Ornithology 101
Part 1 – Taxonomy

By Robert G. Fisher

It is difficult to be a birder for long without wanting to know more about Ornithology. Our on-line text accessed by the links below provides the information we think beginning and intermediate birders need to start learning the science of studying birds. We call it "Ornithology 101" because it is just a beginning.

[1] I have drawn heavily on the following texts in preparing this course: Frank B. Gill, Ornithology, Second edition, W. H. Freeman & Co., 1994; J. Van Tyne & A. Berger, Fundamentals of Ornithology, John Wiley & Sons., 1961. Persons who want a more thorough grounding are encouraged to study the Gill text in conjunction with my written lectures.

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Taxonomy and Nomenclature

Experienced birders occasionally throw around Latin-sounding words like "Procellariforms" and "Icterids." Sometimes they do it to show off, but more often it is just a shorthand way of designating a grouping of birds. For example, rather than say, "We may see birds in the family of auks, murres, puffins, guillemots, dovekies, auklets and murrelets on our pelagic trip today," a knowledgeable birder could say, simply, "We may see alcids today." He means that some of the birds seen on the ocean trip may belong to the family, "Alcidae," which includes all of the auks, murres, puffins, guillemots, dovekies, auklets and murrelets. If you want to understand the talk of experienced birders, you need to have a basic knowledge of bird taxonomy, the science of classifying and naming birds.

The Binomial System

If you took high school General Science or Biology, you may remember that every animal and plant has a two-part Latin name according to the "binomial system." The Swedish naturalist, Linnaeus, founded it in the 18th century. Humans are *Homo sapiens*; wolves are *Canis lupis*; earthworms are *Lumbricus terrestris*, and so forth. The first, or genus name, denotes the general kind of plant or animal it is. The second, or species name, denotes what particular kind it is. The Linnaean System is still in use today.

Taxonomy has become quite elaborate since Linneaus devised his system. Some scientists now split some species into subspecies. Some speak of sub-genera and super species. For the purpose of the lists that most birders keep, only species count.

So who decides what is or is not a species? In North America, the American Ornithologists Union ("AOU.") does it. The American Birding Association ("ABA") generally goes along with whatever AOU decides.

A Work in Progress

Before we go any further, you need to know that DNA study is revealing that many relationships among animals are different than what scientists have supposed them to be. AOU has announced many changes in the last few years, and it keeps declaring more of them. Most of the field guides that birders use, including some published after the changes were announced, still follow some or all of the old rules. This is bound to cause confusion. Thus, you and some of the most experienced birders will be learning some of this information together.

The Hierarchy of Classification

Scientists are not satisfied just to give all living creatures two Latin names. They want to describe relationships more generally. So they have created a hierarchy of classifications, descending from the most general to the most particular. To see how this works, let us use *Charidrius vociferus*, Killdeer, as an example. A Killdeer is simultaneously in all of the following classifications:

Kingdom Animalia	It is an animal, not a plant.
Phylum Chordata	It belongs to those animals which have a notochord, or spinal cord. It is not a sponge (Porifera), jellyfish (Cnidaria), flatworm (Platyhelminthes), round worm (Nematoda), segmented worm (Annelida), insect, spider, lobster, etc. (Arthropoda), snail, clam, octopus, etc. (Mollusca) or starfish or sea urchin (Echinodermata).
Class Aves	It is a bird, not a fish, amphibian, reptile or mammal.
Order Charidriiformes	It is in the same group as the gulls, terns, shore birds and auks.
Family Charidriidae	It is grouped with the plovers.
Genus Charidrius	It is grouped with the “ringed” plovers -,e.g., Snowy, Piping, Semi- palmated, Wilson’s and Common Ringed Plover.
Species vociferus	It is a Killdeer.

