AVIAN TOPOGRAPHY

FEATHERS

Among the many engineering accomplishments that birds have achieved, the development and muscular control of feathers stands out as one of the major keys to their success. No other taxa possesses these remarkable structures. Feathers are both light and flexible and can be controlled with precision and agility. Yet each feather has the strength required for the stresses imposed by flight, there being no stronger substance of equal size and weight in nature. Feathers provide smooth and streamlined contours that are essential for reduction of air friction and turbulence and, when properly groomed, they are completely waterproof. They form one of the most efficient types of insulation known, because of the profusion of dead air spaces that they enclose, and thereby aid in maintaining the birds' high body temperature (usually 105^{o}-111^{o} F).

All feathers have the same basic structure. A long central shaft supports a broad flat vane. The hollow base of the shaft is called the **calamus**. This becomes the **rachis** where the vane begins. The vane is composed of many parallel rows of **barbs**, Each barb has many smaller **barbules** projecting from the sides. Barbules on adjacent barbs may be attached to one another with hook like structures called **barbicels or hamuli**. The hamuli hold the barbs together maintaining the shape of the feather. If adjacent barbs are separated, they may be reattached when the bird **preens** (the original velcro). Study the feathers that have been put on display. Distinguish the various feather types; **contour**, **semiplume**, **filoplume**, **down**, and **bristle**. Downy feathers do not have barbicels and the barbs are long and flexible, this is called **plumulaceous** feather texture. **Pennaceous** feathers such as contour feathers are more rigidly structured. Many contour feathers have both plumulaceous and pennaceous portions. Can you suggest an explanation for this arrangement? Many body feathers also have an **afterfeather** which emerges from the underside of the rachis. What is the structure of the afterfeathers?

Feathers are not evenly distributed over the body but are concentrated in to areas called **tracts or pterylae**. Intervening areas are called **apteria**. Using the fresh specimens and the figure provided in lab, locate and identify the feather tracts. What is the advantage of apteria to birds?

The flight feathers are collectively known as the **remiges**. These include the **primaries** and the **secondaries**. The primaries are all attached to the bones of the hand and are numbered from the inside out. Most birds have 10 primaries but storks, flamingos, grebes, and rheas have 11, ostriches have 16 and some passerines have 9. Secondaries are attached to the ulna while **tertiaries** are attached to the brachium. The tail feathers are primarily associated with turning and are called the **rectrices**. Other feather groups you should identify include the **scapulars**, **wing coverts**, and **axillars**.

When identifying birds in the field, it is important to know the topographical terms associated with various body parts. Study the accompanying figure and identify the topographical features on the specimens.

Characteristics of bills and nostrils

Use the handouts in the lab to identify the following structures.

Bill

compressed	hooked	decurved
crossed	recurved	spatulate
toothed	serrate	
lamellate		

Other structures

gular sac	nail of bill	cere
tubular nostril		

Characteristics of the legs

scutellate	reticulate	booted
compressed		

Characteristics of the feet

incumbent	elevated	phlange (toe)
claw		

Toe patterns- The relative position of the toes is an important taxonomic character. Use the handouts to identify the following arrangements.

anisodactyl	syndactyl
heterodactyl	zygodactyl
pamprodactyl	

Webbing and foot patterns

palmate	semipalmate
totipalmate	lobate
raptorial	

SKELETON

The skeletons of all birds are quite similar. This arises partially because the primary modifications for flight are basic and rather unmodifiable, and also because true single ancestor origin (monophyly) closely unites all birds. **As you study the skeleton remember the development of flight in birds depended upon a solution to the seemingly conflicting demands of economy of weight vs rigidity and strength of structure**. Consequently, the distinctive features of avian anatomy and physiology, compared with other vertebrate taxa, are those associated with flight and with the related high rate of body metabolism. In every case, when we point out a unique characteristic of birds, you should immediately ask yourself "How is this an adaptation to flight"?

A special feature of bird bones is their lightness. This stems, in part, from **air spaces** that are in direct communication with respiratory systems. These **pneumatic** bones make possible an increase in bone size for greater muscle or feather attachment without a corresponding increase in weight. As a rule, the more efficient, large flying birds (albatrosses) have many pneumatized bones, whereas flightless taxa have few. The skeleton you will study is pneumatized. The histological structure of the **compact bone** of birds is similar to that of mammals. A long bone of a bird, such as those of the pectoral and pelvic limb, is a cylinder of compact bone often permeated by **marrow cavities**. Marrow is the site of much blood cell formation (especially that of red blood cells) in most adult amniotes. In the center of the bone, much of the marrow may be replaced by **pneumatic channels**, invading extensions of those specialized portions of the lungs called **air sacs**. Bird species noted for their achievements in flight have many pneumatized bones for greater strength and size, but without proportionate weight increase. Some flightless and/or diving species have greatly reduced pneumatization (i.e. loons that fly and dive) or lack this specialization altogether (i.e. penguins that dive but don't fly). Examine the humerus and sternum of the skeleton for pneumatization.

Changes in the mineral content and structure of bones accompanies egg-laying and molting; mineral salts are removed from the bone matrix for use in egg shell formation, etc. Occasionally, the mineral drain from the bones may prevent a bird from perching or even discourage walking! Identify all skeletal elements illustrated on the accompanying figures.

Because of the fusion of the vertebrae posterior to the neck, the **cervical** region of the bird is both long (the number of vertebrae correlates positively with the length of the leg) and flexible (owls can rotate 180^{o} right and left). Considerable **fusion** and elongation of the elements of the avian vertebral column is a result of modifications for feeding and locomotion. Although flexibility is of prime importance, strength of the neck must be maintained because of the forceful use of the head in feeding, nest building, and in some instances, climbing (e.g. parrots). The forces acting upon the rib cage in respiration and flight require considerable rigidity and result in fusion of the **thoracic** vertebrae, which act as the mid-dorsal fixed attachment site for muscles. In response to the mechanical problems posed by the impact of landing, bipedal balance, and

climbing, there is a fusion of all **lumbar** and sacral vertebrae to the ilium of the pelvic girdle on either side. The number of vertebrae in each of the vertebral regions is usually constant for each species, but varies greatly among species. The only freely moving vertebrae are the cervical and (to a lesser extent) **caudal** vertebrae.

