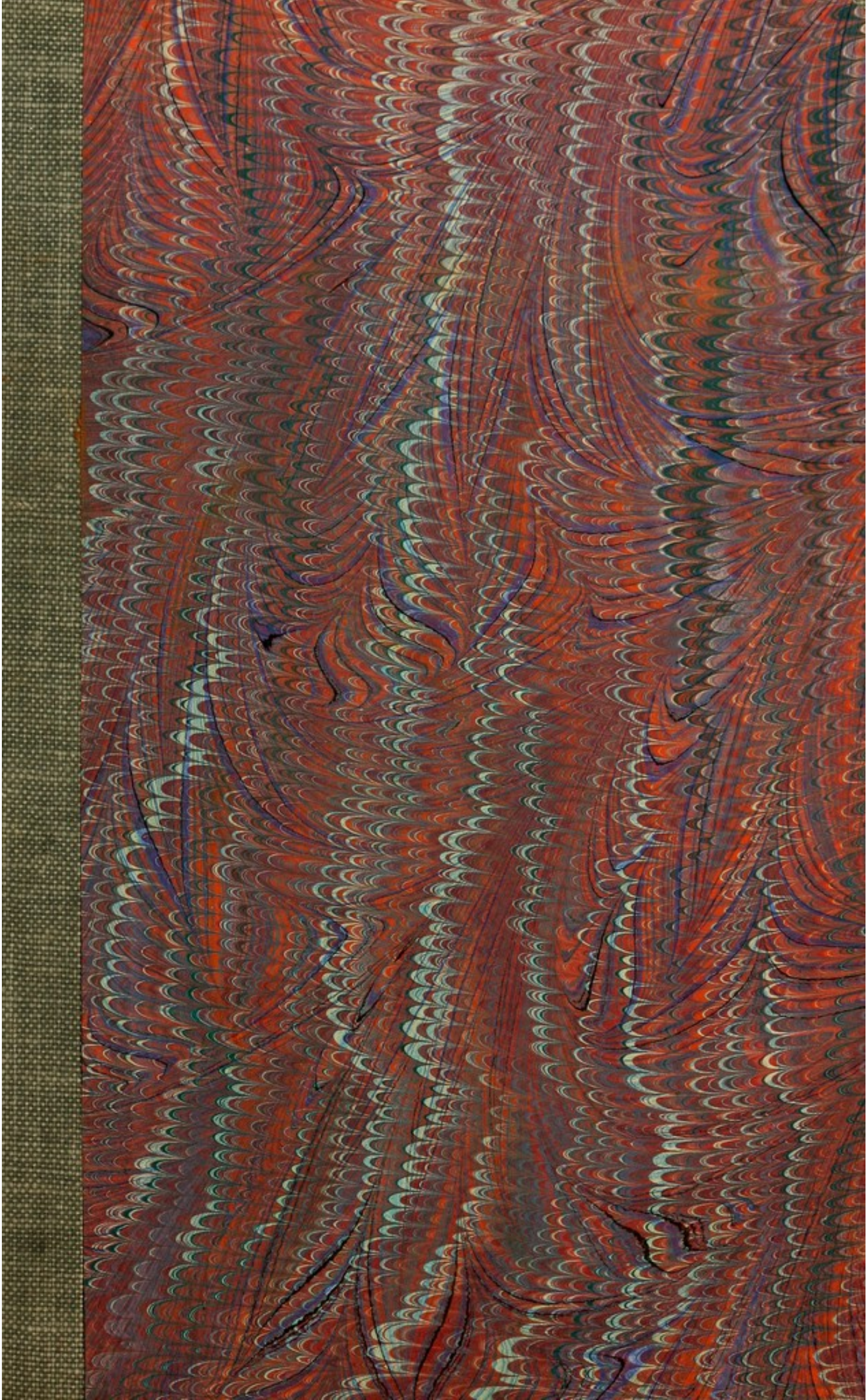
Laboratory guide for the modeling of the human bones in clay / by Vilray Papin Blair.



LABORATORY GUIDE

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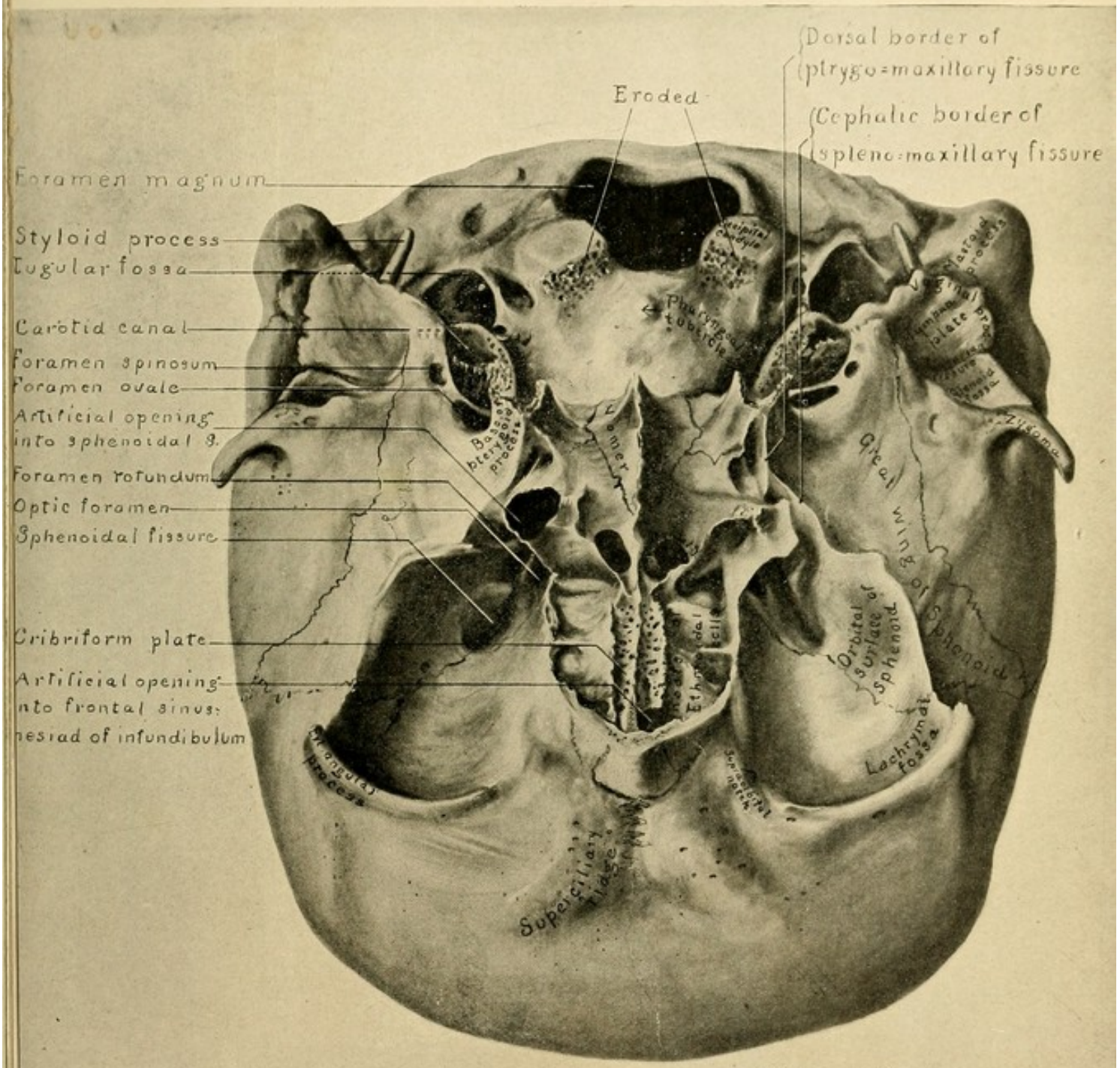
MODELING OF THE HUMAN BONES IN CLAY.



R. Walter Mills
1907

Base of Cranium
Face bones removed

LABORATORY GUIDE

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MODELING OF THE HUMAN BONES IN CLAY.

BY

VILRAY PAPIN BLAIR,
A. M. M. D.,

ASSOCIATE PROFESSOR OF ANATOMY,
MEDICAL DEPARTMENT, WASHINGTON UNIVERSITY.

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INTRODUCTION.

The object of this guide is primarily to lay down specific directions for the moulding of the human bones in clay. Observation of this work in other colleges and three years' experience here have demonstrated that this method of teaching human osteology is not only practical, but advantageous. Though names are necessary, what the student of medicine most wants is not so much the power to describe the bones, but to have a lasting impression of the outline. This is best obtained by close observation, and reproducing them in clay fosters such observation. The general directions for their reproduction should be carefully studied, for these will not be repeated in the consideration of the individual bones.

It is intended to make this a practical course for the medical student rather than a complete course in osteology. Parts will be emphasized or hurried over according to their bearing on this aspect of the subject.

Those bones which practically form solid masses, such as the bones of the skull, the anterior part of the tarsus and the two rows of the carpus, will be treated as parts of such a mass, and the mass rather than the individual bones will be described. For the skull a very simple special description is given from this view point.

Following the instructions for the reproduction of each bone will be found a few questions referring to its form. These, and other questions which must present themselves to the student, should be studied and answered by referring to the bone and the text books. These answers should not just be committed to memory, but the student should work out the problems for himself in an intelligent manner. By doing this he will change osteology from the bug-bear it is usually reputed, with the memorization of a mass of disassociated points, lines and surfaces to the intelligent consideration of all of these as integral parts of the whole, with the ability to read in each its cause, reason and effect. In this way the retention of these facts is made more a matter of reason than memory.

Before the reproduction of any bone is undertaken, it should be carefully studied with the text book and bone. By this is not meant, simply the reading of the description with the bone

in the hand, but the identification on the bone of each point mentioned and its relation to surrounding points and to the whole bone and then the consideration of the bone as a whole.

Then the problems suggested by the questions on the form of the bone should be studied and understood and finally the bone reproduced in clay and each point re-identified. If the bone is simply copied with no attempt to understand the things reproduced, little good will result.

GENERAL DIRECTIONS FOR MODELING THE BONES.

There are four things to consider in reproducing in clay.

First, the preparation and handling of the clay.

Second, the reproduction of the different aspects of the object.

Third, the preservation of the finished portion while reproducing another part of the same object.

Fourth, the constant study of the mutual relations of the various parts.

Clay is furnished of various consistencies and the student by manipulating and mixing is to prepare for himself the proper quantity of each of the different consistencies that he will require.

Clay of three different consistencies is usually required.

First, that used for beds and foundations should be rather stiff, just yielding enough to take the impression of a bone with pressure short of injury to the pattern bone.

Second, medium clay that is used to make the rough core or form of the bone.

Third, a much softer clay with which the details are worked on this firm core.

In reproducing an object in clay, the pattern (which is here a bone) and the copy are placed as nearly as possible in the same field of vision and both on proper supports. The student chooses one outline at a time on the pattern and reproduces that outline on the copy. Then, by changing the view point or by shifting the position of both the pattern and the copy, successive outlines are reproduced until a rather accurate rough copy is completed and ready to receive the details and finish. It is while doing this latter work that the real study of the whole bone and its surface markings is made. The preservation of the copy as it is being made is done by the use of beds of firm clay. That is, a pad or dyke of clay of the first kind, is laid on the table and a certain surface of the pattern bone is impressed upon it. Then before removing the pattern bone, the superfluous clay is removed by passing a knife around the pattern bone and cutting the bed down to the board. After removing the clay outside of the cut, the bed is fastened to the board by pressing around the base and drawing parts of the clay out on the board with the fingers. Now, the pattern bone is removed and placed parallel to the bed at a distance of 15 cm. on pillows of clay, the bed sprinkled with a little clay dust and it is ready for use. It is more than probable that the bearing surface of the bed should be further trimmed before receiving the clay core. It should be just large enough to support the soft copy, but should not obstruct

the view of the lateral surfaces. For long bones it is not necessary to leave this bearing wider than 1 cm.

The study of the mutual relation of parts is most important and is best accomplished by the student turning his attention at intervals to the relations of surrounding parts; he should mark, at times, the relations, to surrounding parts, of the special part he is reproducing.

MODELING OF THE FEMUR.