<u>Orders</u>

The next most general grouping after Class is Order. So what do you need to know about the twenty-eight living orders of birds? Unless you plan to go to Antarctica or to some other cold, southern ocean place, it may be a waste of time to learn that penguins are in the order, *Sphenisciformes.* Likewise, you can probably forego knowing that the mouse birds of Madagascar are in the order, *Coliiformes*. It may be interesting to learn that some orders contain only a single living species (e.g., *Struthioniformes* includes only the Ostrich). But you don't need to know that. What you do need to have is a general idea of the twenty-five different orders of birds depicted in most North American field guides, including the five new orders (see italics) recently described by AOU. They are:

Anseriformes	Ducks, geese, swans
Galliformes	Grouse, quail, turkeys, pheasants, Chukar, guinea fowls, partridges.
Gaviiformes	Loons
Podicepiformes	Grebes
Phoenicopteriformes	American Flamingo
Procelariiformes	Shearwaters, petrels, albatrosses, Fulmar, storm-petrels,
Pelicaniformes	Pelicans, herons, bitterns, ibis, spoonbills.
Phaethonitiformes	Tropic birds
Ciconiiformes	Storks.
Suliformes	Boobies, Northern Gannet
Accipitriformes	Hawks, eagles, condors, vultures, caracaras, osprey, kites, harriers
Falconiiformes	Forest falcons, caracaras, falcons
Eurypygiformes	Sun Bittern
Gruiformes	Rails, cranes, Limpkin, coots, gallinules, moorhens, crakes. Sun Grebe, wood-rails.
Charidriiformes	Gulls, terns, auks, sandpipers, plovers, jacanas, avocets, skuas, Jaegers, thick-knees, lapwings, pratincoles.
Columbiiformes	Pigeons and doves
Psittaciformes	Parrots, budgerigars, parakeets.
Cuculiformes	Cuckoos, anis, Greater Roadrunner
Strigiformes	Owls
Caprimulgiformes	Nighthawks, Whip-poor-wills, Chuck-wills-widow, poorwills, Pauraques.
Apodiformes	Swifts and hummingbirds
Troganiformes	Trogans
Coraciiformes	Kingfishers
Piciformes	Woodpeckers
Passeriformes	Perching birds.

Do you really need to learn those long Latin names? Probably not. But note that while you were going down the list of orders, you learned a few things. For example, you learned that loons and grebes, which both spend a lot of time swimming, diving and eating fish, are not related closely enough to be placed in the same order. You learned that coots and moorhens are related to rails and cranes. You knew already that ducks and geese must be related, but you may not have known that hawks and owls are unrelated or that swifts and hummingbirds are related. If you take the trouble to learn the orders, you will learn who are distant cousins and who are not.

How scientists decide upon the relationships denoted by the different orders is something you probably do not need to know to be a good birder. But learning the orders may make you curious to know it. The more curious you get, the more you will explore the science of Ornithology.

You may have noticed that your field guide is organized according to the orders of birds recognized by AOU when the guide was published. In the older guides, the loons come first, next the grebes, then the albatrosses, petrels and shearwaters, etc. Even with the new additions, only eighteen orders are regularly represented in Missouri. (A nineteenth, *Procellariformes*, is represented by a single specimen of a Band-rumped Storm Petrel found dead here. The now-extinct Carolina Parakeet once represented a twentieth, *Psittacaformes*). If your birding has been limited to this part of the country, your curiosity may be sparked to look up the ocean-going albatrosses, shearwaters and petrels in your field guide and to find out what parrots and trogons are found north of the Rio Grande River. (Carolina Parakeets and Red-fronted Parrots are extirpated, but Red-crowned Parrots and Green Parakeets have moved in from Mexico, and Monk Parakeets have escaped and established themselves. The Magnificent Trogon, and occasionally the Eared Trogon, breed in Arizona). The more you let your curiosity lead you on, the more you will learn.

You may have noticed that the names of orders all end in "formes." You do need to know that, because you will occasionally hear more experienced birders refer to a bird as a "Procellariform" (e.g., a Northern Fulmar) or a "Caprimulgiform" (e.g., a Common Poor-will). More often, you will hear an anglicized version. Thus, you will frequently hear Passeriforms referred to as "Passerines." Galliforms will be called "gallinacious birds". Caprimuligiforms will be called "nightjars" or "goat suckers." If you want to speak the language of birding fluently, or at least to understand it when others speak it, you have to learn this stuff.

Families

Birders sometimes say that kites belong to the "hawk family" or road runners to the "cuckoo family." Strictly speaking, it is not correct to use the term "family" to denote an order, but advanced birders do it all the time. You need to be aware that the distinction between orders and families sometimes gets blurred in ordinary usage.