Examine disarticulated cervical vertebrae. The faces of the centra are rather saddle-shaped, with the major axis of curvature of the face running laterally on the anterior face and dorso-ventrally on the posterior face. Such an arrangement of the central faces is called **heterocoelous**. Articulate two vertebrae and note the great mobility this gives between vertebrae. This is, of course, multiplied by the number of such joints along the length of the neck and accounts for the neck's great versatility. Just dorsal to the articulating faces of the centra are the broad, smooth articulating surfaces of the paired **prezygapophysis** and **postzygapophysis.**

Similar to some reptiles, the first cervical vertebra is called the **atlas** and it is highly modified and ring-like. The single **basioccipital condyle** articulates in a ball and socket joint with its anterior surface. The second cervical vertebra, the **axis,** also is modified. These changes allow very free movement of the head. An idea of the mobility of these joints can be gained by properly articulating a first and second vertebra and then twisting them around each other's longitudinal axis. Both the atlas and axis lack transverse processes, pleurapophyses and the transverse foramina that are characteristic of other cervical vertebrae. It may help you to remember that Atlas was the Greek god who bore the pillars of heaven or according to some legends the earth on his shoulders - just as the first cervical vertebra bears the weight of the skull. The axis of an object is that around which it turns and careful observation of the anterior face of the centrum of the second cervical vertebra will reveal a tooth-like (odontoid) process around which the atlas turns.

The only other freely moveable vertebrae outside the neck are the anterior caudal vertebrae. It is necessary to have a mobile tail for use in flight. Nevertheless, the tail is much shortened by fusion of the distal vertebrae to form a single blade-like **pygostyle.**

The five fused thoracic vertebrae are characterized by the presence of ribs. The articulations for each rib are **lateral facets** on the centrum. The **capitulum** (ventral attachment for each rib) rests on the centrum, and the **tuberculum** (dorsal attachment) joins the transverse process. Since fusion of the vertebrae with each other and with adjacent structures increases greatly as we pass posteriorly, exact lines of suture are often difficult to identify. The avian rib cage and sternum form an expandable cylinder that encloses most of the viscera and acts as a bellows for respiration. The ribs, as described above, articulate with the vertebrae by means of diarthrodial (double bone attachment) joints dorsally and typically join the **sternum** ventrally. Most of the ribs are composed of a distinct dorsal, or vertebral, portion and a ventral, or sternal portion. The hinge joint between the two parts of the rib allow it to be folded or extended, thus raising or lowering the sternum. By this mechanism, the size of the thorax can be changed for

inspiration and expiration in the manner of a bellows. Midway on the vertebral portion of the shaft of the ribs a flat spur, the **uncinate process** projects from the caudal border of the rib and overlaps the rib behind. This arrangement strengthens the rib cage, provides more attachment surface for muscles, and assures synchrony of movement of the ribs in respiration. The ribs have air passages within them.

The fusion of **lumbar** and **sacra**l vertebrae results in a rigid anchorage for the pelvis and hind limb. This is important for support of the weighty posterior portion of the bird in flight (imagine the difficulty and danger of carrying a long, flexible trunk) and to absorb shocks on landing. The last few thoracic vertebrae and the first few **caudal** vertebrae fuse with the combined **lumbo-sacral** region to form the **synsacrum**. Since the avian sternum is large and functions to support the viscera, there is little development of the abdominal wall of the **pubis**. The pubis can be seen as a thin splint of bone passing from the **acetabulum**, or socket for the articulation of the femur, posteriorly along the ventral border of the pelvic girdle. In the ostrich-like birds a **pelvic symphysis** remains but in other taxa the two halves of the girdle are widely separated ventrally and no pelvic canal encircled by bone is present. This probably is an adaptation to laying relatively enormous eggs. The loss of strength resulting from absence of a pelvic symphysis is compensated by the strong fusion of the **ilia** along their dorsal borders with the synsacrum. The ilia have two portions: an anterior, broad, concave face for muscle attachment and a posterior convex face that forms an internal pocket for the kidneys. During development, the **ischium** fuses with the ilium; the only remnant of their suture is the sharp angular bend that runs along the lateral edge of the convex region of the ilium.

The avian pelvic limb consists of several parts: the thigh, enclosing the **femur**; the leg, containing the small needle-like **fibula** and the stout **tibiotarsus** (drumstick on turkeys); the **tarsometatarsus**; and the **phalanges** of the digits. A distinct tarsus, as is found in other vertebrate tetrapods, is absent in birds. Developmentally, the proximal tarsal bones fuse with the tibia and the distal tarsal elements fuse with the metatarsals. The major region of flexion in birds is therefore between fused tarsal elements or **intratarsal joint** - not between epipodium and the second mesopodium as one might expect from our own anatomy. Actually, most reptiles living today show some degree of movement across the tarsus in the transverse plane and the development of the avian intratarsal joint is another of those very reptilian features of birds. Yet the fossil record indicates that mammals, too, evolved from reptiles and mammals lack intratarsal joints. How might this be explained?

On the anterior surface of the knee joint between the medial and lateral ridges of the **trochlea** (the pulley-like end of the femur) rests the **patella**. The patella is neither an endochondrally developed bone nor a dermal bone, but it is formed in the tissue of a tendon; such bones are known as **sesamoid** bones. The feet of birds are variously and well adapted for performing a particular function associated with their habitats or feeding behavior. No bird has more than 4 toes, the fifth or lateral digit having been universally lost. The more terrestrial the

species, the more rudimentary is the first digit. The ostrich has the most reduced foot of all birds with only 2 digits remaining of the ancestral 5 (digits 1 and 2 have been lost). Some birds have 3 toes, but the great majority of avian taxa have 4 toes.

The **sternum** or breastbone is well ossified and highly developed in contrast to that of reptiles. Although it is characteristic for each species, it is highly variable among birds. Since it is the origin of flight muscles, the sternum is modified accordingly. In carinate (flying) birds a well developed keel or **carina** projecting ventro-medially from the body of the sternum is present. Ratites (e.g. ostrich, emus, cassowaries, rheas, and tinamous) are flightless and have a flat bowl-like sternum without a keel. In strong fliers (e.g. hummingbirds) the keel is deeper than the sternum is broad. Consequently, the size of the keel is a fair index of power in flight. It should be noted that the penguin, though flightless, possesses a keeled sternum. Can you explain this? Two mid-dorsal, anterior openings on the medial surface of the sternum are **pneumatic fossae**; they permit entrance of air sacs into the sternum. A pair of perpendicular ridges on the anterior, external surface indicate the internal air passageway for these sternal diverticula.

The **pectoral girdle** consists of a blade-like **scapula** parallel to the vertebral column, a stout **coracoid** bone extending to the sternum and stabilizing the pectoral girdle, and usually well-developed **clavicles** fused mid-ventrally by an **interclavicle** to form a **furcula** (wishbone). The scapula and coracoid together form the **glenoid fossa** for the reception of the head of the humerus. Medially, the scapula, coracoid, and clavicle form the walls of the important **foramen triosseum** (or triosseal canal), which will be noted in our muscle dissection. The furcula holds the wings away from the sternum during muscle contractions in flight in the fashion of airplane struts.