On the center of the board make bed for posterior surface of the femur with inner surface towards you, the bed to extend from condyles to head inclusive. Place femur on far side of board with clay pillow under neck. Roll out clay core for shaft and place on bed. Fill in outlines of antero-external border of shaft and external condyle, great trochanter, upper border of the neck, the head, inner border of the neck, inferior border of the neck, small trochanter and outline of internal condyle. Now, turn board around and place bone on opposite side with outer borders towards you. Finish lower border of neck, noticing that it is longer than the upper. Make antero-internal border of bone, giving due prominence to internal condyle and adductor tubercle. Finish outline of external condyle, inferior articular surface and external border of shaft. Now turning the board so that the lower ends of both copy and bone are towards you, fill in outline of lower end with its intercondylar notch. Reproduce the obliquity and curve of internal condyle. Turning the board as necessary, build up the condyles ventrally, noticing that the external condyle extends forward more nearly perpendicular to the table. Finish the rest of the visible part of articular surface, which extends farther up on the anterior surface of the external than on the internal condyle. Outline the articular surface and its various areas—refer to text book if necessary. Give full breadth to lower part of shaft and notice that anterior surfaces of it and of internal condyle incline downwards, inward and backwards. Show nutrient foramina. Give slight flattening to shaft, especially in upper part. Fill in the anterior muscular facet on great trochanter, the tubercle of the femur and the anterior part of spiral line. Finish anterior surface of neck, noticing that it inclines downwards and backwards. Show muscular areas on the anterior surface for vastus internus, externus, crureus, psoas and gluteus minimus. Finish anterior half of head and articular surface and outline the latter. Place teres fossa in its innermost extremity; so placed to avoid pressure. Make bed by impressing anterior surface and place clay copy in new bed. Place bone on

far edge of board with outer border towards you. Give proper flatness to the postero-external and postero-internal surfaces in middle third of the bone and indicate nutrient canal. Reproduce linea aspera in middle third diverging into two lines below, which reach the condyles and enclose the flat popliteal surface. Indicate surfaces of origin of gastrocnemius and plantaris muscles. Perfect outline of the condyles. Perfect visible outlines of lesser and greater trochanters and ridge for gluteus medius muscle. Turning board with inner side of bone towards you, perfect visible outline of great trochanter with ridge for gluteus medius and facet for pyriformis muscles, the digital fossa with insertion of obturator externus. Make posterior surface of neck and head and obturator groove and outline articular surface, make lesser trochanter and show ilio-psoas attachment, the posterior intertrochanteric line and ridge for quadratus femoris. Make lower part of spiral line, which limits attachment of vastus internus, and the line joining the small trochanter, to which the pectineus is attached. Also show the gluteal ridge for the gluteus maximus. Turning the board as necessary, finish condyles and articular surface and outline the latter posteriorly. Notice that a transverse axis through the condyles does not correspond to the direction of long axis of neck. The latter passes forwards as well as upwards and inwards. Show facets for crucial ligaments. Show popliteal groove in external condyle and facet of origin of popliteus muscle. Complete adductor tubercle for adductor magnus and show facets for external and internal lateral ligaments. Turning board as necessary, finish neck, giving proportion and direction to its anterior, posterior and superior surfaces, but do not obliterate obturator groove. Finish head, allowing bone to harden just enough to be handled. Outline attachments of all muscles not already mentioned and of the capsular ligaments of the knee and hip joints.

QUESTIONS ON THE FORM OF THE FEMUR.

What are the advantages of a long neck placed obliquely to the shaft?

What effect on the action of the ilio-psoas muscle has the inward projection of the lesser trochanter?

For what purpose are the lines on the back of the femur?

What is the direction of the axis of the shaft of the femur?

What is the direction of the axis of rotation of the femur?

What relation does the axis of gravity of the body bear to the knees? To the hip joints?

Account for the posterior concavity of the shaft of the femur?

What is the plane of the knee joint with reference to the axis of the shaft?

Is the internal condyle longer than the external?

Which condyle bears the greater weight?

What suggests this fact?

In line with which condyle does the patella move?

What effect on the action of the knee joint has the anterior oblique part of the articular surface of the internal condyle?

How much of the patella is in contact with the internal condyle in flexion? Why?

MODELING OF THE PATELLA.

On a piece of clay of proper size make anterior surface, then rest the copy on a clay bed made by impressing the anterior surface of bone and make posterior surface, lateral and upper and lower borders. If articular facets are not distinct, refer to text book. Make facets on posterior surface, not neglecting the innermost.

QUESTIONS ON THE FORM OF THE PATELLA.

Name each of the facets on the posterior surface, telling on what bony surface it rests and in what position of the knee joint?

How do you tell the side to which each patella belongs?

MODELING OF THE HIP BONE.

Rest the bone on symphysis, with a large pillow of clay under ilium that will hold the dorsum ilii and the posterior surface of the ischium about horizontal. Press out a flat piece of clay of sufficient size and one cm. thick and cut in the shape of the dorsum ilii and posterior surface of ischium. Lay this flat on the board, dorsal surface up, with clay pillows of proper size placed underneath the crest at point of greatest convexity and also under the posterior edge, between posterior spines. This preserves the concavity and convexity of the dorsum ilii. Now model this surface, starting with external lip of crest, marking attachment of tensor fascia femoris, external oblique, latissimus dorsi and gluteus maximus muscles. Make posterior superior spine and posterior inferior spine to the latter of which, part of great sacro-sciatic ligament is attached. Bevel anterior border of ilium and put in anterior superior spine for Poupart's ligament and sartorius muscle; put in the anterior inferior spine for rectus muscle and ⅄-ligament. The notch between them gives origin to part of the sartorius. Finish dorsum ilii, putting in superior, middle and inferior curved lines and spaces for gluteus maximus, medius and minimus muscles; indicate attachment of reflected head of the rectus muscle. Finish the borders of the great and small sciatic notches with the spine of the ischium, attaching the lesser sacro-sciatic ligament. Make superior and posterior borders of acetabulum bulging from this surface and also the posterior surface of the tuberosity of the ischium, to which the hamstring muscles, quadratus femoris and gemellus inferior are attached. Place groove for tendon of obturator externus between acetabulum and the tuberosity of ischium.

Now turn the copy and rest it on dorsal surface on properly made clay bed. Note that in the pattern bone the pubis and ramus of the ischium stand at right angle to the ilium. Build up inner surface of the ischium and spine, the former attaching

the obturator internus, the latter the levator ani and coccygeus muscles. Build up the rami of pubis and ischium, the pubic body and borders of obturator foramen. At the anterior border of the latter, make groove for obturator vessels passing downwards, forwards and inwards (in the orientated bone). Make inner surface of the body smooth and indicate attachment of levator ani and obturator internus and externus muscles. Make inferior surface of tuberosity of ischium and turn inner border of ramus slightly outward. Show the attachment of crus penis and the erector penis, compressor urethrae, transversus perinaei and gemellus inferior muscles. Make symphysis, pubic angle, pectineal crest also pubic spine, showing attachments of rectus and pyramidalis muscles and Poupart's ligament. Show space for pectineus muscle. Make ilio-pectineal eminence (which is a bulging of the acetabulum on the pectineal surface), with a groove between it and the anterior inferior spine for the ilio-psoas muscle. Finish and give proper elevation to all of the ilio-pectineal line having in front the iliac fossa for iliacus muscle, and behind its posterior termination the articular surface and the surface for ligament attachments. Make these surfaces. Make internal lip for quadratus lumborum, erector spinae, multifidus spinae, and transversalis muscles. On middle lip mark attachments of internal oblique muscle. Now impress a clay bed that will support the clay bone with unfinished acetabulum and external surface of pubis uppermost. Finish the borders of acetabulum with cotyloid notch and cavity. Notice that the acetabulum is excavated from the thickness of the bone posterior to the ilio-pectineal line. Make obturator crest. Finish groove for obturator externus muscle below acetabulum. Show attachment of adductor magnus, obturator externus and internus, the gracilis and adductor longus, brevis and magnus muscles. Outline attachment of capsular ligament of hip joint.

The ilio-pectineal line is a ridge caused by a thickening in the bone from the sacral articular surface to the pubis and best marked in its superior part. It transmits force from the pubis and the sacrum to the acetabulum. In the body of the ischium is a third thick portion of the innominate bone. The ischium terminates below in the tuberosity, which bears the weight of the trunk in the sitting posture. The body of the ischium transmits this weight to the bony mass about the ilio-pectineal line. Thus it is seen that in the innominate bone three strong pyramidal masses meet by their bases at the acetabulum as do the spokes at the hub of a wheel. The pubic and ischial pyramids lend mutual support by being connected at their extremities by the ramus, which completes the obturator foramen. The reason for all this will be considered with the pelvis as a whole. The hollow of

the acetabulum encroaches on the thickness of the hip bone. The strength is maintained by the thick lip which surrounds the cup and which furnishes the articular surface for the head of the femur. This lip is incomplete below, where there is no necessity for a bearing surface and the ramus connecting the pubis and ischium compensates for its lack of strength at this point.

Now with a saw remove from the clay bone the crest of the ilium from above the ilio-pectineal line showing that this is for muscular attachment and visceral support, but not an essential part of the locomotor apparatus. Next remove the ramus connecting the pubis with the ischium. Now with three saw cuts meeting at the center of the acetabulum divide the remainder of the bone into its three component pyramids of bone. Study how the iliac pyramid transmits weight from the sacrum to the head of the femur, or through the border of the acetabulum to the ischial pyramid, and then to the chair. Notice that the pubic element is simply to brace the other two in position. An understanding of all these points will be needed in the study of the pelvis as a whole.

QUESTIONS ON THE FORM OF THE INNOMINATE BONE.

According to its form, into what two parts might this bone be divided?

How do the planes of these two parts meet?

Account fully for the sinuosity of the crest of the ilium?

What is the ilio-pectineal line?

What is its use in bearing weight?

Name the three thick portions of the innominate bone?

Name the parts of the innominate bone that transmit the body weight in sitting. In standing?

What has the thick edge of the acetabulum to do with weight transmission?

Why is there a cotyloid notch?

What compensates for lack of strength at this notch?

Compare the bone to the hub and spokes of a wheel.

MODELING OF THE TIBIA

On the center of the board make a bed for the inner surface of the tibia, crest towards you, with the internal tuberosity and malleolus resting firmly on the board. Roll out a piece of clay the size of the smallest part of the shaft and with a knife remove a vertical slice that will leave a surface corresponding to the inner surface of the bone. Now lay this face down on the clay bed and make the external surface and external part of posterior surface, filling in the interosseous ridge and triangular surface for inferior interosseous ligament; also inferior articular surface for fibula. Now outline the head and form the outer tuberosity and tubercle for ilio-tibial band. Now, turning the board and the bone, form exposed part of the inner tuberosity, the remaining part of the posterior surface of shaft and the lower end. Outline attachment of tibialis anticus muscle. Make the oblique line and outer part of facet for semi-membranosus muscle and superior articular facet for fibula, outlining its cartilage; make the popliteal notch. Make the ridge between the surfaces for the tibialis posticus and flexor longus digitorum muscles, outlining these and the attachments of the politeus and soleus muscles. Make the nutrient canal. On the posterior surface of the lower end, place grooves for the tendons of tibialis posticus and flexor longus hallucis muscles and outline the lower border. Next make the inferior articular surface, noting that it is narrower behind to prevent backward dislocation of the astragalus, and that it extends onto the outer surface of the internal malleolus. Place facet on the tip of malleolus for internal lateral ligament. Now turn the board and finish upper surface of head, putting in external articular facet, broader and shorter than the internal. Put in facets for anterior ends of the semilunar cartilages and anterior crucial ligament; also the

spine of the tibia and the facets for posterior ends of semilunar cartilages and posterior crucial ligament. Prolong posterior part of external articular facet downward for tendon of popliteus. Make new bed for the posterior surface of bone with inner surface towards you and the tuberosities resting on board. Lay the copy on this new bed and finish inner surface of shaft, malleolus and internal tuberosity. Make patellar tubercle and the triangular space above, showing facet for patellar ligament; outline attachment of sartorius, gracilis and semi-tendinosus muscles. Show attachment of internal lateral ligament of the knee. Give proper curves to crest and notice that the transverse axis of the superior and inferior articular surfaces bear such a relation to each other that when the leg is so placed that the superior is transverse, the foot will point outwards as well as forwards. Outline attachments of the capsular ligaments of the knee and ankle and finish facet for semi-membranosus muscle.

QUESTIONS ON THE FORM OF THE TIBIA.

What is accomplished by the upper external and the lower internal concavities of the shaft?

Of what use is the internal malleolus?

Why the great breadth of the head?

Why does the crest of the tibia disappear in the lower part?

Why does the crest of the tibia extend slightly forward as well as upwards?

Why is the head set back from the crest?

How does this affect the position of the calf muscles?

What further adds to the concavity of the shaft?

Why does the foot naturally point outwards?

MODELING OF THE FIBULA.

Make clay bed by impressing upper 3-4 of inner surface and the lower 1-4 of the posterior surfaces. Upon this rest clay core the diameter of the bone, carve out and mould the external surface, giving attachment to the peronei muscles above and turning backwards below to support their tendons. It is bounded by the antero and postero-external borders, giving attachment to the anterior and posterior fascial walls of the peroneal compartment. Complete the former border, which divides below to bound subcutaneous surface of shaft. Make this and outer surface of external malleolus and make postero-external border. Make anterior and external bicipital surfaces of head and styloid process and show attachment of external lateral ligament of knee. Mark upper part of external surface for soleus muscle. Make clay bed by impressing opposite side and place copy in new position. Make anterior surface for extensor longus digitorum and peroneus tertius muscles, and interosseous border, which encloses triangular space for inferior interosseous ligament and which attaches the interosseous membrane. Make internal surface and show attachment of tibialis posticus muscle bounded behind by the postero internal border, which turns forward to join the interosseous in lower third and attaches the fascia of the deep muscular compartment. Make this and put in nutrient canal. Make posterior surface turning forwards below the internal surface and attaching the soleus above and the flexor longus hallucis below. Outline these. Make articular surfaces and complete head. Complete external malleolus, putting in fossa for lateral ligament and outline articular surface. Notice that surfaces and borders turn, in the lower end of the bone, as if the lower fourth had been given a 1-4 twist outward. Mark attachments of capsular ligaments and external lateral ligament of the ankle joint.

QUESTIONS ON THE FORM OF THE FIBULA.

Of what use is the fibula?

Why are its surfaces so deeply excavated?

What causes the posterior convexity of the upper part of the shaft?

What produces the concavity in the outer side of the shaft?

What does this latter curve accomplish?

MODELING OF THE BONES OF THE FOOT.