Families are more particular groupings of species than orders. But they are still quite general. You could say that members of orders are one millionth cousins; members of families are one thousandth cousins, and members of genera are one hundredth cousins. (Actually, the relationships are probably much more distant). Going back to our Killdeer example, placing the species in the order, *Charidriiformes*, says it is about as closely related to a Pomaraine Jaeger as a Least Sandpiper is to a Tufted Puffin. Placing it in the family, *Charidriidae*, indicates it is about as closely related to a Black-bellied Plover as a Snowy Plover is to an American Golden-plover.

Family names end in "idae." The Sibley Guide to Birds (Alfred A. Knopf, 2000) lists approximately 70 families of birds in North America. Other guides include more or less families, depending upon how many strays from Eurasia and elsewhere that they cover. In some cases, there is only one family in an order. For example, all of the five living species of loons belong simultaneously to the order, *Gaviiformes*, and to the family, *Gaviidae*. (There may, or may not be extinct fossil species and/or families in the order). A large order, like Passeriformes, includes many families.

Do you really need to learn the names of 70 different families? No. Many hot shot birders probably do not know half of them. Once again, however, if you want to speak birding language fluently, you need to know the names of some of them. And you need to have a general idea which species belong to which families, even if you do not know the family names.
Your field guide mentions each family it includes, often with a brief description of its characteristics. However, many birders bypass such text and go right to the pictures and descriptions of individual species. If you want to know the families, you can find them in your field guide.

Advanced birders sometimes use Latin family names. At other times, they use common family names. I don't believe I have ever heard a birder mention the *Podicipedidae* (grebe family) as such. Not only is it too much of a tongue twister. All of the birds in the order of grebes are also in the grebe family. It is a lot easier just to say "grebe family."

Advanced birders use Latin family names most often when it is the easiest way to describe the grouping. They usually use the suffix, "id," rather than the Latin "idae." Ravens, crows, jays, nutcrackers, magpies, Rooks, Jackdaws and choughs are all in the family, *Corvidae*. It is easier to call them "corvids" than to list the different varieties in the family. Sometimes you will hear an advanced birder refer to "the crow family" or "the crow and jay family." But it is shorter, and more accurate, to refer to them as corvids.

Birders occasionally use one or more of the following Latin family names:

Anatids	Ducks, geese and swans
Gruids	Cranes
Rallids	Rails, Sora, crakes
Charadrids	Plovers
Scolopacids	Sandpipers
Larids	Gulls, etc.
Alcids	Auks, etc.
Columbids	Pigeons and doves
Cuculids	Cuckoos, etc.

Psittacids	Parrots and parakeets
Strigids	Owls (except Barn Owl)
Caprimulgids	Nighthawks, Whip-poor-wills, etc.
Trochilids	Hummingbirds
Tyrannids	Flycatchers
Corvids	Crows, jays, etc.
Parids	Chickadees, titmice
Sylvids	Old World warblers, gnatcatchers
Turdids	Thrushes (including Am. Robins, bluebirds, wheatears, etc.)
Sturnids	Starlings and mynas
Mimids	Thrashers, catbirds and mockingbirds
Parulids	New World warblers (i.e. "Wood Warblers")
Emberizids	New World sparrows, towhees, juncos, buntings, longspurs
Icterids	Blackbirds, grackles, cowbirds, orioles, meadowlarks
Fringillids	Finches
Passerids	Old World sparrows (i.e. House Sparrow, Eurasian Tree Sparrow)

Very occasionally, you will run into a birder who refers to swallows as Hirundinids or larks as Alaudids, or who uses some other Latin family name not listed above. He is just showing off.

If you will review the above list of family names, you may note that the birder who uses a term like "Caprimulgids," "Columbids," "Psitticids," "Cuculids," or "Strigids," is really choosing the family name as a shorter way of designating the order. Birders also often choose common names as the easiest way to designate families. "Wrens" are a lot easier to say than "Troglodytids." "Vireos" are easier to say than "Vireonids." It seems silly to call "nuthatches" and "kinglets," "Sittids" and "Regulids" when it is just as easy to call them "nuthatches" and "kinglets." It is much more important to know family relationships than to learn their Latin names.

Genera

Genera are more particular groupings than families. As with the names of orders and families, experienced birders use the Latin names for some genera more often than others. Some genera are of great importance even to beginning birders. For example, every birder learns early on that *Buteos* are hawks with broad rounded wings and short, rounded tails; *Accipters* have short, rounded wings and long tails, and falcons (i.e., hawk-like birds in the genus, *Falco)*, have pointed wings and long tails.