The pectoral appendage of birds is characterized by a reduction and fusion of the distal elements. The stout **humerus** fits into the shallow **glenoid fossa** and on the medial surface of the greater tuberosity (the large ventral bump for muscle attachment) is the large **pneumatic foramen** for the axillary diverticulum of the interclavicular air sac. The **radius** and **ulna** are equal in length and longer than the humerus. In the normal folded wing, the radius is dorso-medial to the ulna. The ulna also may be identified by the **olecranon process**, which forms the apex of the "elbow".

The wrist is greatly reduced and the hand and digits fused and reduced. The bones of the hand and wrist are fused into the **carpometacarpus** while digits 1 and 5 have been lost. The bones in digits 2, 3, and 4 have been reduced and fused. The primary feathers attach to the bones of the hand.

The skull continues the economy of the avian skeleton by being lightly built and with individual bones fused together. In fact, the avian skull exhibits a greater degree of fusion than in any other vertebrate class; the bones are, therefore, next to impossible to distinguish in the adult -

so we won't study them (lucky you!). Note the large **cranium** housing the well developed brain. This is not a new skeletal element but merely a new feature of the skull produced by the expansion of the skull dermal and chondrocranial elements. The **orbits** of the eyes are large and spacious to accommodate the exceptionally well developed avian eye. The eyes would actually be confluent with each other were it not for a thin sheet of bone, the **interorbital septum** medially. Note the well developed **sclerotic ossicles** of the eyeball. Bones forming in the connective tissue sclera of the eye are common vertebrate features, such elements being found in some fishes, and virtually all lizards, turtles and birds. These bones probably aid in maintaining the nonspherical shape of the eyes, and therefore assure proper image focus. The beak is supported by the **premaxillaries** and **maxillaries** above and at least five distinct bones below (dentary, splenial, angular, surangular, and articular). The lower jaw articulates with the upper by means of a joint between the articular and quadrate bones. The palate has little secondary development and does not rigidly attach the upper jaw to the chondrocranium. This, combined with the free mobility of the frontals and nasals, allows the upper jaw to move as well as the lower jaw. Such movement and structure is called **cranial kinesis** and it permits a wide variety of uses of the bill. Again, this feature is also found in many reptiles. The structure of the palate is an important characteristic used in the classification of birds. The **foramen magnum** and **basioccipital condyle** may be seen in posterior aspect. The **hyoid apparatus** supports the tongue and larynx and consists of the second and third visceral arches. The long posteriorly projecting horns are attached to the skull and act as an anchor on the tongue when it is protruded. Woodpeckers have an extremely protrusible tongue for pulling insects from the holes they have drilled; their tongues wrap around their heads and incorporate the hyoid apparatus.

ANATOMY

We will continue to examine avian adaptations to flight by surveying the intact bird with special attention paid to the muscle adaptations, and the respiratory, digestive and urogenital modifications. Lastly, we will briefly look at the sense organs and nervous system. Your dissection will be of a pigeon (Columba livia).

The head terminates in an elongate **bill**, the shape of which is highly variable among birds. The bill consists of an upper and lower mandible covering the mouth. Each mandible consists of a bony structure of the skull covered by a horny, epidermal sheath. Teeth are absent in all recent birds. Why do modern birds lack teeth? How is this an adaptation to flight? The horny beak will grow constantly and must be worn down by normal use to maintain optimum shape. By cutting at the angle of the jaw identify the typical tetrapod oral cavity containing **external and internal nares**, **laryngeal prominence**, and **glottis**, as well as the **tongue**.

Especially in the pigeon, note the fusiform outline of the trunk in lateral aspect and its cross-sectional shape. What is the significance of this form? Manipulate the trunk with the fingers and determine that it is a very rigid, inflexible structure. This is accomplished largely through skeletal modifications, which is considered in another segment of the lab. Run your fingers along the midline of the ventral aspect and feel the ridge representing the keel of the **sternum**. The prominent muscle masses lying on each side of this line are the **pectoral muscles**, which are the principal flight muscles.

The cloaca lies on the lower surface at the posterior end of the trunk. It consists of a transverse opening with protruding lips and is surrounded by a ring of short, stout feathers termed the **anal circlet**. On the dorsal surface of the posterior end of the trunk is situated a prominent papilla containing the opening of the oil or **uropygial gland** from which the bird obtains oil for preening the feathers.

Skin the neck and breast of your pigeon, taking care not to remove or destroy underlying structures. Keeping your scalpel close to the sternum, dissect away the **origins** of one side of the large breast muscles. It will be necessary to cut the **clavicle** as well, since the muscle also takes origin along this bone's posterior surface. Deflect the muscles, clearing away connective tissue, and find its concentrated **insertion** on the ventral surface of the **humerus**. This is the **pectoralis major**, the **adductor** or powerful downbeat muscle of the wing. Taking its origin deep to the above muscle and running via a stout tendon through the **foramen triosseum** to insert medially (and dorsally) on the humerus, is the **supracoracoideus**. Although the muscle fibers of this latter muscle pull virtually the same direction as the **pectoralis major**, their action is the exact opposite by virtue of their tendon-pulley insertion. The **supracoracoideus** is the upbeat or **abductor** muscle of flight. Since greater aerodynamic stability is gained if the concentration of weight is at or below the level of the wings, large muscles on the back would

present a problem to a flying bird. They would, in fact, be balancing a large, heavy mass between and above the wings were it not for this superb example of engineering design, which allows a muscle located well below the wings to raise them in flight.

Skin one leg, including the foot, taking particular care from the **tibiotarsus** down. **Scales**, structurally identical with those of reptiles, are found on the **tarsometatarsus** and foot regions. Though it may not be obvious from the preserved specimen, you are familiar with the color, texture and taste differences between the flight muscles and those of the leg. The muscles of the breast are adapted for quick, short bursts of energy in game and domestic birds (e.g. turkey, pheasant, etc.), whereas their leg muscles must withstand prolonged contractions in the running habits of these birds. Birds have physiological adaptations to such a way of life: the breast muscles have less myoglobin (an oxygen storage molecule), they are lighter in color, and they become anoxic and fatigued if overworked. White meat is muscle especially useful in powerful, quick starts but not for long durations. The dark meat of the legs and thighs, on the other hand, contain much myoglobin and hence have a greater resistance to fatigue - the birds are able to stand and run or perch indefinitely. This is not the case with the breast muscles of migratory birds, hence the darker muscles of ducks and geese.

Bird muscles are remarkable in their division into **contractile** and **tendinous** portions. This is well illustrated in the lower leg. The digital extensor muscle originates mainly on the preaxial surface of the tibiotarsus. It inserts on the distal phalanges of digits #2, #3 and #4 to extend them and flex the tarsus. The toes are flexed by superficial and deep flexor muscles and tendons running on the posterior surface of the tibiotarsus. Some of the most astounding names in anatomy may be found in the drumstick. The **muscularis flexor digitus perforatus et perforans digiti tertii** is the smallest muscle, naturally. These leg muscles and their tendons constitute the automatic energy-free "perching mechanism" of birds. When the leg is bent as the bird roosts, flexion of the tarsometatarsus stretches the flexor tendons as they pass over the tarsal joint, automatically bending the toes around the perch without muscular contraction. Loosen the tendons and operate the digit flexion and extension apparatus (unfortunately, this often does not work with preserved specimens).