Os Calcis.—Mould an oblong block, as long and as wide as the body of the calcis and as thick as its thickest part. Lay it on its inner side and with the external surface of the bone in view cut out from the antero-superior border of the clay block a section of proper size to reproduce the outline of the bone at this part. Round off superior border. Make astragalar articular surface and transverse concavity behind it. Add external tubercle and spine for peronei tendons and finish outer surface. Make clay bed for outer surface and lay copy in same. On inner surface build sustentaculum tali, with groove for flexor longus hallucis tendon and large internal tubercle. Clip off anterior end of inferior internal border to make facet for inferior calcaneo cuboidal ligament. Make cuboidal, and finish astragalar articular facets, also posterior surface of the tuberosity, which is smooth above for a bursa, and show attachment of tendo Achillis on lower part. Make facet on tip of sustentaculum tali for calcaneo-navicular ligament. In front of the articular surface for astragalus make rough surface for calcaneo-astragaloid ligament and extensor brevis muscle. The under surface of inner tubercle attaches abductor hallucis and flexor brevis digitorum muscles; the inner and outer give origin to the abductor minimi digiti muscle. The surface in front of these attaches the outer head of the flexor accessorius muscle and long plantar ligament. Above the peroneal spine is attached the external lateral ligament of ankle joint. Mark out attachments.

Astragalus.—Make a biscuit of stiff clay 5 cm. in diameter and 3.5 cm. high. Upon this make an impression of the tibial articular surface and neck. Cut away superfluous clay obliquely in such a way that the base will be still 5 cm. in diameter. On this bed build up, first, the body of the bone, and the neck and head. Notice that neck springs from the inner part of front of body. Add the internal and external tuberosities with groove for the tendon of flexor longus hallucis between them. Make articular facet for body of calcis, prolonged forward and outward and concave in this direction. Add anterior facet for sustentaculum tali on under surface of the neck. Make the groove for the interosseous ligament running forward and out-

ward, widening anteriorly onto the neck. Finish scaphoid articular surface and ligamentous articular surfaces of the head. Complete outer surface with fibular facet and inner surface with tibial facet and rough facet for deep fibers of internal ligament. In similar manner to first impression, make new clay bed by an impression of under surface of the bone and turn copy on to new bed. Finish and outline the superior articular facet; this is narrow and prolonged downwards behind and the external border is clipped by the transverse tibio-fibular ligament. Finish external tubercle for posterior part of external lateral ligament of ankle and internal tubercle for internal astragalo-calcanean ligament. Make upper surface of the neck rough, sloping downwards and inwards.

The Scaphoid.—From a flat piece of clay of proper thickness, cut a mass the shape of the scaphoid. Into one of its flat surfaces impress the head of the astragalus so as to reproduce the facet for that bone. Without removing the clay from the head of the astragalus, make anterior surface convex and outline cuneiform facets. Put on tubercle and indicate the attachment of tibialis posticus and rough place on under surface for attachment of inferior calcaneo-scaphoid ligament and put in cuboid facet, if present on the bone you have.

Internal Cuneiform.—Make wedge of clay of proper size. Clip external surface at superior posterior angle to make facet for middle cuneiform bone. Make facets for first and second metatarsal and scaphoid bones. Show attachment of tibialis anticus, tibialis posticus and peroneus longus muscles.

Middle Cuneiform.—Make clay wedge. Clip surface of base at posterior internal angle. Make facets for second metatarsal and first and third cuneiforms and scaphoid.

External Cuneiform.—Make wedge with base the length of the greatest dimension of the base of the bone. Placing this wedge on its base, cut the facet for the scaphoid, looking slightly inwards as well as backwards and do not have it extended to the edge of the wedge. From the posterior superior angle of external surface, clip facet for cuboid bone. Make facets for second, third and fourth metatarsal.

Cuboid.—Make wedge with base the size of the largest dimensions of internal surface. From anterior part of internal surface, cut facet for external cuneiform. Make anterior and posterior surfaces of such inclination that the external border is but one-half the length of the internal surface. Make facets for fourth and fifth metatarsal bones. On under surface make peroneal groove for peroneus longus tendon and tubercle for short plantar ligament.

METATARSAL BONES.

Make the first, second and fifth metatarsal bones by rolling out clay of proper size and shaping the shaft, head and base with the finger and a tool. Mark facets for interosseous muscles. Make tubercles on each side of head nearer to the dorsal than the ventral surface. On the base of the second metatarsal bone make facets for the three cuneiform bones. On the others make lateral as well as tarsal facets. Indicate the muscular attachment.

PHALANGES.

In the same manner make phalanges of one toe, giving proper shape to each end and place the ridges on each side of the shafts of the first and second for attachment of the tendon sheaths.

Now articulate the bones of the foot by sticking the clay bones in proper relation with soft clay. Fill in the space of the two missing metatarsal bones with clay and study on this articulated foot the attachments of the tendo Achillis, the lateral ligaments of the ankle joint, the calcaneo-scaphoid ligament, the long and short plantar ligaments and all of the muscular attachments given in the text book.

THE FOOT AS A WHOLE.

The foot as a whole forms, first, a longitudinal arch, the inner border of which is longer than the outer. The inner border extends from the internal tubercle of the os calcis posteriorly to the distal end of the first metatarsal bone, while the outer border of this arch extends from the external tuberosity of the calcis to the proximal end of the fifth metatarsal bone; this can always be felt as a prominent tubercle about the middle of the outer border of the foot. Besides the longitudinal arch, there is a transverse one which is most marked at the heads of the metatarsal bones. The outer end of this arch rests on the ground, while the inner end is swung into the high part of the internal border of the longitudinal arch; the astragalus articulates with the tibia and fibula near the posterior part of the foot, resting below on the calcis. The anterior ends of both the astragalus and the calcis articulate with the remaining mass of the tarsus. The bony points that rest upon the ground in a shoe-molded foot are the tubercles of the calcis, both ends of the fifth metatarsal bone and the sesamoid bones found under the distal end of the first metatarsal bone, while the heads of the three other metatarsals rest on the ground to a varying degree.

QUESTIONS ON THE FORM OF THE FOOT AND OF ITS COMPONENT BONES.

Which bone of the foot receives the whole weight of the leg?

On what bony points does the foot rest in standing?

What toes are supported from the calcis?

From the astragalus?

What bones intervene?

Describe the two arches of the foot.

At which points is each most marked?

In walking the foot is a lever of what class?

Indicate the positions of the power, load and fulcrum.

What is the general shape of the body of the calcis?

For what purpose is the sustentaculum tali?

Why is the internal tubercle of the os calcis larger than the external?

What advantage is gained by the length of the tuberosity of the calcis?

What is accomplished by the anterior end of inferior-internal border of the calcis being clipped off?

Why is there an articular facet on either side of the upper part of the astragalus?

Why is the upper articular facet broader in front than behind?

Why does the external surface of the astragalus slope outwards as well as downwards?

Where do we find the groove for the tendon of the flexor longus hallucis represented on the astragalus?

In the axis of which digit does the head of the astragalus project?

What articular facets are found on the head of astragalus?

What is the direction of the long axis of the scaphoid in the articulated foot?

What amount of motion is allowed at the tarso-metatarsal articulations?

Why does the articular surface extend further on to the dorsum of metatarsal than of the metacarpal bones?

Why is the tubercle situated nearer to the dorsal than the plantar surface?

For what purpose is the tubercle on the proximal end of the fifth metatarsal bone?

Why are sesamoid bones placed under the distal end of the first metatarsal bone?

How would you distinguish a first from a second phalanx?

A third phalanx from the other two?

QUESTIONS ON THE FORM OF THE LOWER EXTREMITY.

In what way do the axes of the thigh and leg not correspond?

Are the legs parallel? The thighs? Why?

What makes the foot point outward as well as forward?

ESSENTIALS OF OSSIFICATION OF THE LOWER EXTREMITY.

That each bone must have at least one primary center for the shaft or body and also at least one secondary center for such epiphysis.

That most primary centers appear about the eighth week of interuterine life.

That most secondary centers appear after birth.

That epiphyses unite with shaft usually about age of maturity.

That the three parts of the hip bone unite at about the age of twenty.

That the epiphyses entering the knee joint appear at term and unite at the age of twenty-one and those of the upper end of the femur and lower ends of the tibia and fibula unite a little before this time.

That each tarsal bone has a center appearing before the fifth year and that the calcis has one secondary for the tuberosity; that the astragalus may have one secondary for the internal tubercle, which sometimes does not unite.

That the first metatarsal bone has one secondary center at the proximal end and rarely an extra one at the distal end.

That the four outer metatarsal bones have each one secondary center at the head or distal end, and the fifth may have an extra secondary center at the proximal end; all these uniting at twenty years.

That the phalanges each have one secondary center at the proximal end, uniting at eighteen years.

There is a general law that the epiphysis of a bone in which the ossific center appears first will unite last and vice-versa, and also as the result of the greater growth at the epiphysis that unites last, the nutrient canal is built up in that direction so that the course of the canal is away from the last uniting and towards the first uniting epiphysis.

The lower end of the fibula offers an exception to the first part of this law. The ossific center for the lower end appears before that for the upper, yet the upper end unites after the

lower. This early appearance of the center for the lower epiphysis as compared with that for the upper, is due probably to the great development of this lower extremity in man as compared with the head of the bone in man. In man the head is rudimentary, while in birds it enters into the formation of the knee joint, and on the other hand, man is the only animal in which the lower end of the fibula extends below the tibia. The early union of the lower extremity as compared with the upper, is because of the early strength required here, the external malleolus being long and slim. The nutrient canal runs towards the first uniting epiphysis as is the rule.

THE VERTEBRAL COLUMN, RIBS AND STERNUM.

THE MODELING OF THE COCCYX

Take a flat piece of clay 1-4 inch thick, laying it on the ventral surface of the coccyx. Cut it to the same outline. Now laying clay and bone on the table, ventral surface up, reproduce this surface. Make a clay bed by impressing the ventral surface of the bone and rest copy on this bed. Reproduce first piece of coccyx with transverse processes and cornua. Make the three lower pieces of decreasing sizes. It may be that only the first coccygeal vertebra will be found in the box. If this be the case, reproduce this part in the way mentioned and add the three smaller pieces by consulting a neighbor's bone. It may also be that the first coccygeal vertebra may be found fused to the fifth sacral vertebra. In this case it may be modeled with the sacrum. Mark in areas of attachment of coccygeus and levator ani muscles and lesser sacro-sciatic ligaments.

THE MODELING OF THE SACRUM.

First. Make a wedge of clay the size and thickness of the sacrum.

Second. Lay this upon the ventral surface of the bone and remove superfluous clay by cuts along lateral boundaries of the bone.

Third. Make clay bed by impressing ventral surface of the bone.

Fourth. Reverse the curve in the clay copy so as to make ventral surface concave, and lay it on the bed.

Fifth. Mould dorsal surface making the sacral grooves and spinous processes (the fifth always and the fourth sometimes missing), and make the articular processes looking mostly backward.

Make the mammillary tubercles of the lower vertebra, the posterior foramina and rough areas for ilio-sacral ligaments.

Sixth. Finish superior surface, surfaces for iliacus muscle, articular surface and mammillary tubercles.

Seventh. Make lateral articular surfaces and areas for sacro-sciatic ligaments.

Eighth. Make upper and lower entrances of sacral canal.

Ninth. Turn copy onto new clay bed moulded from dorsal surface.

Tenth. Make ventral surface with ridges at unions of the bodies, with ventral foramina larger than the dorsal and at the level of the inter-vertebral ridges which shows that originally these foramina are the remains of spaces between the transverse processes of those vertebrae that compose the sacrum. Mark areas of attachment of iliacus, pyriformis and coccygeus muscles and make coccygeal articular surface.

Eleventh. Make notch for anterior division of fifth sacral nerve.

Twelfth. Again reverse bone onto bed made from ventral surface and mark in muscular areas and attachment of sacro-ilac and great sacro-sciatic ligaments, erector spinæ and gluteus maximus muscle.

THE MODELING OF A LUMBAR VERTEBRA.

Make body transversely concave posteriorly, vertically concave in front and laterally and with vertical diameter the same in front and behind. Make bed of hard clay 5 cm. high from the board to its upper surface, by impressing lower surface of body and having a clay core extending up into the neural canal. This bed is to be so made that while it is 5 cm. in diameter at the board, the outlines of the upper surface in front and at the sides correspond to those of the body of the vertebra. Behind, the core extends up into the neural canal and inter-vertebral grooves, while the inferior articular processes rest on the posterior surface of the clay bed. Remove bone and lay clay body in place. Add pedicles laminæ, transverse processes, spinous process, make upper articular processes, facing each other, and bearing the mammillary tubercles. Reverse the copy onto new bed made from upper surface of body. Finish the lower surface and inferior articular processes with articular facets turned from each other. Finish inter-vertebral grooves for nerves. Preserve triangular outline of neural canal. Show areas of attachment of anterior and posterior spinal ligaments and ligamenta subflava.

THE MODELING OF A THORACIC VERTEBRA.

Make body with vertical diameter less in front than behind and more cylindrical than a lumbar, but also transversely concave behind and vertically concave in front and on the sides. Place in articular facet for head of rib and notice whether there are two demi-facets, or a whole and a half facet, a part of one facet or a whole facet, and whether the whole facet is on the body or pedicle. All of these points help to indicate from what part of the thoracic series the verterbra has been taken. Make clay bed (as described under lumbar vertebra). Make pedicles, laminæ and spinous process. Make upper articular facets facing backward and outwards. Make transverse processes with facets for tubercle of rib on upper part of outer surface of tip. The eleventh and twelfth have no articular facet for costal tubercle and in many other ways somewhat resemble the lumbar vertebra. Reverse the copy onto new bed and make inferior surface of body, lower articular facets facing forwards and inwards and finish inter-vertebral notch. Preserve vertebral foramen almost circular.

