empyemia, while others estimate it to be as low as 5%. The second bicuspid and first molar are in closest proximity to the floor of the antrum, and in proportion to the increased size of the antrum an increased number come into intimate relation with the cavity of the antrum.

The base of the pyramid, which is also the outer wall of the nasal fossa, and is frequently called the inner wall of the antrum, is composed of bone varying in thickness from 1/8 inch at the floor to that of a sheet of paper above and also of mucous membrane without bony support at its upper third.

The ostium, which is the natural opening of the sinus, is situated just behind the uncinate process and empties into the hiatus semilunaris, and thence into the middle meatus of the nose, just below the attachment of the middle turbinate. In about 20% of cases a second ostium is found which may open below the other or just behind the bulla.

The roof of the antrum is normally composed of a thin lamina of bone which is covered with mucous membrane, but in old people the bone often becomes absorbed in places, leaving nothing but the membrane, thus bringing the contents of the orbit and the antrum into close contact.
Plate I

Fig. A. Maxillary sinus having very thick walls and whose floor is above the floor of the nasal cavity.

Fig. B. Maxillary sinus extremely developed and the floor being on a level with that of the nasal cavity.
Plate I

Fig. A

Fig. B
Plate II

Fig. A. Extremely developed maxillary sinus, with the floor below that of the nasal cavity.

Fig. B. Extremely developed maxillary sinus, with a septum below and anterior walling off a separate sinus.
Plate II

Fig. A

Fig. B
Plate III

Fig. A. Extensive development of each antrum, extending toward the midline into the hard palate, well into the alveolar process, in the malar process, and also in the orbital region.
Plate III

Fig. A
Plate IV

Fig. A. Extreme variation in size and position of the two antra; the right being very much over-developed, with a thin wall extending far over the floor of the nasal cavity. The left antrum is but slightly developed; the walls are comparatively thick, but the floor is well above the floor of the nasal cavity, being on a level with the inferior turbinate. The outer wall and inner wall on the left are developed at the expense of the sinus. Reabsorption has extended back into the palate bone on the right side.
Plate IV

Fig. A
Plate V

Lateral walls of nasal cavities pushed out at the expense of maxillary sinuses.
Plate VI

Maxillary sinus well up and posterior due to sinking in of facial wall of antrum.
Plate VII

Extensive development of each antrum, especially into the alveolar processes. The lateral wall on the left side bulges out also enlarging the antrum in that dimension.
Plate VII
Plate VIII

Extreme variation in the size of the two antra, that of the right showing little reabsorption at all. The walls of each are very thick, especially the nasal wall of the right (Hajek).
Plate VIII

Plate VIII
Plate IX

A perpendicular septum dividing the maxillary sinus into two separate cavities, each having its own ostium (Skillern).
Plate IX
A study such as this has been of the accessory sinuses of the nose is a revelation in many ways. When one realizes how commonly these sinuses may vary in size, extent, and position, it is not difficult to suspect these variations as the potent factors in many of the obstinate clinical sinusitis cases. Blind pockets, such as are formed at times, when not suspected, could quite effectually evade the curette of the surgeon and thereby remain as foci of infection. It seems to the writers to be very important that the clinical men know in what numbers these variations exist in the anatomical specimens, so that they may better understand those cases in which the ordinary surgical procedures fail to eradicate sinusitis. New variations are constantly being found, and it is more than likely that as Doctor Brentiss continues his investigations, still anomalies will be discovered and described.