Open the single body cavity by a cloaca-to-chin incision. In the pigeon you may wish to cut along one side of the keel. The long **esophagus** expands into the **proventriculus** or anterior (cardiac) portion of the stomach. Is the esophagus modified or any way different from the typical vertebrate straight tube? How is the **crop** an advantage to granivorous birds such as a pigeon?

The proventriculus has glandular walls that secrete both acid and enzyme. The next section of the gastrointestinal tract is the muscular **gizzard**. The lining of the gizzard is hardened, though not by keratin, as sometimes is stated. To aid the gizzard in grinding food, grit, small pebbles or sea shells are frequently swallowed and appear to remain for a time in the lumen of the gizzard. The gizzard is analogous to what structures in most other vertebrates? Why do birds have gizzards if they are an adaptation to reducing weight, yet behaviorally fill them with stones? Why would frugivorous birds lack a gizzard?

The **duodenum** is associated with the **pancreas** and receives the **bile duct** from the **gall bladder** embedded in the **liver**. The gall bladder is present in forms whose feeding habits involve the taking of large meals at long intervals, and consequently the need for copious bile to deal with the massive intake of fat. Actually, the majority of vertebrates including fish possess a gall bladder, and it is only in some herbivorous forms such as pigeons and deer that it has disappeared; these animals spend much of their time feeding, so that a steady trickle of bile direct from liver to intestine is adequate for their needs.

Long **caeca** (singl.=**caecum**) mark the junction of the small and large intestines in birds (smaller ones occur in mammals). They are often large in herbivorous taxa. Paired caeca are large and long in the chicken and owl, very small in the pigeon and passerine birds, and absent in parakeets and some other taxa. What is the function of caeca? The **large intestine** is short and only slightly wider than the small intestine. It is, however, distinct histologically. The **cloaca** receives all waste and reproductive products. Split open the cloaca. On the mid-dorsal wall near the rim of the **vent**, where an opening to the **cloacal bursa** can be seen. The bursa is large and saccular in young birds but may be small and dense or absent in adults. This structure was first described and illustrated in the hen by Hieronymus Fabricius of Aquapendente in 1604, but only recently has its function been determined. It is packed with **lymphocytes** and is part of the antibody production system in early life. The pattern of intestinal loops has been used for taxonomic purposes. The two-lobed **liver** is located in the forward end of the abdominal cavity. The **pancreas** is situated in the loop of the duodenum. Although not part of the digestive system, the **spleen** is located near the **proventriculus**.

Return to the respiratory tract and trace the **trachea**. Its anterior end is encased in remnant portions of the **hyoid arch** and is called the **larynx**. No vocal cords are present in the avian larynx. The **cartilaginous rings** that keep the trachea from collapsing are complete circles, unlike those in mammals. In some swans and geese, the trachea takes a serpentine course and may lie partly enclosed in the hollowed-out sternum. The **syrinx**, at the posterior end of the trachea, is diagnostic of birds; it is the vocal organ. Muscles of the region change the shape of the cavity and the tension of membranous parts of the syrinx. Leading into either **lung** from the syrinx is a **bronchus**, which has both an extra- and intra-pulmonary portion.

The lungs occupy **pleural cavities** and are separated from the abdominal cavity by a

membranous septum. Note the close association of the lungs with the ribs and vertebrae. In the absence of a muscular diaphragm, slow respiration is effected by intercostal and abdominal muscles. Rapid respiration during flight is aided by the action of the pectoral muscles. Avian lungs are unique in several ways. They possess no terminal alveoli, as in mammals, this arrangement being replaced by a bronchial capillary network. They also have outpocketings filled with air, the **air sacs**, which extend between various organs and penetrate some bones. Try cutting open the trachea near the **glottis** and inserting an eye-dropper. By aspiration, try to see the lungs and airs sacs fill with air.

Examine the large **heart**, which is four-chambered. The **ventricles** comprise the greatest mass of the organ. Note the discrepancy in the size of the ventricles. The four chambered heart leads to a series of vessels as illustrated. The **atria** are small and somewhat indistinct from each other. The **right atria** is larger than the **left atria**, and it receives the two **precaval veins** and the single **postcaval vein**. From the **right ventricle** the **pulmonary artery** immediately divides into right and left trunks, which enter the lungs. Blood is returned to the **left atrium** through the **pulmonary veins** and enters on the dorsal surface of the left atrium via short trunks, which are hidden from view unless the apex of the heart is reflected cranially. The single **aorta** leaves the base of the heart and gives rise to a **right** and **left brachiocephalic trunk**, then courses posteriorly as the single **dorsal aorta**. Unlike mammals, birds have retained the **right aortic arch** instead of the left.

The avian **kidneys** are of the metanephric type and are located just behind the lungs in a depression in the dorsal wall of the sacrum. The **ureter** extends from the medial border of the kidney to the cloaca. A bladder is not present in birds, temporary storage of the urine taking place in the cloaca. Why is a bladder not necessary for a bird?

In the female, the single (left) **ovary** lies somewhat anterior and ventral to the left kidney. A coiled **oviduct** originates at a point slightly behind and lateral to the ovary and extends to the cloaca. The right ovary and oviduct appear in the embryo, but regress before hatching. A rudiment of the right oviduct may persist in the adult, and a few birds have functional right ovaries.

The paired **testes** of the male are located in the same relative position to the kidneys as the ovary of the female. The left testis is generally more developed than the right. A small projection on the medial border of each testis represents the **epididymis**, which is continuous with the much-coiled **deferent ducts** extending to the cloaca. During the breeding season the coiled deferent ducts develop to form **seminal vesicles**. In some birds, these form such a swelling that the cloacal region becomes enlarged and protruded, thus aiding in identifying males and determining the stage of the sexual cycle. A copulatory organ is present only in primitive groups and develops in the ventral wall of the cloaca. Most birds copulate by simply apposing their external openings in a "cloacal kiss".

The **adrenal glands** are not part of the urogenital system, but they are anatomically associated with it. They lie at the anterior poles of the kidneys. Although typically paired, the adrenals exhibit variation and may be fused into a single mass. They are not easy to find.

Skin the head and note the large **eyes**. The majority of the eye (the **sclera**) lies under the skin and only a very small portion of the eye is externally visible (**iris**).