THE MODELING OF A CERVICAL VERTEBRA.

Make the body narrower from before backwards above than below, concave transversely above, and with anterior lip protruding downwards and slightly forwards below. Make bed with cores extending into spinal foramen and into the foramina of the transverse processes. Place body on bed. Make pedicle, laminæ, spinous processes. Make transverse processes springing from the pedicle and body each with anterior and posterior tubercles and groove on upper surface for the nerve. Make superior articular process with facet looking upward, backward and very slightly outward. Make inter-vertebral notch on upper surface of pedicle. Reverse onto new bed and make inferior surface concave from before backwards. Make articular processes with facets facing downward, forward and slightly inward. Preserve the spinal canal triangular in shape and preserve slight inter-vertebral notches at lower border of pedicles. Make spinous process of seventh cervical long and with a downward slope, also in the same vertebra the foramen of the transverse process is small or lacking.

MODELING OF THE AXIS.

Make axis the same as other cervical vertebra, but with superior articular facets on body and with small transverse pro-

cesses. For the present omit odontoid process. When inferior surface of body is finished, reverse the bone onto new bed made for this surface and make odontoid process on upper surface with constricted neck, facet for anterior arch of atlas and areas for check ligaments. Notice that inter-vertebral notch is behind the upper articular process.

MODELING OF THE ATLAS.

Make atlas without body or spinous process with superior articular surfaces for occipital condyles and with inferior articular processes for axis in front of inter-vertebral notches on lateral masses. Make odontoid articular facet on posterior surface of anterior arch and groove on posterior arch behind condylar sockets for suboccipital nerves. With the real bones examine the motion that is allowed by the articular processes of the different series. Also see that on the clay bones these processes are of the shape and position to allow the same movements.

QUESTIONS ON THE FORM OF THE VERTEBRAE.

Why is the body expanded above and below?

In what vertebrae are the homologues of the ribs found and what processes represent them?

From what is the odontoid process of the axis derived?

Of how many pyramids does the vertebral column as a whole consist?

Where is each situated?

Are the changes from one character of vertebrae to another sudden or gradual? Illustrate.

In what part of each region will the typical specimens be found?

What is the developmental significance of the foramen in the transverse process of the cervical vertebra? Is a corresponding space found in the thoracic or lumbar regions?

THE MODELING OF THE STERNUM.

It is rare that the upper part is united to the middle segment of the bone, though the middle may be united to the lower segment. The student usually receives the manubrium and gladiolus in two separate pieces.

On a piece of middling firm clay 1 1-2 cm. thick, and sufficiently large, lay the manubrium, dorsal surface down and cut out clay copy. Remove the bone, turning it with dorsal surface uppermost on the board; on the copy reproduce the dorsal surface with its venous foramina and outline attachments for the sterno-hyoid and sterno-thyroid muscles. Make clay bed for dorsal surface and rest copy on it. Reproduce the thickness of the upper end of the bone and the lateral concavities below, which give the thin lateral edges to this part of the bone. Make suprasternal notch, clavicular articular surfaces, facets for first ribs and demi-facets for second ribs and articular surface for gladiolus. Outline muscular attachment of sterno-mastoid and pectoralis major muscles.

Gladiolus.—Cut from clay as described above. Reproduce dorsal surface with attachments of triangularis sterni and diaphragm. If ensiform appendix is attached, reproduce same. Make bed for dorsal surface and rest copy on it. Reproduce ventral surface with transverse ridges between costal facets. Make demi-facet for second rib, whole facets for the third, fourth, fifth and sixth ribs and demi-facet (or whole facet if ensiform is attached) for seventh rib. If lower part of bone is fenestrated or bifurcated reproduce in that manner and see text book for explanation. Show attachments of pectoralis major and rectus abdominalis muscles.

QUESTIONS ON THE FORM OF THE STERNUM.

How do you account for the fenestrated or bifurcated condition sometimes seen in the lower part of the body of the sternum?

What causes the ridge on the front of the sternum at the level of the second rib? (See development.)

THE MODELING OF THE RIBS—A TYPICAL RIB.

Cut out clay of proper size. Make clay bed that will support rib by its upper border and shape up internal and external surfaces. Make sub-costal groove, giving origin by its borders to internal and external intercostal muscles. Make internal border continuous with lower border of neck of rib. Make outer surface of neck for median costo-transverse ligament. Make tubercle with articular facet and area for ligaments. Lay rib in bed made by impressing inferior border. Make upper edge round. Make superior crista colli for anterior costo-transverse ligament. Make head with two facets and ridge for inter-articular ligament and anterior lip for stellate ligament. Make sternal end. See that angle and curves are properly reproduced.

THE FIRST RIB.

Cut out of medium clay of proper thickness, make upper surface with grooves for subclavian vein and artery, scalene tubercle, insertions of scalenus medius and serratus magnus muscles. Make head, neck, tubercle and sternal end. Make outer border for external intercostal muscle and internal border for Sibson's fascia. Make clay bed for upper surface and reverse, and make under surface with origin of internal intercostal muscle.

THE TWELFTH RIB.

Make conical with single facet on head and without neck, tubercle, angle or intercostal groove.

To reproduce the curves in a typical rib, take a piece of sheet lead 1-16 inch thick, 1-2 inch wide and 12 inches long. First give it a general curve on the flat and then a sharp bend in the same direction at the angle. Also at the angle give it a sharp upward bend on the edge and then holding it at the angle, give the sternal end of the shaft a 1-8 twist inwards.

QUESTIONS ON THE FORM OF THE RIBS.

Why are the ribs connected to the vertebrae by movable joints?

Why do the ribs slope downwards as they pass forwards?

For what purpose is the subcostal groove?

ESSENTIALS OF THE OSSIFICATION OF THE STERNUM AND RIBS.

The first two segments of the sternum have usually each one ossific center and the succeeding each two laterally placed centers.

The first and second bone rarely unite, the fifth and sixth unite late in life.

The ribs each have one primary center near the angle appearing early. An epiphysis appears for the head and one for the tuberosity, both uniting at adolescence.

ESSENTIALS OF THE OSSIFICATION OF THE VERTEBRAE.

Each vertebra is developed from three primary centers. One and sometimes two in the central part and one on each side forming the lateral part of the body and half of the neural arch. These three parts later unite. The neural arch may fail to do so behind, giving the condition of spina bifida, or the central part or a lateral half of a body may be suppressed, causing various deformities.

About puberty five secondary centers appear, the most important of which are the two forming the upper and lower epiphysis of the body which unite at adolescence.

The axis, atlas, sacrum and coccyx have special modifications in their development. The lower vertebræ of the sacrum lose certain of the primary and secondary centers. The upper sacral vertebræ coalesce later than do the lower.

The coccygeal vertebræ are developed each from one center.

The vertebræ just above and below the thoracic may have special primary centers for a costal process and the fifth lumbar may have its laminæ develop by extra centers which may fail to unite with the pedicles.

QUESTIONS ON THE FORM OF THE SPINE.

What are the functions of the spinal column?

How many sacral vertebræ articulate with the ilium?

Where are the curves of the spine situated?

Which are the primary and which the compensatory curves?

How is each produced?

Are these curves accomplished by changes in the bodies, intervertebral discs or both?

Between which two vertebræ is the promontory of the sacrum situated?

What kinds of motion are allowed in each of the three upper divisions of the spine?

What is the chief factor in accurately limiting the motions of the spine?

How is this accomplished in each region?

How do the nerves gain exit from the spinal canal?

TOPOGRAPHY OF THE SPINE.

On the subject how would you identify the second cervical spine?

The seventh cervical?

The third dorsal?

The eighth dorsal?

The twelfth dorsal?

The first, second, third and fourth lumbar?

The third sacral?

Tell what other parts of the spine may be identified through the soft tissues and where they are to be sought?

QUESTIONS ON THE FORM OF THE PELVIS.

Of what bones is the pelvis formed

What is the space in front of the ilio-pectineal lines called?

Of what bones is it formed?

What is the name of the space behind the ilio-pectineal lines and what bones enter into its formation?

What is the shape of the upper part of the true pelvis?

How would you orientate an articulated pelvis? (See Morris' Anatomy.)

Are the ascending rami of the ischium and descending rami of the pubis correctly named? Why?

How is weight transmitted from the spinal column to the heads of the femora?

How are the ilio-pectineal lines concerned in this?

How is weight transmitted from the spinal column to the chair in the sitting posture?

How are the heads of the femora and the rims of the acetabula both concerned in this?

In the standing position does the weight of the body, resisted by the heads of the femora, tend to drive the acetabula further apart or closer together? Why?

Why are the stronger pubic ligaments situated at the narrow borders of the symphysis.

What prevents the sacrum from being driven into the pelvis by the body weight?

How are the sacro-sciatic ligaments concerned in this?

In the sitting posture does the weight of the body tend to separate or compress the symphysis pubis? Why? (Von Meyer.)

Of what use, in the mechanism of standing, is the superior ramus of the pubis?

In what part of the rim of the acetabulum is the cotyloid notch situated?

Give two reasons why it could not be in any other part of the rim?

What relation do the ramus of the ischium and inferior ramus of the pubis bear to the strength of the acetabulum at the cotyloid notch?

How do you explain all of the differences between the male and female pelvis?

What parts of the pelvis can be identified through the soft tissues and where are they to be sought?

QUESTIONS ON MORPHOLOGY OF THE THORAX.

What occupy the spinal grooves?

Why do the bodies of the vertebræ extend into the thorax?

Which are the most movable of the true ribs?

Which is the most movable part of the sternum?

Give the mechanism of the movements of the bony thorax in inspiration. In forced expiration?

TOPOGRAPHY OF THE THORAX.

How can you accurately locate the 12th rib or tell if it is absent or rudimentary?

What ribs are overlain by the scapula when the hand is hanging by the side?

Opposite what part of the spine is the upper border of the sternum in inspiration? The lower border? The upper border in infancy?

What other individual parts of the thorax can be identified through the soft tissues and where are they to be sought?

THE MODELING OF THE CLAVICLE.

Roll out clay core slightly longer than the clavicle and by pressure flatten the outer third. Make bed by impressing the inferior surface of the bone and lay the core on this bed, having properly reproduced the curves. Make upper surface flat and rough externally and show attachments of trapezius and deltoid muscles; smooth and round in inner 2-3 and expanded at its inner extremity. Show attachment of the sternomastoid muscle. Make bed by impressing superior surface lightly and reverse copy onto new bed. Reproduce trapezoid ridge ending at the junction of the outer 1-4 with the inner 3-4 of the posterior border of the bone in the conoid tubercle. Make groove for attachment of the subclavius muscle bounded posteriorly by the prominent part of the posterior—inferior border of the bone. Make rhomboid impression; facet for 1st rib cartilage. Prolong this facet well backward. Make posterior surface narrow in its outer 1-4, where it gives attachment to the trapezius muscle; show this attachment. The posterior surface is encroached upon by the conoid tubercle and is smooth, broad and concave in its inner 2-3 where it arches over the subclavian vessels. Show attachment of sterno-mastoid extending onto this surface. Look for and reproduce nutrient canal on the posterior or inferior surface. Make anterior surface narrow in its outer third, where it attaches the deltoid muscle; show attachment of deltoid muscle. The anterior surface is encroached upon by the deltoid tubercle, broad and convex in its inner 2-3, where it shows a facet for the attachment of the pectoralis major muscle. Make the inner end large and flat with prominent borders for attachment of sterno-clavicular and inter-clavicular ligaments. This surface is somewhat triangular in shape and is enlarged by the posterior, inferior angle being prolonged backwards and downwards. Make outer end with oval acromial articular facet, looking outwards and slightly forward and downward.

QUESTIONS ON THE FORM OF THE CLAVICLE.

What is the function of the clavicle?

What advantage is gained by the outer third of clavicle being flat?

Why is the inner articular surface so large?

What causes the inner two-thirds to bow forwards?

Why does not the outer third bow forwards?

What three things are gained by these curves?

What is the axis of the clavicles? (Von Meyer.)

MODELING OF THE SCAPULA.

Lay a piece of medium clay .5 cm. thick and proper size on the ventral surface of the scapula and, after impressing it, cut to the outlines of the body, head and coracoid process. Lay this copy on the board, concavity upward, with pillow of clay under upper part to preserve the subscapular fossa. Now reproduce the ventral surface with subscapular ridges and ventral fossa. Put in triangular and linear attachments of the serratus magnus muscle and the ridge extending from the head to the inferior angle of the bone and the groove between this ridge and the axillary border. Outline attachment of subscapular muscle. Place suprascapular notch in upper border bounded externally by the base of the coracoid process, which process extends first upward and forward, and then, by bending at right angles, outward and slightly forward. Notice that the outer limit of its base does not reach the glenoid fossa and that the vertical part is flattened from before backwards, while the horizontal portion is flattened from above downward. Give prominence to the anterior surface of the head of the bone. Show visible parts of areas of attachment of pectoralis minor, biceps and coraco-brachialis and triceps muscles.