Birders use Latin genus names most often when it is the easiest or most precise way to designate a grouping. Thus, birders often refer to the grassland sparrows collectively as *Ammodramus* sparrows. Chipping, Clay-colored, Tree and Black-chinned Sparrows are *Spizellas.* Aimophila denotes the group that includes Rufous-crowned, Rufous-winged, Cassin's, Botteri's, Five-striped and Bachman's Sparrows. One hardly ever hears discussion of *Amphispizas* (Sage, Black-throated Sparrows), *Melospizas* (Song, Lincolns, Swamp) or *Zonotrichias* (White-crowned, Harris, Golden-crowned, White-throated) as such, but it is nice to know the species in those genera are generic cousins.

After sparrows, birders probably use some of the generic names for wood warblers (i.e, Parulids) most often. It is a good thing to know that plain-breasted warblers, like Orange-crowned, Tennessee, Blue-winged, Golden-winged and Nashville, are in *Vermivora;* the streaked warblers are in *Dendroica*; some of the thicker-billed types, like Kentucky, Mourning and Connecticut Warblers, are in *Oporornis*, etc.

Birders also use Latin generic names when they cannot identify an individual bird to species. Common examples are *Accipiter*, used when someone cannot tell whether a fly-by hawk is a Cooper's or Sharp-shinned, *Selasphorus*, when it is unclear whether a hummingbird is an Allen's or a Rufous, and *Empidonax*, used when the flycatcher is small, has an eye ring and two wing bars and does not call or sing.

Should a beginning or intermediate birder try to memorize the names of genera? It would be a waste of time. However, the birder who notes the Latin names for species when looking them up in the field guide will begin to develop a sense of their relationships and eventually remember some of the Latin names and find them useful.

What is a Species?

Implicit in the classification system is the idea that it describes evolutionary relationships. Closely related birds have more recent common ancestors than distantly related birds. Ancestral species "evolved" to become new species better adapted to survive in particular environments. Approximately 10,000 species of birds live in the world today. Many others are now extinct.

The idea that species are end results of evolution is complicated by the fact organisms are continually evolving, and scientists are continually learning more about them. Unless you are a Creationist, who believes that God made just so many species, and each one (including 500,000 species of beetles) is descended from a pair sheltered in Noah's Ark, the concept of a "species" is somewhat plastic. Scientists are apt to disagree on how to classify species. Organizations like AOU may resolve their disputes for birders by making changes from time to time. But they remain open to making new changes as more is learned.

Deciding speciation issues is a major challenge for scientists. Birds of the same species adapt to different climatic and other conditions in different places. Sometimes the adaptations change appearances strikingly. Eastern Fox Sparrows are reddish. Some northwestern Fox Sparrows are a chocolate brown color. Scientists call recognizably different regional variations of a species, "subspecies." They use trinomials to separate them. Right now, the AOU calls the reddish eastern Fox Sparrows *Passerella iliaca iliaca* and the sooty colored northwestern forms *Passerella iliaca fuliginosa*. The day may soon come when AOU "splits"some of these subspecies – i.e., recognizes them as separate full species.

The bases for defining species have changed a lot over the years. The Linnaean System lets the first person to describe a species give it its two Latin names. Initially, many North American bird species were described by amateur ornithologists. Two of the most famous early North American ornithologists, Alexander Wilson and John James Audubon, sold paintings of birds. The Rev. John Bachman, for whom Audubon named Bachman's Warbler, was a minister. Quite a few Great Plains species were described by medical doctors attached to military expeditions.

Some amateur ornithologists were pretty good scientists, who knew bird anatomy well and drew careful pictures of the species they described. But the primary bases for their decisions were anatomical and plumage (i.e. "morphological") characteristics. This led to some horrendous mistakes. For example, male and female Williamson's Sapsuckers, which look very different, were classified as separate species for a while. My favorite separate species is the "Red-legged Black Duck," which showed up on Long Island only in January. Eventually, someone recognized that Red-legged Black Ducks were just American Black Ducks that had been swimming in very cold water!