The brain of birds is relatively larger than that of reptiles, correlating with their more active lifestyle. The olfactory lobes of the telencephalon are reduced, but there is an overall proportionate increase in this portion of the brain. The large **cerebral hemispheres** are smooth, and the pallium, or dorsal cover, though thin, contain more neurons than that of reptiles. The **diencephalon** and part of the **mesencephalon** are not exposed on the dorsal surface, being obscured by the expanded cerebral hemispheres and the very large **cerebellum** (**metencephalon**). The surface of the cerebellum is folded, further increasing the surface area where nerve cell bodies lie. What is the significance of these trends in the cerebellum of birds? The **corpora bigemina**, or optic lobes of the mesencephalon region, are larger than in reptiles and bulge out laterally between the cerebrum and cerebellum. How do the brains of birds reflect the role of various kinds of sensory stimuli in the their lives?

As in all amniotes (with certain aberrant exceptions), birds possess 12 pairs of cranial nerves.

MOLT, SEXING AND AGEING

Sexing and aging birds is fundamental to understanding their demography (birth and death rates). Because birds molt their feathers on a regular schedule, understanding molt patterns can provide clues to a bird's age. In this lab we will review some of the terminology associated with molting and plumages and summarize the methods for sexing and ageing birds in the hand.

Molt- a process of feather replacement over all or part of the bird's body. Molting is energetically expensive, increasing a birds basic metabolic rate by as much as 15%.

Molt patterns- Humphrey-Parks (1959), described molt sequence in birds with respect incoming plumage. This terminology is used by most ornithologists but you may encounter other terminology in the literature.

Plumage- all the feathers on the body. All or part of the plumage changes with each molt, and thus plumages are described in sequence from the first molt onward.

The sequence of plumages is as follows:
Natal down- downy covering of newly hatched young, lasts 1-2 weeks
Juvenal plumage- generally more cryptic than adult plumage, begins at 1-2 wks.
Basic plumage- acquired in late summer or early fall, also called winter plumage. May vary across ages (gulls) and with feather wear. Final adult plumage is called the definitive plumage.
Alternate plumage- acquired in spring, also called breeding plumage. May vary across ages.

Molts- also defined with respect to incoming plumage
Prejuvenal- from natal down to juvenal
Prebasic I- from juvenal to first basic
Prealternate I- from first basic to first alternate
Prebasic II- from first alternate to second basic
... etc.

Molt of flight feathers- the flight feather are generally replaced in a specific sequence. The most common patterns are given below.
Primaries- inner to outer
Secondaries- outer to inner
Rectricies- center to outer

Variation in molt patterns- not all birds have an alternate plumage. Birds with one annual molt are in basic plumage all year although the appearance may change due to feather wear (i.e. European Starlings and American Robins). Ducks replace all of their flight feathers

simultaneously at the end of the summer and therefore are flightless during this period. While they are replacing their flight feathers they molt into a cryptic **eclipse** body plumage. In most ducks, the males molt into alternate plumage in the late fall or early winter.

Timing of molt- There is great variation in the timing of molt. Some migrants complete their prebasic molt before migration (many passerines, most ducks), others after (many shorebirds). Because molting is energetically expensive it generally does not coincide with periods of environmental stress (winter) or other periods of high energy expenditure (breeding, or migration).

Age codes- based on calendar year. Used by USGS Biological Resources Division (until Congress decides to change the name again) bird banding laboratory.
Juv- Juvenile, a bird in juvenal plumage before the first prebasic molt.

HY- Hatch year, a bird in its first basic plumage in its first calendar year (ie. from the first basic molt until 31 December of the year it fledged.

SY- Second Year, a bird in its first basic or first alternate plumage in its second calendar year (ie. the year following fledging)

AHY- After hatch year, a bird in at least its second calendar year.

TY- Third year, a bird in its third calendar year, most applicable for species such as gulls that take several years to reach adult plumage

ASY- After second year, a bird in at least its third calendar year.

Ageing techniques

1. Plumage
2. Skull Ossification
3. Other morphological characters
    a. eye color
    b. bill/cere color
    c. tarsus color
    d. spurs
    e. Bursa of Fabricus
    f. size of penis
4. Behavior
    a. song
    b. begging behavior

c. sexual displays

Sexing techniques

1. Plumage
2. Color of soft parts
3. Other morphological characters
4. Behavior
    a. singing
    b. sexual displays
    c. copulatory position
    d. incubation
    e. territorial behavior
5. Brood patch
6. Clocal protuberance
7. Presence of penis
8. Laporatomy
9. Genetic techniques

FIELD NOTES FOR ORNITHOLOGY

One of the most important skills you can develop when doing field work is to keep accurate, complete field notes. If you do not make a permanent record of your field activities, much of the information you collected will be lost. Think of yourself as an active historian recording things as they are now to be used by some future naturalist. If you develop a satisfactory system of notes for yourself and take them consistently, your notes will become one of your most valuable sources of information. They will be the only authentic record of you field life. Remember, your memory is not a reliable data source at the level of detail needed for good natural history, ecological and biological field work. This means you should write down at least the bare essentials of significant observations at the time the events happen, not later. These preliminary rough field notes taken in the field should never be discarded not matter how dog-eared they become. In the rough field notes, put in as much detail as conditions of weather, time, etc. will allow. It is usually useful to summarize and enlarge on the rough field notes in a journal as soon as you can, usually in the evenings.

How much to write? If in doubt, write it down. You can always ignore items not appropriate to any particular summary, but you can never summarize or reconstruct something not there.

Begin each day's observation with a complete heading: This should include the following as a minimum.

Date: Use the military system, written thus: 14 May 1992. Always spell the month out; don't forget the year.

Place(s): List the specific locality (ies) visited, including distance and direction from the nearest map place name; include the county and state all spelled out, no abbreviations. Example: "Fickel Hill, 12 km southeast Arcata, Humboldt Co., California". If you change locations during the day, so indicate as many times as necessary.

Times: Use 24 hour clock system. Example: 0800 (for 8 a.m.) and 2000 (for 8 p.m.). Include numerous time checks in the notes; when you begin and end observations, when you change locations, when you make significant observations. Be sure to indicate if the times are in Standard or in Daylight Savings times.

Weather: Minimum needed: 1. Temperature(s) (2) Cloud cover and type (3) Precipitation (type, intensity, duration, current and previous 24 hours) (4) Wind direction and velocity (wind direction is the direction from which the wind is blowing) (5) Snow or ice cover is applicable.

Other information

- Plant phenology

- Short descriptions of habitats
- Names of companions
- Characteristics of terrain
- Description of days activities

The field notebook should be the largest you can get **and still be able to fit into a pocket of your field clothes.** Clipboards or large books are cumbersome and awkward to hold when you are trying to use binoculars, climb cliffs, etc. The notebook can be either loose leaf or not, but make sure it has good quality ruled paper so the notes can be kept neat and well organized. Date and number each page of the notes separately so you can reorganize them in case of accidental mixing.

The field notes should be written with a permanent marker. Ball point pens run if the paper gets wet. A number 2 pencil works well on most paper.