Make clay bed by impressing the ventral surface and be sure that the clay extends well into the ventral fossa. Now lay copy on the new bed and build up posterior border of glenoid fossa and then put in the spine of the scapula in the proper place. It will be proper here to examine the scapula with reference to the angles at which the parts of the body forming the supra and infraspinatus fossa join with the spine. Though it does not appear so, examination of an antero-posterior saw-cut through the body and spine would show that these three bony

planes join each other at the attachment of the scapula spine at almost equal angles. The spine is concave on its upper surface, which makes the supraspinatus fossa narrower than the infraspinatus fossa. Show attachment of muscles of the same names. Preserve suprascapular notch and make the great scapular notch. Make ridge extending from head to dorsal border near angle dividing infraspinatus from teres surface. Show attachments of the triceps, teres major and minor and latissimus dorsi muscles. Make acromion process with more than half of its body extending beyond the glenoid fossa. Notice that the acromion is formed by the free part of the spine being continued outward and then bent on itself with an even, gentle curve so that the inferior surface of the tip is continuous with the upper surface of the spine and the rough superior surface of the tip with the inferior surface of the spine. However, these two latter surfaces are separated by the inferior border of the crest of the spine, so that in reality the crest on the free border of the spine expands out into the superior surface of the acromion. Make posterior free border of the spine with superior and inferior borders, a tubercle about its middle and a triangular space where it expands into the dorsal border. Make anterior part of acromion turn forward, and articular facet for clavicle on the tip, looking inwards and slightly forwards and upwards. Make the inner border of the acromion continuous with the upper border of the spine and the outer border joining the inferior border of the spine at right angles. This angle should be noted particularly. Outline the attachments of the trapezius, deltoid, omo-hyoid and suprascapular muscles and acromio-clavicular ligaments. Do not lose sight of the fact that when the scapula is orientated its ventral surface looks forwards and inwards and the dorsal surface backwards and outwards. Make articular surface of head with space above for biceps and below for triceps. Make lower part of anterior lip of glenoid fossa extend forward so as to give cavity a somewhat pear shape. Mark attachments of biceps and triceps muscles and glenoid ligament. On dorsal border mark attachments of levator scapulæ and rhomboids. Looking directly at the glenoid fossa the parts of the coracoid and the acromion visible are in the circumference of a common circle. Mark the attachments of the coraco-acromial ligament and represent this ligament by a narrow band of paper. Now it will be seen that the coracoid and acromion with this ligament altogether make a representative of the acetabulum in the hip bone and prevent the upward dislocation of the humerus. As strength at this point is secondary to mobility, the structures are light, the cavity large and the open space

below, corresponding to the cotyloid notch of the acetabulum, is very extensive.

QUESTIONS ON THE FORM OF THE SCAPULA.

Why has the scapula the broad expanded blade?

Why is the blade concave on its ventral surface?

Why has the scapula a spine?

What are the uses of the coracoid and acromion processes?

Make a comparison between the sockets of the shoulder and hip joint.

In what way does the spine strengthen the attachment of the head of the scapula?

Why is the axillary border thick?

For what purpose is the anterior edge of the lower part of the glenoid fossa extended forwards?

When the scapula is in its normal position in what direction does the coracoid process point? In what direction does the glenoid fossa look?

MODELING OF THE HUMERUS.

Make a core the length of the bone and the size of the middle of the shaft. Make a bed by impressing the posterior surface of the bone with the condyles transverse and the external surface towards you. Lay the core on this clay bed. With a hair-pin carve lateral areas on the lower part of the shaft so as to indicate position of external and internal surfaces and anterior border. Make greater and lesser tuberosities and bicipital groove. Make external bicipital lip continuous with the great tuberosity above and anterior border below. Outline the external condyle and supracondylar ridge, the trochlea, capitellum and coronoid fossa and make the lower end of the bone properly flattened and turned forward. Outline the articular surface. Complete the external surface, supracondylar ridge, deltoid tubercle and lower portion of musculo-spiral groove. Turning the board so that the inner borders of the copy and bone will be towards you, complete internal supracondylar ridge, which is more concave in outline than the external. Outline the internal surface and lesser tuberosity and internal bicipital ridge. Outline the head and the part of the posterior surface of the shaft that now appears below the anatomical neck and behind the internal bicipital ridge. Note that this ridge is continuous with the internal supracondylar ridge and completes the internal border. Show areas of attachment of the pectoralis major, latissimus dorsi, teres major, subscapular, deltoid, coraco-brachialis, brachialis anticus, supinator longus, extensor carpi radialis longior and pronator radii teres muscles and common tendons from the external and internal condyles.. Turning the upper ends of the copy and bone towards you, complete the visible parts of the head, anatomical neck and greater tuberosity. Note that the greater tuberosity is in the outer surface of the shaft and extends higher up than does the lesser. Note that the whole shaft, surfaces and borders, has a 1-4 twist inwards as it descends.

Reverse the copy onto bed made from anterior aspect, internal condyle towards you. Complete head and visible part of the anatomical neck, which becomes a groove between the head and greater tuberosity. Give full inward extension to the lower part of the head and obliquity to articular surface. It is on account of this that the upper part of the shaft is called the surgical neck. Complete the upper part of the posterior surface of the shaft, which is turned rather towards you, by adding and by slicing away the clay and then complete the condyles and articular surfaces and put in olecranon fossa. Now com-

plete the posterior surface bounded sharply in the lower part by the supra-condylar ridges and showing above and internally the beginning of the musculo-spiral groove. Note that it is the posterior surface above that forms the inferior non-articular surface of the head. Show attachment of internal head of triceps muscle. Note that the head and internal condyle look in the same direction and remember this fact. Turning the head towards you outline and complete the articular surface with its long diameter running transverse. Complete upper part of anatomical neck and muscular facets on the greater tuberosity, for supraspinatus and infraspinatus muscles. Turning outer border towards you, make external surface of capitellum and external condyle showing facets for anconeus and extensor carpi ulnaris muscles. Give full posterior convexity to external supracondylar ridge and show attachment of supinator longus muscle. Complete the deltoid tubercle with the musculo-spiral groove lying between it and the ridge. Complete the upper part of external surface and show attachment of brachialis anticus, triceps, deltoid and teres minor muscles. Now make a bed by impressing the external lateral aspect of the bone, but in such a manner that none of the articular surface of the capitellum is hidden. Lay copy onto new bed and complete capitellum and outline the articular cartilage limited to anterior and inferior surfaces and surrounded internally and in front by a groove for the edge of the head of the radius. Note that the ridge between the capitellum and trochlea is continuous with the anterior border. Note that internal border of trochlea extends farther down than internal condyle and that the articular surface itself completes 3-4 of a circle and is placed on a spiral so that the posterior part is more external than the anterior. Notice also that the internal condyle turns slightly backward and that there is a groove on its posterior surface for the ulnar nerve. Complete outline of the articular surfaces and make the coronoid and olecranon fossa of proper size. Outline attachments of lateral ligaments of elbow and of capsular and gleno-humeral ligaments of shoulder.

QUESTIONS ON THE FORM OF THE HUMERUS.

What causes the inward convexity of the shaft of the humerus?

Why is the lower end flat from before backwards?

Why has the upper a spherical expansion?

What are the uses of the tuberosities? With reference to the contents of the bicipital groove?

In what direction does the lesser tuberosity point? The greater?

Make a comparison between the head, neck and tuberosities of the humerus with those of the femur.

What point on the lower end of the bone indicates the direction in which the head looks? (Treves Applied Anatomy.)

For what purposes are the coronoid and olecranon fossæ?

Why is articular cartilage found only on the anterior and inferior surfaces of the capitellum?

Why is it found on all surfaces of the trochlea?

Why is the trochlea slightly spiral?

Why is the internal condyle long? In what animals will it be found of greater length than the outer?

Is the axis of the elbow joint horizontal or oblique? Why?

MODELING OF THE ULNA.

Make a tapering clay core, the lower part of which shall be the diameter of the neck of the bone, while at the junction of the upper third, with the middle third, it shall have a diameter equal to the greatest diameter of the bone at this point. In the upper one-third, the core shall again taper to the same size as the lower end of the core. From the middle three-fifths of the core remove a slice that will leave a surface corresponding to the anterior surface, and from the same part of the posterior surface remove a slice so as to reproduce the posterior surface. If this is done correctly you will have also indicated the internal surface and the anterior, posterior and external borders in the middle three-fifths of the bone. Make clay bed by impressing posterior surface of the bone, internal surface towards you, and lay core in this bed. Now outline the internal surface and visible part of coronoid and olecranon processes and great sigmoid fossa, noticing that the triangular posterior surface of the olecranon is almost entirely in view and is here separated from the inner surface by the posterior border. Outline visible part of the lower end and of styloid process, and show the anterior and posterior borders joining both it and head. Show visible part of attachment of flexor profundus digitorum muscle. Turn the bone and copy so that the outer border will be towards you and continue to outline head, making olecranon process and coronoid process, enclosing the great sigmoid fossa between them. Make anterior surface of coronoid and show facets for brachialis anticus, flexor sublimus digitorum, pronator radii teres and flexor longus pollicis muscles. Make anterior surface showing attachment of flexor profundus digitorum. Make visible part of neck with pronator ridge continuous with the internal border. Turning the upper ends of bone and copy towards you, make upper end of olecranon, rough posteriorly for attachment of triceps muscle and having a smooth area in front. Perfect visible outline of coronoid process and the inner half of the great sigmoid fossa. Reverse copy on to new bed made by resting the bone on its anterior border with the external border towards you. In the upper one-third show the external border dividing into two ridges to join either end of the lesser

sigmoid fossa. The posterior of these, and the more prominent, is the supinator ridge. Make lesser sigmoid fossa, which articulates with the radius, and the rough triangular space below it for the supinator brevis muscle. Complete greater sigmoid fossa with vertical ridge in the center and a constriction on either side where the shaft joins the olecranon process. Outline the articular surfaces. Finish posterior surface, putting in the ridge that divides it into an external and internal part. Make and put in attachment of anconeus, behind supinator ridge, the extensor ossis metacarpi pollicis, the extensor longus pollicis and the extensor indicis muscles. Make groove for extensor carpi ulnaris tendon. Put in ridge dividing the surface of attachment of the anconeus from that of the extensor carpi ulnaris. Turning the lower end of bone and copy towards you, finish head by making fossa for triangular fibro cartilage and noticing that the styloid process is attached to the postero-internal portion, while the radial articular surface is on the anterior and external surfaces of the head. This allows the lower end of the radius to rotate on the anterior surface of the ulna. Outline the articular cartilage. Turning the inner surface of the bone towards you, indicate attachments of the flexor and extensor carpi ulnaris muscles and complete triangular subcutaneous surface. See that the curves of the shaft are properly reproduced. Outline the attachments of the orbicular and the internal lateral ligaments.

QUESTIONS ON THE FORM OF THE ULNA.

Of what use are the coronoid and olecranon processes?

Of what use are the lesser sigmoid fossa and the articular surface of the head?

On what surfaces of the head is articular cartilage found? Why?

When the hand is pronated what part of the ulna presents at the back of the wrist? In supination what part presents?

MODELING OF THE RADIUS.

Make clay core the diameter of the neck of the radius. With a hairpin carve area on the lower two-thirds to represent outer part of the posterior surface of the bone. Make bed from posterior surface and lay core in place, outer surface towards you, giving proper curves to the shaft. Put in visible part of the head and bicipital tubercle, the posterior part of the inner surface of the latter being rough for the attachment of the muscle, while the anterior part is smooth to support the bursa lying between the bone and the tendon. Carve facet on inner part of anterior surface in the upper one-half of the shaft to represent outer part of anterior surface. Reproduce oblique line bounding it externally and place nutrient foramen. Extend anterior surface inwards till internal border has proper position, completing this surface of shaft, also anterior border from tubercle to styloid process. Show attachments of the supinator brevis, flexor sublimis digitorum, flexor longus pollicis and pronator quadratus muscles. Make styloid process and anterior border of articular surface. Reverse copy onto bed made from the anterior surface, external surface towards you, and take care that none of the latter surface is hidden. Reproduce this surface and visible part of head, giving full antero-posterior thickness. Show attachments of supinator brevis and supinator longus muscles. Make grooves on outer side for the tendons of the thumb extensors and radial extensors, and grooves on posterior surface for thumb extensors and finger extensors. Give full prominence to the tubercle between the groove for extensor longus pollicis and the groove for radial extensors. On most prominent part of convexity of external surface of the shaft make rough surface for the attachment of the pronator radii teres muscle. In the lower part the external surface is covered by extensor tendons. Turn the lower ends of bone and copy towards you. Finish carpal articular surface with its triangular and quadralateral areas, making the posterior lip extend down farther than the anterior. Give due prominence to the styloid process. Outline articular cartilage and show it extending up into sigmoid cavity. Turn the inner borders of bone and copy towards you, finish posterior surface, with markings of the attachment of the extensor ossis metacarpi pollicis and extensor brevis pollicis, bounded externally and above by the posterior border, which in the upper part is called the posterior oblique line and runs into the bicipital tubercle. Internally it is bounded by the internal border which divides below to enclose sigmoid cavity and a rough triangular space above. Complete these.

Finish visible parts of bicipital tubercle and head, noticing that the lateral surface is broadest where it articulates with the ulna and that it is cupped above to fit capitellum. Give proper curves and see that bicipital tubercle points in the right direction. Outline attachment of external lateral ligament of wrist.

QUESTIONS ON THE FORM OF THE RADIUS.

Why is the head circular?

Why is it cupped on top?

For what purpose is the tubercle of the radius?

What is gained by the shaft of the radius being bowed with the convexity outwards?