The 1947 edition of Roger Tory Peterson's, A Field Guide to the Birds (Houghton Mifflin Co.), the preeminent field guide of its time, describes eleven species of birds that have since been downgraded to color morph, hybrid or sub-specific status. They are: Blue Goose (color morph of Snow Goose), European Teal (lumped with Green-winged Teal), Harlan's Hawk (subspecies of Red-tailed Hawk), Great White Heron (color morph of Great Blue Heron), Red-shafted Flicker (lumped with Yellow-shafted Flicker as "Northern Flicker"), Sutton's Warbler (believed to be a hybrid between Northern Parula and Yellow-throated Warblers), Bronzed Grackle (color morph of Purple Grackle, renamed "Common Grackle"), Ipswich Sparrow (sub-species of Savannah Sparrow), Dusky Seaside Sparrow (now extinct subspecies of Seaside Sparrow), Cape Sable Seaside Sparrow (subspecies of Seaside Sparrow) and Oregon Junco (lumped with Slate-colored Junco and several other juncos to become "Dark-eyed Junco). Had Peterson's guide covered western as well as eastern species, it would probably have included other "species," since lumped, like Black Brant, Mexican Duck, Brown-throated Wren, Black-eared Bushtit and Audubon's Warbler.

Clines

By the early 1970's, when the "species" described in the preceding paragraph were lumped, morphology no longer drove species definition as it once had. By then, scientists knew that some birds that appeared very different, like Blue and Snow Geese, could actually be siblings from the same nest. They had also studied "clines" – gradual variations of a species from one climate or habitat to another. The individuals at one end of a cline were not necessarily separate species from those at the other end, although they differed in appearance.

The concept of clines has produced some interesting "rules" describing how birds (and other organisms) vary with environmental conditions. Brief statements of some of these "rules" follow:

Bergmann's Rule: Warm-blooded species increase body size as the mean temperature of the climate gets colder. Subspecies of Bald Eagle, Red-tailed Hawk, American Kestrel, Bobwhite, Great-horned Owl, Screech Owl, Hairy Woodpecker, Red-winged Blackbird and Song Sparrow follow this rule. Sandhill Crane and Phainopepla are exceptions.

Kelso's Rule: "The ears of northern owls are relatively larger than those of southern owls."

Gloger's Rule: Intensity of melanin (black) pigmentation tends to decrease with mean temperature; the amount of black pigment increases with more humidity; yellowish and reddish-brown pigmentation go with high temperature and aridity. Northern Gulls are whiter. Fox Sparrows from the humid northwest are darker. Red morph Eastern Screech Owls predominate in hotter, southern climates; Gray morph Eastern Screech Owls predominate in cooler, northern climates, etc.

Differentiating Species from Subspecies

If adaptations change structural and appearance characteristics gradually along clines, as the various "rules" suggest they do, scientists need some basis other than physical appearance to decide how to differentiate a species from a subspecies. How they actually decide where to draw the line is somewhat murky. The subject is complicated by the fact that they do not all do it the same way.

Perhaps, the best we can do is to try to discern a general trend. Since the big rash of lumps in the early seventies, AOU has made many more splits than lumps. The history of these splits indicates a trend toward splitting..

The Alder Flycatcher split, which occurred soon after the lumping rampage, may have established the trend. Previously, AOU recognized two subspecies of "Alder Flycatcher." Although they were nearly indistinguishable even in the hand, they occupied different habitats and sang different songs. Careful study demonstrated that they rarely, if ever, interbred. Yet portions of their ranges overlapped – i.e. they were "sympatric.". Using absence of hybridization in areas of sympatry as its main criterion, AOU split them into "Alder Flycatcher" (*Empidonax alnorum*) and "Willow Flycatcher" (*Empidonax traillii*).

How often two populations hybridize when given the opportunity is remains a major criterion for deciding whether they are separate species, but DNA study is fast also becoming important.

Learning from the Willow Flycatcher experience, scientists are now focusing their study more on populations of a species that sing differently, occupy different habitats or behave differently than on groupings that just look different. Song, habitat and behavior differences tip scientists off to the need to study how often they interbreed. If they interbreed only occasionally, they split them. If they miscegenate too often, they lump them. But if DNA study indicates a closer or more distant relationship, they may think twice before making any change.