The body of the notes will contain your detailed observations concerning your particular studies, not necessarily limited to birds--it is often useful to include a list of all species observed during the day (usually compiled at the end of the day), including those you studied in detail as well as those seen casually. Species seen by other members of your party but not by yourself should be entered as "seen by so and so". Also make the distinction between those seen and those only heard.

A minimum entry for a species should include its name, the number seen and something about its habitat use. Additional minimal data would include notes on behavior and perhaps a description of the bird if it is unknown or in an interesting plumage.

Notes are the most valuable if written up into an organized form as soon as possible after the day's activities. There are many acceptable ways. One is to keep a journal, or naturalist's diary. Another is to have a larger notebook (one not taken into the field) in which separate pages are devoted to individual species and all data concerning that species are entered on the page. You are not required to keep a journal for this class, just take field notes.

Make descriptions of unknown birds as complete as possible. Include the names of other people that saw the bird. Also, make note of interesting or atypical behavior. I enclose examples taken from Stan Harris' notes from a typical field trip.

Wear warm clothes--be prepared for rain - it does occasionally rain here--bring field guides, a notebook and extra pencils. Some kind of hiking boots are essential. Binoculars are essential and there is not excuse for showing up for a trip without a pair. Practice with your binoculars in free time until you can point them at a bird and find it immediately every time you pull the binoculars to your eyes. If you don't own a pair, you may check them out from the Wildlife Stockroom.

Since our trips will all begin at 0700 (or earlier), you will have to check them out the late afternoon the day before the trip. They must be returned to the stockroom immediately after each trip as the next class needs them.
Be on time. We will leave exactly at the announced time. A satisfying bird trip is a trial at best with a group larger than about 8 or 10 and unless we have complete cooperation from everyone all of the time, you will not get much out of it. Don't rely on the instructor to show you every single bird; learn to find and identify birds on your own as soon as you can. If you get involved, you will be more satisfied. No private cars please, there are insurance problems and you may get lost if I happen to change my mind in mid-trip (as often happens).

Grading: Your field notes will be graded twice during the semester (25 pts each). Grades will be based on format, completeness of the information, accuracy, and readability.

FIELD PROJECT

Each student is required to complete a field project during the class. You must collect some of all of the data for your project during the semester you take the class. **Projects must be done specifically for this class, papers that have been written for another class cannot be used.** The topic for your project is up to you, I will provide ideas during lab and lecture. I encourage you to start reading (the sections on behavior and communication, behavioral and the environment, and reproduction and development in your text may be particularly helpful) and thinking about ideas as soon as class begins. It is also helpful to bounce ideas off your instructor, TA's, other students, and anyone else who cares to listen. The more thought you put into your project at the beginning, the better it will be.

Hypothesis

Selecting a well defined and specific hypothesis to address is critical to the success of the project. A hypothesis refers to a tentative question or prediction that is made in order to test its empirical consequences. Hypotheses can be stated as null or alternative. A null hypothesis is usually stated as a prediction of no difference while an alternative hypothesis predicts a difference in a particular direction. For example suppose you were interested in comparing the foraging success of young and adult Brown Pelicans in Humboldt Bay. Your null hypothesis would be: I predict there is no difference in foraging success between young and adult pelicans. An alternative hypothesis would be: I predict that foraging success is greater for adult than for young pelicans. The prediction for the alternative hypothesis is based on literature accounts, or logical extensions of behavioral or ecological principles.

Field work

There is no time requirement for the field work. I anticipate that most projects will require 10-30 hours of field time but some may require more. The effort and time will be determined by the question you choose to address. You may work with another student while collecting field data but all of the data you use in your project must be your own or it must be clearly stated which data you collected. You may not use data that was collected for a project in another class. Binoculars and spotting scopes may be checked out from the wildlife stockroom.

Write up

Each student must write their own paper. The papers should be written in the style of manuscripts for **The Condor**. Instruction on the preparation and submission of articles are given in The Condor 94:311-312 (February 1992) (this is on reserve in the library). You do not need to write a cover letter, nor do you need to submit multiple copies when you turn in your paper. Pay special attention the conventions regarding units (metic!), literature citations, and writing style.

Field project **20**

Proposal

Project proposals are due **12 February**. Proposals should include an introduction, methods, and literature cited. Proposals should be written in the style of The Condor with appropriate literature cited in the text and corresponding citations given at the end. The introduction should present background on the topic you chose and a **clearly stated hypothesis**. The methods section should describe your study area and the methods you intend to use. You may include a separate study area section if your description is sufficiently long to warrant it.

Free reading

Your lab instructor will give a "free reading" to any student who turns in their paper on or before **16 April**. Papers will be returned by **23 April** to give you time to revise your paper before you turn it in on **30 April**. I strongly recommend that you type your paper on a word processor.

Grading

Grades for the papers will be based on the following categories.

Proposal	10 (completeness, format)
Literature	15 (in-depth, up-to-date, format)
Hypothesis	10 (original, interesting, well defined, specific)
Endeavor	15 (amount of effort)
Analysis	10 (appropriate, sufficient, presented correctly)
Writing style	25 (active voice, grammar, spelling, etc.)
Format	15 (correct format for scientific journal)

PELAGIC BIRDING TRIP INFORMATION

Getting There: The ship, the Coral Sea, is docked at the Woodley Island Marina. The ship departs promptly at 6:00 a.m. (ugh!). Please be on time. We will not wait for late comers.

How to Dress: Warmly!! Bring as many layers as possible. It will be cold, damp, and very windy, and with little shelter. Even bring gloves and a hat (the railings can be cold to hold onto). A raincoat is also helpful in the event of rain and also for spray. Rain capes should be fastened with a belt so they won't flap in the breeze, blow you overboard, or worst of all, disturb other birdwatchers. Umbrellas would be absurd. Shoes should have good traction.

What to Bring: Lunch - we will be out a long time; without food you will just be cold, hungry, and miserable. A thermos of something hot is also a good idea. Crackers and carbonated beverages are excellent for settling upset stomachs. Binoculars (don't forget to check them out the Friday before) and a field guide (if you have a guide to marine mammals you may also want to bring that). Two lbs. of Popcorn (popped in oil, not raw), and any meat fat or grease. Both of these are used to feed and attract birds.

How not to get Seasick: Drugs - Scopolamine patches are very effective (put them on the night before). You can get them at the health center. Dramamine also helps but will make you very drowsy and therefore isn't recommended. Bonine is a more recent drug with fewer side effects. Take it a few hours before the trips (4 in the morning). Eat a big breakfast rich and starch and protein, low in fat. You are far more likely to get seasick on an empty stomach.

If you start to feel queasy, do NOT go inside. The disparity between what your eyes perceive (a stable room) and what your ears feel (a lot of motion) will definitely make you sick almost immediately. If you do get sick, please stay downwind of others (ie, the back of the boat).