Why is the lower end of the radius expanded?

MODELING OF THE CARPUS.

First row:

On a pad of soft clay place the scaphoid, lunar and cuneiform bones properly articulated, preserving anterior concavity, ventral surface up and not impressed deeply into the clay. For guidance in articulating the carpal bones consult text book. This best illustrated in Cunningham's Anatomy, Second Edition. Now reproduce this mass in middling firm clay. Make the anterior surface concave from side to side, bounded externally by the tubercle of the scaphoid and having at its inner extremity (on the cuneiform) the facet for the pisiform bone. Make the articular surface for the radius convex from side to side and from before backward. Notice that this articular surface is almost entirely upon the two outer bones. Make the inferior articular surface for the intercarpal joint, the outer part of which is formed by the scaphoid; this is transversely straight and convex from before backward to articulate with trapezium and trapezoid of the second row. Internally it is deeply concave and receives the os magnum and the unciform. Finish the lateral surfaces of the first row. Outline articular surfaces and indicate on these and the palmar surfaces the articulations between the different bones. Reverse this on to a properly arched

clay bed and make the posterior surface of this first row, indicating the articulations and noticing that the superior articular surface extends more on to the posterior than anterior surface. Outline this articular surface. Reverse the copy and make pisiform bone and fasten it in place. Outline attachments of adductor pollicis, flexor carpi ulnaris and adductor minimi digiti muscles.

Second Row:

On a soft pat of clay articulate the bones of the second row, ventral surface up. Make copy of this row, making ventral surface concave transversely, the concavity being bounded internally by the hook of the unciform and externally by the ridge on the trapezium. Make superior articular surface with the transverse external part formed by the trapezium and trapezoid and convex part formed by the magnum and unciform. Make the metacarpal articular surface; that for the thumb being entirely on the trapezium and separated from the others; those for the other metacarpal bones being rather continuous. Outline the articular surfaces. Indicate the articulations and finish external and internal ends of this row. On the ventral surface mark attachments of the adductor pollicis, the flexor ossis metacarpi pollicis, flexor brevis pollicis, adductor obliquus pollicis, flexor ossis metacarpi minimi digiti, flexor brevis minimi digiti and flexor carpi ulnaris muscles. Reverse copy and finish posterior surface, indicating articulations and outline articular surfaces. See that the 1st and 2nd row articulate properly with each other and with the radius. Impress the bases of the metacarpal bones in their proper places on the inferior surface of the 2nd row. Notice the styloid process of the 3rd metacarpal bone. Outline the attachments of the tendons of the long muscles and attachments of the short muscles and let the copies harden, but not dry.

The metacarpus:

Make five metacarpal bones. Do not neglect styloid process on the third, nor facets for sesamoid bones on the first. Preserve proper relations between the articular surface and tubercles on the head. Outline muscular attachments.

Phalanges:

Make the phalanges of one finger, showing ridges for the sheaths of flexor tendons and indicating muscular attachments. Articulate the bones of the hand.

QUESTIONS ON THE FORM OF THE HAND AND WRIST.

Why is not the carpus just one bone?

Why is there an intercarpal joint?

What sorts of motions are permitted between the radius and first row of the carpus? Between the 1st and 2nd rows? (Manual of Anatomy, Cunningham. Vol. 1.)

What are the advantages of the concavity of the palm of the carpus?

In what way is this concavity related to apposition of the digits?

Of what use is the styloid process of the 3rd metacarpal bone?

Why is the central metacarpal bone fixed and the lateral ones less so?

Why is such free movement permitted at the first carpo-metacarpal joint?

In what other animals is this found?

Why is this free movement not permitted in the other carpo-metacarpal joints?

Why are the fingers not all of the same length? (See Bell on the Hand.)

QUESTIONS ON THE FORM OF THE UPPER EXTREMITY.

What bony points indicate the axis of the upper extremity?

In what way does the upper extremity deviate from a straight line?

How is this deviation accomplished?

What is the purpose of this deviation?

What are the pronation and supination of the forearm?

How are they accomplished?

In the erect position, with the hand hanging by the side, at what level of the trunk is the elbow? The tip of the hand?

With the arms simply extended vertically upwards, are the elbows as high relatively as when hanging by the hands? Why?

What is the essential difference between the attachment of the shoulder girdle and the attachment of the pelvic girdle?

ESSENTIALS OF OSSIFICATION OF THE UPPER EXTREMITY.

The epiphyses about the elbow have united by the eighteenth year. Those at the upper end of the humerus and lower ends of the forearm bones by the twentieth year. The epiphysis of the olecranon is a mere scale, while on the humerus it includes the condyles and on the radius the articular surface. The clavicle has an epiphysis only at the inner end uniting about the same time as the elbow.

The acromion process of the scapula is formed by an epiphy-

sis and the coracoid is developed from a special primary center, that may fail to unite with the scapula.

The ossification of the hand is similar to that of the foot except that there are no epiphyses in the carpus, but there may be one extra bone.

GENERAL PLAN OF THE SKULL.

The skull is composed of a bony box superiorly, which contains the brain, and a mass of bony processes, attached to the anterior part of the under surface of the floor, which, enclosing a number of cavities, form the face. The roof of the brain cavity is called the vertex and the floor is the base of the cranium. The lower jaw, which is a movable part of the face, is articulated to the base of the skull behind the fixed portion of the face. Posteriorly the base is perforated by the foramen magnum (1), and on either side of this opening are the articular condyles (2) by which the skull is supported on the spinal column. The outline of the base is irregular, smallest in front and composed of masses of bone of different thickness which are traversed by sutures and pierced by numerous openings. On each side of the base, just behind the articular fossa of the lower jaw (3), are the ear openings (4), and starting from in front of these and running forward to the lateral surface of the face, are two lateral supports called the zygomatic arches (5), which form the lateral limits of two adjoining spaces called the temporal (6) and zygomatic fossæ (7). The inner wall of each temporal fossa is formed by the skull wall, that of the zygomatic by some of the face bones with a process protruding from the base. The face bones form the anterior boundary of both. Looking at the cranial floor from the inside, it will be seen to be divided into three fossæ by two transverse ridges. The former are called the anterior (8), middle (9), and posterior cerebral fossæ (10), and contain the frontal and tempero-sphenoidal lobes of the cerebrum and the cerebellum respectively. Looking into the skull cap, it will be seen that the vault of the skull is not so divided. The cranial floor has a general inclination downwards and backwards. This is not a continuous slope, but a series of steps, the anterior fossa being higher than the middle and the middle is higher than the posterior. In the center the floor is raised into a longitudinal mass of bone, which extends from the anterior to the posterior fossa, and is formed by the basilar processes of the occipital and the body of the sphenoid bones. This contributes greatly to the strength of the base. On

the floor of the posterior fossa is the foramen magnum. On either side the ridges between the posterior and middle fossæ are formed by the heavy masses of the petrous portion of the temporal bones (11), which contain the organs of hearing. By referring to the under surface of the skull, it will be seen that there is a deep, transverse concavity just behind the face, and that it is the anterior part of the floor of the posterior fossa that bounds this hollow behind. The central portion of this hollow forms the roof of the pharynx and the anterior boundary is formed by the pterygoid processes and facial bones. The lateral wall of the middle fossa is the mesial wall of the temporal fossa, while the two middle fossæ are connected by a narrow transverse groove crossing the central ridge. This is the sella turcica which contains the pituitary body and is part of the middle fossa (12). The lateral portion of the anterior boundaries are formed by the posterior parts of the orbits. The anterior fossa is well above the middle fossa. Its lateral walls separate it from the temporal fossa, while in front it is bounded by the forehead. On either side the floor presents an elevation formed by the roof of the orbits, impinging into the cavity, while between these the floor is depressed over the roof of the nasal cavity. In the middle line is a vertical crest of bone, which gives attachment to the dura mater and is continued through the floor into the nose as part of the nasal septum.

The walls of the skull, though strong, are of solid bone in only a few places. In most places they are composed of two compact plates called the inner and outer tables, separated by some cancellous bone diploe. This diploe contains veins which communicate both with the veins of the brain coverings and those of the scalp. In many places we find the two tables separated widely, enclosing mucosa-lined, air-filled cavities, which open into the nose, pharynx, or ear. We find such air cavities in the thickness of the wall in front of the anterior fossa, the frontal sinus (13), in the central portion of the floor of the middle fossa—the sphenoidal sinuses (14), in the petrous portion of the temporal bone—the ear cavities (15), (16), and the mastoid cells (17), which are in the mastoid process found on the base of the skull behind the external opening of the ear. At definite places in the vault and base of the skull, and in the face, we find sutures which are the lines of junction of the various component bones. The course of these sutures is more or less serrated and they do not pass straight through the bony walls, but are sloped in such directions as give the greatest resistance to muscular force and external violence. Some of the cavities in the face contain special organs, as the orbit and mouth, while

others, such as the maxillary antrum (18), found below the floor of the orbit and the nasal fossa, give expanse to the face, and, as they contain air, they give resonance to the voice. Along the under surface of the floor of the anterior fossa are two rows of thin-walled air cells. They run from before backwards and the two masses are separated from each other by the width of the upper part of the nasal fossa which lies between them. These are composed mostly of the lateral masses of the ethmoid, containing the ethmoid cells (19). There are three of these cells on either side separated from each other by thin, bony partitions and each communicates with the nasal fossa. In front they rest against the face wall at the side of the upper part of the nose and posteriorly they abut against the basilar part of the sphenoid bone and its contained air cells (14). They form the lateral wall of the upper part of the nasal fossa and the mesial wall of the orbit. This upper part of the nasal fossa is limited above by the floor of the anterior fossa, in front by the face bones and behind by the thick part of the base of the skull containing the sphenoidal cells (14). These and the frontal sinuses (13) both open into the nasal fossa. From the under surface of the mass of ethmoid cells (19) a plate of bone of varying thickness (20) drops down as far as the floor of the nasal fossa. It forms the separation between the maxillary antrum (21) and the nasal fossa. The floor of the nasal fossa is the hard palate (22), which is also the roof of the mouth. This fossa opens on the face in front and posteriorly into the deep groove under the central part of the base of the skull. The general cavity of the nasal fossa is divided into two lateral halves by a septum (23) of bone which drops from the under surface of the floor of the anterior and middle fossa above, to the upper surface of the floor of the nose below. This septum is complete behind, but in front it presents a gap, which in the recent state is filled by cartilage.

Text Book of Anatomy: Gerrish, 1902. Figs. 240, 243, 244, 245.

Gray's Anatomy, 1905. Figs. 98, 100, 101, 102, 103.

Text Book of Anatomy: Cunningham, 1905. Figs. 120, 121, 122, 123, 124.

Human Osteology: Holden, 5th Edition. Fig. 17, plate 14; Figs. 2 and 3, plate 21; Figs. 1 and 2, plate 24.

The orbits which contain the eye-balls are situated on either side of the nasal fossa. As already seen, the roof is formed by the floor of the anterior cerebral fossa and the inner wall mostly by the mass of ethmoid cells (14). The outer walls are formed from parts of the walls of the middle cerebral and temporal fossæ.

MODELING OF THE SKULL.

The parts of the skull furnished are one-half of a lower jaw and a lateral half of the skull, the cap of which has been removed by a transverse cut. The half skull cap and one-half lower jaw will be found intact, but it is more than probable that the thin bones about the inner wall of the orbit and the lateral wall of the nasal cavity will be found more or less damaged.

Directions for reproducing the missing parts will be given in the proper places.

The half skull should be handled carefully so as not to inflict further damage; never seize it about the orbits or nasal fossæ!

The scheme followed in the modeling of the skull is similar to that used with the other bones, but the skull being much more complex a little further explanation will prevent errors. The base of the cranium is first formed from a sheet of clay moulded over a form that is an impression of the inner surface of the base. Then the positions of certain prominent points are indicated on the external surface of the base so that the general relations will be maintained and finally the various parts of the base are reproduced. When the under surface of the base is completed, and not until then, the face is added.

DIRECTIONS FOR MODELING THE UNDER SURFACE OF THE BASE OF THE SKULL.

After requesting the instructor to dust the inner surface with talcum powder to prevent the clay from sticking, the cranial cavity should be filled with middling soft clay. This is accomplished by impressing the clay, small pieces at a time, so that the various spaces will be reproduced accurately, without danger of crushing or cracking the bone in the process. The half skull furnished to you is most likely to give way about its middle. Here the petro-sphenoidal suture extends almost entirely across the base and the two parts are held together by what remains of the squamous part of the temporal bone and of the body of the sphenoid joined to the basilar process of the occipital. The cavity should be filled so that the clay is level with the upper edge and extends 1 cm. beyond the sagital cut and a good outline is obtained of the foramen magnam, the opisthion and basion. Lay the filled skull down on the board, resting on the upper surface. On the sagital surface press the clay down onto the board to help steady it and gently manipulate the skull until it is loosened and removed from the clay. If, in removing the clay, it is distorted, replace it in the skull and after pressing it gently into position

remove a second time. Repeat the operation until it is successfully removed. The clay occupying the middle fossa must necessarily be somewhat distorted during removal, but this can be moulded into shape with the fingers. Let this core stand for twenty-four hours, uncovered and exposed to the room temperature. During this time it will both shrink and harden, which will allow for the extra thickness of the walls of the clay skull and prevent alterations of shape during manipulation. After the core has hardened (not dried), the extra clay 1 cm. beyond the sagital cut is removed, the form is dusted, with talcum powder and the reproduction of the skull begun.