Relatively recent splits have included the following, to mention only a few: Northern Oriole again became Baltimore and Bullock's Orioles. Sharp-tailed Sparrow became Nelson's Sharp-tailed and Salt-marsh Sharp-tailed Sparrows. Western Flycatcher became Cordilleran and Pacific-slope Flycatchers. Boat-tailed Grackle became Boat-tailed and Great-tailed Grackles. Most recently, Winter Wren has been split into Winter Wren and Pacific Wren.

If the test of a species is whether or not two populations hybridize where their ranges overlap, how do you decide when their ranges do not overlap any where? (The scientific term for not overlapping is, "allopatric"). Until DNA science came along, there was no easy answer. Recently, however, some of the most prominent splits have been of allopatric populations. Examples are Florida Scrub-Jay, Western Scrub-Jay and Island Scrub-Jay, which formerly were a single species called, "Scrub Jay." Presumably DNA testing helped to demonstrate that those newly-named species are genetically different enough so that they probably would not hybridize if given the opportunity.

Unfortunately, DNA science is relatively new. Standards have not yet been established to differentiate species by DNA testing alone. There is still a lot for scientists to study. Speciation issues will undoubtedly keep them busy researching, writing papers and arguing for some time to come.

Ornithology 101
Part II – Characteristics

by Robert G. Fisher

It is difficult to be a birder for long without wanting to know more about Ornithology. The text below is an attempt to provide on-line the information we think beginning and intermediate birders need to start learning the science of studying birds [1]. We call it "Ornithology 101" because it is just a beginning.

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What is a Bird?

Anyone who has ever carved a chicken or turkey already knows quite a bit about bird anatomy. All birds have wings where other animals have front legs or arms. The wings of birds are like human arms in that they have a single humerus bone, which connects the shoulder to an elbow. As in the human forearm, a radius and an ulna extend forward from the elbow to the wrist joint. But birds do not have paws or hands. Instead, they have somewhat elongated wrist bones, and the bones of the hand are fused together. Together, these wrist and hand bones form the stiff, triangular-shaped tip of a wing. Modern birds also have a have a large, keeled sternum or breastbone to which very large pectoral muscles (the "white meat" on a chicken or turkey) are attached to power the downstroke of the wing beat. Winged, with powerful flight muscles, birds are feathered flying machines.

Nearly everything about a bird, including Ostriches and penguins that have lost the ability to fly, is designed to facilitate flight. The larger bones are hollow or spongy to make them lighter them for flight. Bird ribs overlap and are joined top and bottom to make a light fuselage strong enough to withstand the stresses of flying. Horizontal, backward-curved projections, called "uncinate processes," further strengthen birds' rib cages. Birds have a unique bony structure, the "furcula", or wishbone, which prevents lateral compression of the chest during the downstroke of the wings and anchors the pectoral flight muscles. All modern birds have bills instead of jaw bones with teeth, evidently because heavier maxillary bones associated with teeth would burden flight.

The most unique features of a bird are its feathers. These light, but complex structures not only enable birds to fly. They also keep them warm. Like mammals, but unlike fish and modern reptiles, all birds are warm-blooded.

Having wings instead of arms or forelegs, all birds are necessarily bipedal. The walking/running part of a bird leg has two main bends in it, whereas the human leg has only one knee, plus a flexible ankle. Like the human leg, a bird has a femur, which runs from fused pelvic bones through the upper leg, or thigh (the "second joint" of a chicken or turkey) to a joint corresponding to the human knee. Below that, a tibia runs through the next portion of the leg (the "drumstick") to an ankle joint. But in birds, one ankle bone, or "tarsus," is greatly elongated to form the lower, usually bare part of the leg. The juncture of the tarsus and tibia acts like a second knee, which articulates in the opposite direction from the human knee. Then the lower end of the tarsus joins the bones of the feet at another joint roughly corresponding to the human ankle.

Some birds, like penguins and auks, have adapted their wings so well to "fly" under water that they might be called feathered, under water flying machines. Others, like Ostriches, Rheas and Emus, have developed their legs so well that they have become feathered running machines. However specialized, feathers have made birds masters of air, sea and land in an enormous variety of ecological niches throughout most of the world.

The Origin of Birds

Birds share certain anatomical characteristics with reptiles and are generally recognized to have evolved from them. Both birds and reptiles lay yolked eggs that develop similarly. Both have nuclei in their red blood cells, whereas the red blood corpuscles of mammals lack a nucleus. The scales on the legs of birds are similar to the body scales of reptiles.