Other Preparations: Study the section on shearwaters, albatrosses, gulls, jaegers, terns, alcids (murres, etc.) and cormorants in your field guide. You may get only fleeting glimpses as the birds flit between the waves so it helps to know what sort of field marks to look for. **Practice finding objects with your binoculars!** Both you and the birds will be constantly moving and there are no landmarks on the ocean to help you close in on the birds if you don't get them the first try.

Bird list for Ornithology- You must be able to identify each species from a slide or a specimen and you are responsible for knowing the order, family, and common name of each species on the list.

***Tinamiformes* -** Tinamous
Solitary Tinamou

***Rheiformes* -** Rheas
Greater Rhea

Struthioniformes - Ostriches
Common Ostrich

***Casuariiformes* -** Emus and Cassowaries
Great Cassowary

***Dinornithiformes* -** Kiwis
Brown Kiwi

Gaviiformes - Loons
Family **Gaviidae**
Pacific Loon (PALO)
Common Loon (COLO)

Podicipediformes - Grebes
Family **Podicipedidae**
Pied-billed Grebe (PBGR)
Horned Grebe (HOGR)
Eared Grebe (EAGR)
Western Grebe (WEGR)
Clark's Grebe (CLGR)

Procellariiformes - Tube-nosed Swimmers
Family **Diomedeidae**
Black-footed Albatross (BFAL)
Family **Procellariidae**
Northern Fulmar (NOFU)
Sooty Shearwater (SOSH)
Family **Hydrobatide**
Leach's Storm-Petrel (LHSP)
Ashy Storm-Petrel (ASSP)

***Sphenisciformes* -** Penguins
Chinstrap Penguin

Pelecaniformes - Totipalmate Swimmers
Family **Pelecanidae**
American White Pelican (AWPE)
Brown Pelican (BRPE)

Family **Phalacrocoracidae**
- Double-crested Cormorant (DCCO)
- Brandt's Cormorant (BRAC)
- Pelagic Cormorant (PECO)

Family **Anhingidae**
- Anhinga (ANHI)

Family **Fregatidae** - Frigatebirds
- Magnificent Frigatebird (MAFR)

Ciconiiformes - Deep-water Waders

Family **Ardeidae**
- American Bittern (AMBI)
- Great Blue Heron (GTBH)
- Great Egret (GREG)
- Snowy Egret (SNEG)
- Cattle Egret (CAEG)
- Green-backed Heron (GNBH)
- Black-crowned Night-Heron (BCNH)

Family **Threskiornithidae**
- White-faced Ibis (WFIB)

Family **Ciconiidae**
- White stork (WHST)

Phoenicopteriformes- Flamingos
- Greater Flamingo (GRFL)

Anseriformes - Swans, Geese, Ducks

Family **Anatidae** - Lamellate-billed Swimmers

Subfamily Anserinae - Swans, Geese

Tribe Cygnini
- Tundra Swan (TUSW)

Tribe Anserini
- Greater White-fronted Goose (GWFG)
- Snow Goose (GSGO)
- Brant (BLBR)
- Canada Goose (CAGO)

Subfamily Anatinae - Ducks

Tribe Cairinini
- Wood Duck (WODU)

Tribe Anatini
- Green-winged Teal (AGWT)
- Mallard (MALL)
- Northern Pintail (NOPI)
- Cinnamon Teal (CITE)
- Northern Shoveler (NOSH)
- Gadwall (GADW)
- American Wigeon (AMWI)

Tribe Aythyini
- Canvasback (CANV)
- Ring-necked Duck (RNDU)
- Greater Scaup (GRSC)
- Lesser Scaup (LESC)

Tribe Mergini
- Oldsquaw (OLDS)
- Surf Scoter (SUSC)
- White-winged Scoter (WWSC)
- Common Goldeneye (COGO)
- Bufflehead (BUFF)
- Hooded Merganser (HOME)
- Common Merganser (COME)
- Red-breasted Merganser (RBME)

Tribe Oxyurini
- Ruddy Duck (RUDU)

Falconiformes - New World Vultures & Diurnal Birds of Prey

Family **Cathartidae** (Some authorities put this family in the ***Ciconiiformes***)
- Turkey Vulture (TUVU)
- California Condor (CACO)

Family **Accipitridae**
- Osprey (OSPR)
- White-tailed Kite (BSKI) (Formerly the Black-shouldered Kite, now split into two species)
- Bald Eagle (BAEA)
- Northern Harrier (NOHA)
- Sharp-shinned Hawk (SSHA)
- Cooper's Hawk (COHA)
- Northern Goshawk (NOGO)
- Red-shouldered Hawk (RSHA)
- Red-tailed Hawk (RTHA)

Family **Falconidae**
- American Kestrel (AMKE)
- Merlin (MERL)
- Peregrine Falcon (PEFA)
- Prairie Falcon (PRFA)

Galliformes - Gallinaceous Birds

Family **Megapodidae**
- Brush Turkey

Family **Phasianidae**

Subfamily Phasianinae
- Ring-necked Pheasant (RNPH)

Subfamily Tetraoninae
- Blue Grouse (BLGR)
- Ruffed Grouse (RUGR)

Subfamily Meleagridinae
- Wild Turkey (WITU)

Family **Odontophoridae**
- California Quail (CAQU)
- Mountain Quail (MOQU)

Gruiformes - Marsh Birds

Family **Rallidae**
- Virginia Rail (VIRA)
- Sora (SORA)
- Common Moorhen (COMO)
- American Coot (AMCO)

Family **Gruidae**
- Sandhill Crane (SACR)

Charadriiformes - Gulls, Terns, Shorebirds, Alcids

Suborder Charardrii

Family **Charadriidae**
- Black-bellied Plover (BBPL)
- Snowy Plover (SNPL)
- Killdeer (KILL)

Family **Haematopodidae**
- Black Oystercatcher (BLOY)

Family **Recurvirostridae**
- Black-necked Stilt (BNST)
- American Avocet (AMAV)

Suborder Scolopaci

Family **Jacanidae** - Jacanas
- African Jacana

Family **Scolopacidae**
- Greater Yellowlegs (GRYE)
- Lesser Yellowlegs (LEYE)
- Willet (WILL)
- Wandering Tattler (WATA)
- Spotted Sandpiper (SPSA)
- Whimbrel (WHIM)
- Long-billed Curlew (LBCU)
- Marbled Godwit (MAGO)
- Ruddy Turnstone (RUTU)
- Black Turnstone (BLTU)
- Surfbird (SURF)
- Sanderling (SAND)
- Western Sandpiper (WESA)
- Least Sandpiper (LESA)
- Dunlin (DUNL)
- Short-billed Dowitcher (SBDO)
- Long-billed Dowitcher (LBDO)
- Common Snipe (COSN)
- Red Phalarope (REPH)