Of fairly soft clay make a flat piece 8 mm. thick, the shape of half an ellipse, that shall have a straight edge on its long diameter and be about 15x30 cm. Lay this flat, soft clay on the core, the straight edge corresponding to the sagital cut and press it on to the mould so that its under surface will reproduce the outlines of the core and trim off the superfluous clay where it comes in contact with the board. We now proceed to put in the markings on the base of the cranium. Cut out the foramen magnum and with pieces of clay accurately placed, indicate the positions of the external occipital protuberance, the occipital condyle, the opisthion, the basion, the spine of the sphenoid, the bases of the pterygoid plates, the nasion, the supra-orbital ridge, the pterygoid ridge, the eminencia articularis, the posterior root of the zygoma and the mastoid process. The position of each of these various points is indicated now to preserve the relations of the base as a whole and then these should, before proceeding further, be verified by measuring in various directions with a ruler or modeling tool. Put in the superior curved lines of the occipital and the mastoid process of temporal bone. Show the attachments of the trapezius, occipito-frontalis, sterno-mastoid, splenius-capitis and trachelo-mastoid muscles. Put in the occipital protuberance attaching the ligamentum nuchæ and make external occipital crest. Put in inferior curved line and the attachment of the complexus and obliquus superior. Make the digastric fossa and attachment of digastric muscle and groove for occipital artery. Complete jugular process of occipital bone with the attachment of the rectus capitis lateralis muscle. Make posterior condyloid fossa and foramen and show attachments of rectus capitis posticus major. Make condyle with its articular surface looking forwards, outwards and downwards (downwards with skull in the normal position) in front, and downwards and slightly outwards and backwards behind.

Complete the mastoid process and make the posterior root of the zygoma, the articular eminence (which is the anterior

root), and the floor of the glenoid fossa, place the butt end of a lead pencil in the angle between the anterior surface of the mastoid and cover its exposed anterior superior portion with a layer of clay to represent the tympanic plate of the temporal bone, which encloses the external auditory meatus. Work the end of the pencil so as to make the meatus with its long diameter downwards and backwards. In front of the tympanic plate put in the Glaserian fissure and show canal of Huguier. The fissure runs towards the inner plate of the pterygoid and terminates at the petro-sphenoidal suture behind the spinous process of the sphenoid.

Stuff clay into the depression at the side of the body of the temporal bone, so that it will reach below the level of the floor of the glenoid fossa. Make the anterior condyloid foramen opening forward and outline occipito-mastoid suture with mastoid foramen and outline the petro occipital suture. On this last suture place the jugular fossa extending inwards above and reaching external to the anterior condyloid foramen. In all of this work refer constantly to surrounding points to see that the relative positions and elevations of all are correct. In front of this put in the under surface of the petrous portion of the temporal bone, which is bounded in front by the petro-sphenoidal suture, behind by the petro-occipital suture, externally by the mastoid and terminates internally at the foramen lacerum medium, at the junction of the two sutures. Now put in the other points and areas on this surface of the temporal bone by building up the vaginal process, which is a downwrad prolongation of the tympanic plate and joins the mastoid process enclosing the styloid process. Put in styloid process and stylo-mastoid foramen. Put in openings of carotid canal and aqueductus cochleæ and rough area at apex for levator palati muscle. Internal to this make the foramen lacerum medium. While putting in the foramena consult the interior of copy and pattern. In the plate between jugular fossa and carotid canal make foramen for Jacobson's nerve and in the jugular fossa make foramen for Arnold's nerve. Finish articular eminence outlining the limits of the articular cartilage of the glenoid fossa and finish spinous process of the sphenoid, attaching the internal mandibular ligament and tensor palate muscle. In front and to the inner side put the foramen spinosum. Finish under surface of great wing of sphenoid giving full thickness as seen from sagittal surface. Between the foramen spinosum and the outer pterygoid plate, put in the foramen ovale directly internal to the articular eminence. Indicate the inner opening of the Eustachian canal and attachment of the tensor

palati muscle. Make the basilar process of occipital and body of sphenoid, putting in the pharyngeal spine and showing at tachments of rectus capitis anticus, major and minor. Turning the board so that you look into the orbit of the pattern and at the roof of the orbit of the clay, finish the latter with its lacrimal fossa, supra-orbital notch and the trochlea for superior oblique muscle. Build up the malar process of the frontal bone and that part of the outer wall of the orbit that is formed by the wall of the middle fossa of the skull. Notice that the line of junction between the roof and outer wall pass backward and inward at an angle of 45 degrees, while the line between the roof and inner wall pass vertically back. Between the roof and outer wall, in the posterior part, put in the sphenoidal fissure, which opens into the middle fossa, while above the internal part of this fissure make the optic foramen also entering the middle fossa. Put in origins of superior oblique, levator palpebræ, superior rectus, inferior and internal recti and two origins of the external rectus muscles. Between the sphenoid behind and the articulation of the nasal bones in front, that part of the base of the skull which lies between the median line and the inner margin of the orbit is divided into two parts. The inner and narrower is the cribriform plate of the ethmoid and contributes the roof of the nasal fossa. The space between this and the orbit serves for the attachment of those bones which form the wall between the nasal fossa and the orbit. Outline that part that belongs to the roof of the nose and also the area that affords attachment to the division wall between the orbit and nasal fossa. At the posterior part of the nasal fossa, the body of the sphenoid descends abruptly for 1 1-2 cm. and on either side of the body are found the pterygoid processes. The body of sphenoid with the basilar process of the occipital bone, which is continuous with it behind, form a thickening in the central part of the floor of the skull, which can be seen rising up into the middle and posterior fossæ and which contributes greatly to the strength. Notice that the pterygoid process does not reach the middle line, but that the nasal fossa lies between the two processes. Finish the upper one-third of the pterygoid process with the external and internal plates and the scaphoid fossa for the origin of tensor palati muscle. Just below the inner end of the sphenoidal fissure the inner side of the base of the pterygoid process make the foramen rotundum. (See description in text book.) This foramen can at present be seen opening into the middle fossa of the pattern bone and its anterior opening into the spheno-maxillary fossa, can be made out in the articulated skull by looking through the spheno-maxillary fissure into the spheno-maxil-

lary fossa, into which it opens. The spheno-maxillary fossa is the space just in front of the base of the pterygoid process, the anterior wall of which is formed by the bones of the face. A little below and to the inner side of the foramen rotundum make the Vidian canal, piercing the base of the pterygoid process and having a much longer course and extending between the spheno-maxillary fossa in front and the foramen lacerum medium behind. Make the pterygo-palatine canal which is to the inner side of the base of the process.

On a line, reading from above downward, we have the optic foramen, the inner end of the sphenoidal fissure and the foramen rotundum. To the inner side of, and a little below, the latter is the Vidian canal and the plane of the internal pterygoid plate would about correspond to this canal. The body of the sphenoid extends mesial of the plane of this plate and forms part of the roof of the nasal cavity. Throughout the whole extent of the roof of the nose, from the nasal bones back, there is attached the median septum which divides the nasal fossa into two lateral halves. It will depend upon the accuracy of the median cut whether part of this septum is preserved and if it is, the roof of the fossa will be transversely concave. In a properly preserved specimen, on either side of the median septum, there will be found on the anterior surface of the body of the sphenoid the openings of the sphenoidal sinus, by which each communicates with the posterior superior part of the nasal fossa, from just to the inner side of the Vidian canal and running backwards and opening into the spheno-maxillary fossa at the inner edge of the base of the internal pterygoid plate is found the pterygo-palatine canal. Complete all of these structures. In front this surface of the body is continuous with the middle part of the roof of the nasal fossa. (If these points are not clear, on account the specimen being mutilated, consult the instructor.)

MODELING OF THE BONES OF THE FACE.

Having completed the under surface of the base of the skull, it is now proper to examine the manner in which the face is attached to the fore part of this structure. The face consists of a number of bony laminæ, certain of which latter are attached to the skull. In the first place, as we have already seen, the median septum of the nose is attached to the median line as far back as the level of the posterior limit of the pterygoid process. On either side the boundary walls between the orbit and nasal fossa are attached to the under surface of the base from the body of the sphenoid, as far forward as the nasal bones. (Make out

these points, but the middle part of this wall may be destroyed.) This lateral wall is hollow, containing the lachrymal and ethmoid cells. Cunningham Text Book of Anatomy, 1905. Figs. 124, 125, 125. Gerrish Text Book of Anatomy, 1902. Fig. 224. Gray's Anatomy, 1905. Figs. 110, 102, 103.

Noticing carefully in a good specimen, it will be seen that this lateral wall joins the body of the sphenoid between the opening of the sphenoid sinus and the opening of the pterygo-palatine canal and the downward continuation of its posterior part forms the inner wall of the spheno-maxillary fossa and separates it from the nasal fossa. In front the two nasal bones together form an arch which connects these lateral walls. See illustration in text book of under surface of orbital plate of frontal bone. In the mid line the posterior-inferior surface of this arch rests on the nasal septum and above, it is attached to the fore part of the base of the skull.

There are two more bilateral attachments for our consideration. One is the anterior part of the outer wall of the orbit. The other is that of the lower part of the upper jaw to the lower part of the pterygoid process.

We have seen that the outer orbital wall is directed backward and inward at an angle of 45 degrees. See illustration in text book of under surface of orbital plate of frontal bone. Now notice that, posteriorly, the part that belongs to the base of the skull does not join the outer edge of the floor of the orbit, but there is left a narrow space, extending backward and inward to the spheno-maxillary fossa. This is the spheno-maxillary fissure and it is through it that the spheno-maxillary fossa and the zygomatic fossa communicate with the orbit. The upper parts of the maxillary bone and the pterygoid process are separated by the pterygo-maxillary fissure and spheno-maxillary fossa, as has already been explained.

MODELING OF THE FACE.

On the surface already marked out on the base of the skull, build up the median wall of the orbit and the outer wall of the nasal fossa, and the bridge of the nose, which latter is formed by the nasal bone. Posteriorly this wall should join the body of the sphenoid to the outer side of the opening of the sphenoid cells and just to the inner side of anterior opening of the pterygo palatin canal and lower down becomes continuous with the anterior edge of the internal pterygoid plate. It has here a vertical height of less than 2.5 cm. Do not try at present to reproduce the markings on the nasal surface of this

wall nor the nasal septum. Build up the outer wall of the orbit as far as the upper border of the zygomatic process with its full facial expansion at the anterior free border. Notice that this wall by the anterior facial expansion forms part of the outer boundary of the zygomatic fossa. Of middling firm clay roll out a core that will about correspond in shape to the cavity of the orbit and extend a little beyond. After the orbit has been powdered with talcum powder, press this clay core into the orbit and to insure its filling the space and reaching to the apex, press the finger down into the clay and then fill the hole left by the finger. This pressure should in no case be strong enough to injure the bones of the orbit. Before withdrawing this core, mark on it the position of the supra-orbital notch as a guide to orientating it in the clay skull. Now withdraw the core and after powdering it and the orbital cavity of the copy, place it in the latter and make the external and internal walls conform to the core. If the core is too long for the depth of the orbit of the copy it may be changed slightly if needed. Now powder the upper surface of the core and scrape the upper edges of the external and internal orbital walls to remove any powder that may have fallen upon them. Next with a flat piece of clay of about the proper size, lay on the floor of the orbit. The anterior border of the floor shall correspond with the groove in the core that was made by the same border in the bone. It is to be attached by its inner border to the inner wall of the orbit to within 1-3 cm. of the pterygoid process while its outer border is attached only along its anterior 1-3, leaving a space of 1-2 cm. wide at the outer end and 1-3 cm. at the inner. This space is the spheno-maxillary fissure and it is through this fissure that the orbit communicates with the zygomatic and spheno-maxillary fossæ.

Returning to the base of the skull, complete the pterygoid process, which was not done before for fear of its being damaged. Put in the attachments of the external and internal pterygoid muscles. Notice that is slopes forward as well as downwards. Measure to see that it is the proper length. Now, upon the under surface of the floor of the orbit, build up the body of the maxillary bone. In the skull this body is hollow, but we make it solid. In finishing the nasal fossa we will indicate the communication between the latter space, which is the maxillary antrum, and the nasal fossa. The mass of the maxilla extends in a postero-external direction to such an extent that while looking directly from above (the skull being inverted) no part of the spheno-maxillary fissure is visible. The lateral wall of the nasal fossa extends backward and is continuous with

the anterior border of the inner surface of the pterygoid process, but the upper part of the body of the maxillary is separated from the pterygoid process by a space measuring 1-2 cm. from before backwards, which is the afore mentioned spheno-maxillary fossa. The outer opening of this space is the pterygo-maxillary fissure by which it communicates with the zygomatic fossa.

The median wall of the spheno-maxillary fossa is pierced by the spheno-palatine foramen by which it communicates with the nasal fossa. Posteriorly the lower half of the maxillary body is in contact with the pterygoid process. Complete the mass of the maxillary bone, following the pattern closely and paying strict attention to, and understanding the special points noted. Make the anterior naris extend laterally under the inner part of the orbit and note that the lower part of the maxillary body does not extend inward of a line between the outer limit of the anterior naris and the internal pterygoid plate. Put in the palate the maxillary tuberosity processes of maxilla and palate bones, the alveolar process and anterior nasal spine. Make normal teeth (consult other bones for those missing). Put in inter-maxillary and Stenson's foramen and two half foramina of Scarpa. Show posterior palatine groove, posterior palatine canal extending to the spheno-maxillary fossa and secondary foramina. Make hamular process and posterior nasal spine and show attachments of the azygos uvulæ, the tensor palati and the superior constrictor muscle of the pharynx.