Whether or not birds evolved from cold-blooded reptiles or possibly warm-blooded dinosaurs is debatable. One hypothesis has birds evolving in the middle Triassic (i.e. about 240 million years ago) from a group of reptiles called thecodonts. Evidently, one fossil species of thecodont had elongated scales that suggest the evolution of bird feathers. Paleontologists who favor the thecodont hypothesis place the ancestors of birds close to the ancestors of modern crocodiles.

Another hypothesis holds that birds descended from late Jurassic theropod dinosaurs, a group that included not only the famous *Tyrannosaurus rex*, but also smaller, bipedal dinosaurs. The theropods lived at the same time as the famous *Archaeopteryx*, and one of them, *Compsognathus*, shared 23 of 42 specialized skeletal features with it. The theropod dinosaurs or may not have been warm blooded.

Archaeopteryx lithographica is the Latin name for a crow-sized reptile that lived 150 million years ago in what is now Bavaria. Five fossil specimens of it exist. Unlike modern birds, it had a blunt snout and many, well-developed reptilian teeth. It also had a long, lizard-like tail with 18 to 21 separate vertebrae. Its hand bones were not fused, as they are in the wings of modern birds. Its sternum (which is not apparent in the fossil specimens and was probably cartilaginous) was not keeled. Its ribs lacked the horizontal reinforcements (uncinate processes) of most modern birds. But it did have a well-developed wishbone, and it was covered with feathers that are indistinguishable from the feathers of modern birds.

Archaeopteryx is the closest thing to a “missing link” between birds and reptiles that exists in the fossil record. It undoubtedly used its feathers to glide, and perhaps to fly, but it is doubtful that it could fly well. It is impossible to say whether it is a direct ancestor of modern birds.

Archaeopteryx is the only fossil of a feathered creature from the Jurassic period. Additional fossils of toothed, feathered bird-like creatures have been found in Cretaceous deposits. Thirteen different species of loon-like creatures that swam the shallow seas that covered central North America have been placed in the genus, *Hesperornis.* Six more species of tern-like creatures have been labeled, *Ichthyornis*. Less well known are single species of *Gobipteryx*, found in Mongolia, *Alexornis*, found in Baja California and *Enantiornis*, found in Argentina. All of these proto-birds disappeared in or before the mass extinction, which exterminated the last dinosaurs at the end of the Cretaceous period.

The modern orders of birds, including loons, ducks, gulls, auks, cranes and petrels, began to diverge in the Paleocene epoch, about 55 to 60 million years ago. Primitive woodpeckers evolved during the Eocene, which began 53-54 million years ago. Relatives of kingfishers appeared in the early Oligocene (from 37-38 million). Perhaps the most important diversification paralleled the rapid evolution of flowering plants and insects during the Miocene between 26 and 10 million years ago. Evolution is, of course, still going on. But for the intervention of man, remnant Pleistocene (1.5 to 3.5 million) species, like California Condor and Whooping Crane, would have gone the way of the Wooly Mammoth. Subspecies of many common birds may be on the way to becoming full species.

Feathers

Of all the features that distinguish birds from Reptiles and Mammals, none is more important than the development of feathers. Believed to be modified reptilian scales, but actually quite different from them genetically, feathers provide the insulation for birds to be warm-blooded. The ability to maintain a constant temperature opens up all sorts of ecological niches for birds to occupy. Feathers also enable flight, provide colors that are useful for communication and camouflage, facilitate flotation for swimming birds and perform many other functions.

Feathers are composed mainly of keratin, an inert, long-lasting biological material that mammals and reptiles also use to make hair, claws, fingernails and scales. The typical feather consists of a long, central shaft called a "rachis," whose hollow base (the "calamus" or quill) is anchored in a follicle under the skin. On either side of the shaft is a vane, composed of lateral branches off the rachis, called "barbs." Each barb has rows of smaller "barbules," which may be linked together by tiny hooks called "barbicels." Anyone who has ever handled the flight feathers of a bird has noticed how the barbicels can become unhooked when the feather is treated roughly and re-hooked again by smoothing it out.