Suborder Lari
Family **Laridae**
Parasitic Jaeger (PAJA)
Bonaparte's Gull (BOGU)
Heermann's Gull (HEEG)
Mew Gull (MEGU)
Ring-billed Gull (RBGU)
California Gull (CAGU)
Western Gull (WEGU)
Glaucous-winged Gull (GWGU)
Caspian Tern (CATE)
Forster's Tern (FOTE)
Family **Alcidae**
Common Murre (COMU)
Pigeon Guillemot (PIGU)
Marbled Murrelet (MAMU)
Cassin's Auklet (CAAU)
Tufted Puffin (TUPU)

Pteroclidiformes - Sandgrouse (Some authorities put this order in the Columbiformes)
Lichtenstein's sandgrouse

Columbiformes - Doves, Pigeons
Family **Columbidae**
Rock Dove (RODO)
Band-tailed Pigeon (BTPI)
Mourning Dove (MODO)
Family **Raphidae**
Dodo

Psittaciformes - Parrots
Red-and-green Macaw

Coliiformes - Mousebirds
Blue-naped Mousebird

Musophagiformes - Turacos
White-bellied Go-away Bird

Cuculiformes - Roadrunners, Cuckoos
Family **Cuculidae**
Yellow-billed Cuckoo (YBCU)
Greater Roadrunner (GRRO)

Strigiformes - Nocturnal Birds of Prey
Family **Tytonidae**
Barn Owl (BAOW)

Family **Strigidae**
- Western Screech-Owl (WESO)
- Great Horned Owl (GHOW)
- Northern Pygmy-Owl (NOPO)
- Burrowing Owl (BUOW)
- Spotted Owl (SPOW)
- Short-eared Owl (SEOW)

Caprimulgiformes - Goatsuckers
Family **Caprimulgidae**
- Common Nighthawk (CONI)
- Common Poorwill (COPW)

Apodiformes - Hummingbirds, Swifts
Suborder Apodi
Family **Apodidae**
- Vaux's Swift (VASW)

Suborder Trochili
Family **Trochilidae**
- Anna's Hummingbird (ANHU)
- Allen's Hummingbird (ALHU)

Trogoniformes - Trogons and Quetzals
- Resplendent Quetzal

Coraciiformes - Kingfishers
Family **Alcedinidae**
- Belted Kingfisher (BEKI)

Piciformes - Woodpeckers
Family **Picidae**
- Acorn Woodpecker (ACWO)
- Red-breasted Sapsucker (RBSA)
- Downy Woodpecker (DOWO)
- Hairy Woodpecker (HAWO)
- Northern Flicker (RSFL/YSFL)
- Pileated Woodpecker (PIWO)

Passeriformes - Perching birds (The ordering of the families within the passerines has been changed by the AOU nomenclature committee, I have kept the traditional order, consistent with your field guides).
Family **Tyrannidae**
- Olive-sided Flycatcher (OSFL)
- Pacific-slope Flycatcher (WEFL) (Formerly the Western Flycatcher, now split into two species)
- Black Phoebe (BLPH)
- Western Kingbird (WEKI)

Family **Alaudidae**
- Horned Lark (HOLA)

Family **Hirundinidae**
- Purple Martin (PUMA)
- Tree Swallow (TRES)
- Violet-green Swallow (VGSW)
- Northern Rough-winged Swallow (RWSW)
- Bank Swallow (BANS)
- Cliff Swallow (CLSW)
- Barn Swallow (BARS)

Family **Corvidae**
- Gray Jay (GRAJ)
- Steller's Jay (STJA)
- Scrub Jay (SCJA)
- Black-billed Magpie (BBMA)
- Yellow-billed Magpie (YBMA)
- American Crow (AMCR)
- Common Raven (CORA)

Family **Paridae**
- Black-capped Chickadee (BCCH)
- Chestnut-backed Chickadee (CBCH)

Family **Aegithalidae**
- Bushtit (COBU)

Family **Sittidae**
- Red-breasted Nuthatch (RBNU)
- White-breasted Nuthatch (WBNU)

Family **Certhiidae**
- Brown Creeper (BRCR)

Family **Troglodytidae**
- Bewick's Wren (BEWR)
- House Wren (HOWR)
- Winter Wren (WIWR)
- Marsh Wren (MAWR)

Family **Cinclidae**
- American Dipper (AMDI)

Family **Sylviidae**
- Golden-crowned Kinglet (GCKI)
- Ruby-crowned Kinglet (RCKI)

Family **Turdidae**
- Western Bluebird (WEBL)
- Swainson's Thrush (SWTH)
- Hermit Thrush (HETH)
- American Robin (AMRO)
- Varied Thrush (VATH)

Family **Timaliidae**
- Wrentit (WREN)

Family **Mimidae**
- Northern Mockingbird (NOMO)

Family **Motacillidae**
- American Pipit (AMPI)

Family **Bombycillidae**
- Cedar Waxwing (CEDW)

Family **Laniidae**
- Loggerhead Shrike (LOSH)

Family **Sturnidae**
- European Starling (EUST)

Family **Vireonidae**
- Cassin's Vireo (SOVI) (formerly the Solitary Vireo, now split into three species)
- Hutton's Vireo (HUVI)
- Warbling Vireo (WAVI)

Family **Parulidae**
- Orange-crowned Warbler (OCWA)
- Yellow Warbler (YWAR)
- Yellow-rumped Warbler (AUWA/MYWA)
- Black-throated Gray Warbler (BTYW)
- Townsend's Warbler (TOWA)
- Hermit Warbler (HEWA)
- MacGillivray's Warbler (MGWA)
- Common Yellowthroat (COYE)
- Wilson's Warbler (WIWA)
- Yellow-breasted Chat (YBCH)

Family **Thraupidae**
- Western Tanager (WETA)

Family **Cardinalidae**
- Black-headed Grosbeak (BHGR)
- Lazuli Bunting (LAZB)

Family **Emberizidae**
- Spotted Towhee (SPTO) (Formerly the Rufous-sided Towhee, now split into two species)
- Savannah Sparrow (SAVS)
- Fox Sparrow (FOSP)
- Song Sparrow (SOSP)
- Golden-crowned Sparrow (GCSP)
- White-crowned Sparrow (WCSP)
- Dark-eyed Junco (ORJU)

Family **Icteridae**
- Red-winged Blackbird (RWBL)
- Tricolored Blackbird (TRBL)
- Western Meadowlark (WEME)
- Brewer's Blackbird (BRBL)
- Brown-headed Cowbird (BHCO)
- Northern Oriole (BUOR/BAOR)

Family **Fringillidae**

Subfamily Carduelinae
- Purple Finch (PUFI)
- House Finch (HOFI)
- Red Crossbill (RECR)
- Pine Siskin (PISI)
- Lesser Goldfinch (LEGO)
- American Goldfinch (AMGO)
- Evening Grosbeak (EVGR)

Family **Passeridae**
- House Sparrow (HOSP)