Extend out the temporal process of the malar bone and complete zygomatic arch back to the eminentia articularis which latter has been completed, where the process is joined by its three roots. Note that the process narrows as it goes backward. Notice that in front the surfaces of this arch look inward and outward, while posteriorly there is a twist, which brings the internal to a superior and the external to an inferior position. Make the lower border thicker than the upper and make the tubercle for the external lateral ligament of the jaw. Show temporo-malar suture, attachment of masseter muscle, the squamo-sphenoidal and spheno-malar sutures, temporal ridges, attachment of the temporal muscle and the temporo-malar canals. Complete any part of the external surface that has been neglected and put in spine on the upper external border of the external auditory meatus.

Remove the plug from the orbit. A tool thrust through the spheno-maxillary fissure may help.

If the face has been distorted in the removal of the orbital plug, readjust the shape. The opening of the orbit should be roughly a parallellogram with the obtuse angles above externally and be-

low internally. Readjust and finish the orbital borders. Put in the lachrymal groove on each lachrymal bone leading to upper opening of lachrymal canal.

Consult text book and put in various sutures in the orbit, not omitting to show the orbital portion of the palate bone in the orbit. Show inner openings of malar foramena. Finishing off the face, putting in the supercilliary ridge, supra-orbital notch or foramen, the infra-orbital foramen (6mm. below middle of infra-orbital ridge), the canine eminence, the canine and incisor fossæ, the malar foramena, and the naso-maxillary, the naso-frontal and naso-maxillary and the fronto-maxillary sutures.

With a toothpick or hairpin complete infra orbital canal from infra orbital foramen in front to its opening in the spheno-maxillary fossa posteriorly. Now mark out attachment of facial muscles.

MODELING OF THE NASAL FOSSA.

It is probable that the nasal fossa of the pattern is so disfigured that little besides the floor and roof can be made out, but by turning to a picture of the nasal fossa in the text book and reading the text and with the help of the following notes, you will be able not only to reproduce the nasal cavity, but have an accurate knowledge of its arrangement.

On your clay copy you should already have a nasal cavity with an outer wall and floor and roof. The anterior part of the roof slopes downward and forward and is formed by the nasal bone. The posterior part should slope downward and backward, being formed by the anterior surface of the body of the sphenoid, while the middle part should be almost parallel with the bony palate. The transverse diameter of each nasal fossa at the middle of the floor should be about 1 1-4 cm., while at the anterior and posterior naris it is 1 cm. Above, this transverse diameter widens and then contracts, till at the roof it is but ¼ cm.

Hollow out the nasal fossa to these dimensions, straighten the cut surfaces of the roof and floor and notice that the thickening of the anterior part of the palate is due to a gain on its under surface. Before proceeding with the nasal fossa, read text book description of sphenoidal and frontal sinuses and indicate the position of these by slight concavities on the cut surface. Read also the ethmoid cells and maxillary sinuses, but remember that they have not been sectioned. Now place a small ridge along the under surface of the cut edge of the roof and upper surface of cut edge of floor to indicate the attachments of the median septum, which has been removed to gain a view of the interior of

the cavity. Show palato-pterygoid suture and spheno-palatine foramen. Into the interior of the nasal fossa from each lateral wall there drop three thin, shell like, processes of bone, which hang free, attached only by thin outer edges. The lines to which they are attached are called the superior, middle and inferior turbinate lines, and these lines and not the turbinate bones we will represent. Put in inferior turbinate line extending from middle of anterior nares to the junction of the middle with the lower third of the posterior nares, with a considerable upward convexity between these two points. Just below this line, about 1 1-4 cm. behind the anterior meatus of the nose, represent the lower opening of the lachrymal canal. On the posterior 2-3 of a line running from the nasion to the inferior border of the spheno-palatine foramen (which latter should be just below the body of the sphenoid) make the middle turbinate line and below it in their proper places, put the hiatus semilunaris, bulla ethmoidis and the openings of the maxillary antrum, infundibulum and of anterior and middle ethmoid cells. One-third of a cm. below the roof and above the middle 2-4 of the middle turbinate line, make the superior. Between these two latter the posterior ethmoid cells open. The opening of the sphenoid cells and the spheno-palatine foramen are supposed to be already properly placed. Near the rostrum and half way between the anterior and posterior portions of the under surface of the sphenoid, make posterior opening of the pterygo-palatine canal.

From the work you have just completed you should have an accurate knowledge of the mechanical construction of the skull—you will now proceed to refresh your memory as to details by going over the model surface by surface.

Turn to the text book description of the outer surface of the base, verify each point and suture mentioned, and the outlines of the areas of muscular attachments..

INSIDE OF BASE OF SKULL.

In a clay wall 2 cm. thick and 7 cm. high and 20 cm. long, cut a notch that will just hold the clay skull resting with the upper edge parallel to the wall and not touching the board in any place. Without removing the central core from the clay skull, rest the latter in this notch and support the overhanging part of the skull with pillars of clay placed under the mastoid process and against the jaw bone, below and in front of the zygomatic arch. Be careful not to break the latter. Now carefully remove original clay core from clay skull and proceed with the—

MODELING OF THE INNER SURFACE OF THE BASE OF THE SKULL.

First read the general description of the interior of the base of the skull in your text book. The three fossæ have been accurately outlined by the impression of the core and we have but to finish the surface.

Starting in the anterior fossa, build up frontal crest and crista galli for attachment of the falx cerebri with foramen cæcum between them (if bone is damaged refer to text book for description and cut). On the side of the crista galli make olfactory groove with three rows of openings in the floor. the anterior slit through which the nasal nerve leaves the skull, the groove between the slit and the anterior ethmoidal foramen and the inner openings of the anterior and posterior ethmoidal foramina.

Make convoluted, convex roof to the orbit and the depression external to this. Make posterior border to anterior fossa. The middle fossa lies at a lower level than the anterior. Starting in the middle line make the olivary process, the groove for the optic chiasma, the optic foramen and anterior clinoid process, the pituitary fossa, the dorsum sellæ, the posterior clinoid process, the groove for the carotid artery with the lingula sphenoidalis, petrous process and fossa for the cavernous sinus. Hollow out the anterior part of the middle fossa so as to be slightly overhung by the border of the anterior, put it in proper position so as to correspond with the openings on the outer surface of the skull, the sphenoidal fissure, the foramen rotundum, foramen spinosum, foramen ovale and foramen lacerum medium and fossa for the Gasserian ganglion, the hiatus Fallopii with the groove running to it, and the eminence which marks the position of the superior semi-circular canal. Make general lateral part of the fossa convoluted and make groove for middle menigeal artery running from opening of foramen spinosum to junction of the posterior border of anterior fossa with lateral wall of the skull. This should be over the middle of the zygomatic fossa. Make posterior border of the middle fossa grooved for the superior petrosal sinus.

Posterior fossa.—Make border of foramen magnum (and at the same time finish facet for odontoid ligament). Make half groove of termination of superior longitudinal sinus the half internal occipital crest and if torcular Herophili is on your half skull put it in. Make grooves for the lateral, for the inferior petrosal sinuses and the basilar groove. Make opening of jugular foramen, internal auditory meatus, anterior condyloid foramen, the mastoid foramen and of the posterior condyloid foramen if

present. Finish the general cavity of the posterior fossa and put in all of the sutures on the inside of the base of the skull and be able to indicate the attachment of the dural reflections and the position of the blood sinuses.

THE MODELING OF THE SKULL CAP.

After powdering inner surface with talcum place the one-half skull cap upon the table, resting upon its upper cut surface. Fill the cavity with clay and then remove the bone leaving the core in place. Over this lay on a piece of flat clay of proper thickness and after pressing to the shape of the core, trim the edges. Make temporal fossa, temporal ridges, parietal foramen, coronal, lambdoid and squamo-parietal sutures and indicate muscular attachments and show remains of frontal suture if present. Reverse copy onto new bed made by impressing or stuffing clay under external surface. Make clay thin along the cut edge of the temporal fossa. Make impressions of middle meningeal artery. Pacchionian bodies, 1-2 groove of superior longitudinal sinus and whatever is visible of torcular herophili. Show visible sutures noticing that they are less distinct than on the external surface. Show diploe on cut surfaces and portion of frontal sinus if present. Notice that the vault of the skull is not divided into separate fossæ.

MODELING OF THE LOWER JAW.

Make a bed by impressing the inner surface of the half jaw. Now cut out a piece of clay the shape of, and about the thickness of the bone and lay it on the clay bed. Make the condyle, coronoid process, the external oblique line, the alveolar and mental process and reproduce the teeth. Put in mental foramen and outline attachments of the levator menti, the depressor labii inferioris, depressor anguli oris, phatysma myoides, buccinator, masseter and temporal muscles and external lateral ligament. Reverse copy onto new bed made by impressing external surface. Make internal surface with opening of dental canal, the spine, the fossa for submaxillary gland, the tubercles and mylo-hyoid ridge. Finish teeth and alveolus and make mesial cut surface and show attachments of the external and internal pterygoid, temporal, buccinator, superior constrictor of the pharynx, mylo-hyoid, digastric, genio-hyoid and genio-hyo-glossus muscles and internal lateral ligament. (If your box contains a whole bone make bed by filling the concavity with clay. Cut clay to fit outer surface of one lateral half of the bone and proceed as above.)

MODELING OF THE HYOID BONE.

These bones are rarely preserved in the preparation of the skeleton, so that the bone will have to be reproduced from the specimen in the possession of the instructor and the cuts and description in the text book. Do this and outline the muscular and ligamentous attachments.

QUIZ ON THE SKULL.

This will include the location of all foramina and fissures, the knowledge of what cavities they connect or with which they communicate and the structures they transmit. The location and formation of the various fossæ and cavities of the skull (including accessory cavities and the spheno-maxillary fossa), their relation to the various other cavities and the enumeration of their contents and also (which is included in the first part), the foramina, canals and fissures that open into them.

The relative thickness of the various parts of their walls.

The enumeration of the bones entering into the formation of the cranium and of the face.

The formation and position of the principal sutures of the skull. The positions and general form of the various teeth in childhood and adolescence.

The attachment of the various muscles on the external surface and the location of the various and chief ligaments.

Various sinuses and the principal attachments of the dura mater.

The location of the internal and middle ear cavities.

A knowledge of the following landmarks:

The Supra-orbital Arch.
The Internal Angular Process.
The External Angular Process.
The Zygomatic Arch.
The Mastoid Process.
The External Occipital Protuberance.
The Superior curved line of the Occipital Bone.
The Parietal Eminence.
The Temporal Ridge.
The Frontal Eminence.
The Supercilliary Ridges.
The Nasal Bones.
The Lower Margin of the Orbit.
Henle's Spine.
The External openings of the Mental Foramen.
The Infra-Orbital Foramen.
The Supra-Orbital Notch.
The Surface markings of the course of the middle Meningeal Artery.

The locations of the following fixed measuring points:

The Nasion.
The Glabella.
The Inion.
The Basion.
The Opisthion.
The Lambda.
The Pterion.
The Asterion.
The Bregma.
The Superior Stephanion.
The Inferior Stephanion.
The Gonion.
The Ophryon.
The Vertex.
The Auditory point.

ESSENTIALS OF THE OSSIFICATION OF THE SKULL.

The base of the skull is mostly developed in cartilage while the flat bones of the calvarium and the bones of the face are developed in membrane. Most of the centers of ossification of the skull appear about the time of those of the long bones. The squamous portion of the occipital bone is developed by four centers and if the upper half should fail to unite to the lower the interparietal bone of the lower animals will be the result. A defect in the line of union of the two halves may result in a cerebral hernia, which is most common at this site. Each parietal bone is developed from one center appearing at the eminence, but there may sometimes be two and these failing to unite, the bone is divided into two parts by an antero-posterio suture. The frontal bone develops from two centers. Occasionally the suture between them is persistent throughout and the anterior end can always be distinguished at the glabella. This is a common location of the meningocele. The malar bone may develop and persist as two separate pieces and the lower portion of the styloid process of the temporal bone may fail to unite to the upper. Very important to remember is that the anterior part of the palate with the alveolar processes of the maxillary bone which is formed from the pre-maxillary, is developed from two centers, and that developmentally, this pre-maxillary bone bears a close relation to the septum of the nose. (See cleft palate.)

Of the six frontanelles the lateral are closed at birth, the occipital a few months later and the frontal about the beginning of the second year. Of the accessory cells and sinuses, the maxillary and mastoid antra are formed before birth, the ethmoid cells appear at the third year, the sphenoidal sinuses at the sixth year and the frontal at the seventh year. The mastoid process and articular eminence are both absent at birth.

QUESTIONS ON THE FORM OF THE SKULL.

What is the essential difference in relation between the skull and face of man and of all other animals?

How is this same difference shown between the skulls of higher and lower races of man?

Which racial type had the highest development on these lines?

Why are the foramina of entrance and exit situated on the base of the skull?

Why is the roof of the skull thicker than parts of the base?

What parts of the base are thick?

Why?

Why are the roofs of the orbit and nose and the lateral wall of the temporal fossa not of thick bone?

Why are the edges of the orbit thick?

Why does the squamous part of the temporal bone overlap the outer surface of the parietal bone?

Of what positive use are the accessory sinuses and cavities?

What other advantage is gained by their presence?

What is the cranial index?

What is the facial index?

For what are they used?

What is the base line?

What general analogy is there between the skull and the vertebral column?

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