There are, of course, many kinds of feathers. The longest, broadest, flattest feathers project from the wings and tail to enable flight. The shortest, fluffiest feathers, called "down," are among the most efficient insulating materials known. Other feathers, intermediate between flight feathers and down, provide the remainder of the bird's "clothing."

The number of feathers a bird has varies greatly from one species to another. A Tundra Swan has about 25,000 feathers. Songbirds usually have between 2,000 and 4,000 feathers, about a third of which are on the head and neck. A Ruby-throated Hummingbird may have as few as 940 feathers.

Parts of Birds to Know

Like any other subject, learning about Ornithology involves learning its terminology. A good Ornithology text book, like J. Van Tyne and A. Berger, *Fundamentals of Ornithology* (John Wiley & Sons, Inc., New York, 1961) or F.B. Gill, *Ornithology* (W. H. Freeman & Co., New York, 1995), from which I have drawn much of the information presented here, contains enough new words to intimidate most beginning students. So what does the beginning birder really need to know to be able to understand the discourse of more advanced birders in the field? Is it important to know that the supracoracoideus muscles power the up stroke of a bird's wingbeat, or that melanin pigment in bird's feathers is synthesized from tryosine, an amino acid, by mobile pigment cells called melanoblasts? I have birded with some of the hottest hot shot birders in the country, and I have never heard any of them discuss supracoracoidus muscles or melanoblasts. But there is terminology about bird structure and plumage that one hears frequently. Beginning and intermediate birders need to start to learn it.

When we talk about names that describe parts of a bird, we are dealing with "Bird Topography." Most of the important terminology of bird topography can be found, with illustrations, near the beginning of just about any good field guide. David Sibley devotes pages 15 to 21 and 18 illustrations to bird topography in *The Sibley Guide to Birds* (Alfred A. Knopf, New York, (2000). The National Geographic's *Field Guide to the Birds of North America* (Nat. Go. Society, 4th ed., Washington, D.C., 2002) covers it in two pages with two illustrations. It may be helpful to refer to such illustrations while reading this.

Generally, the terminology of bird topography is expressed in both technical and common language. For example, "auriculars" is the technical term for "ear patch." Experienced birders use both terms interchangeably.

Bare Parts

In general, birders describe only the parts of a bird's body that they can see. Persons who have eaten birds know that they compensate for their lack of chewing teeth by crushing and/or grinding their food in "gizzards" – i.e., heavily muscled stomachs. But I have never heard a birder refer to a bird's gizzard in the field. However, every birder should know where the tarsus is, because it can be a field mark. Thus, Rough-legged Hawks are known to have feathers on the tarsus; most other buteos do not; Arctic Terns have a shorter tarsus than Common Terns, etc. Similarly, birders need to know that the iris (eye) of a California, Mew or Thayer's Gull is dark, whereas it is pale in an adult-plumaged Ring-billed or Herring Gull. Likewise, someone who thinks he might have a Kelp Gull needs to know that the bare skin around the eye, called the "orbital ring," is red in Kelp Gulls, whereas it is bright yellow in a Yellow-footed Gull, red in a Great Black-backed Gull, pinkish-red in a Slaty-backed Gull, orange-yellow in a Western Gull, and red in a Lesser Black-backed Gull.

Apart from the tarsus and the eye, the most important “bare” (i.e., unfeathered) part of a bird is its bill. Birders need to know that the upper edge of a bird’s bill, seen in profile, is the “culmen;” the lower mandible is called the “gonys;” the end of the bill is called the “nail” and the area where the base of the bill joins the feathered face is the “gape.” A birder who knows those terms can understand how Common Loons are distinguished from Yellow-billed Loons by their “dark culmens,” why it is significant that the “gonydeal angle” of a Long-tailed Jaeger is about midbill and inconspicuous, whereas it is near the tip of the bill on a Parasitic Jaeger, and how to distinguish Greater from Lesser Scaup on the water by the Greater’s larger nail. Likewise, they can understand that adult Neotropic Cormorants often have white or pale feathers in the vicinity of the gape.

Two other words denoting bare parts that a birder might want to know are “gular” and “semi-palmated.” Cormorants are in the same order as pelicans. They have much smaller pouches beneath their bills than pelicans do, called “gular’ pouches. The size and color of these can be important in field identification. “Semi-palmated” refers to the webbing between the toes of a bird. Western and Semi-palmated Sandpipers have half webs between their toes. Thus, they are “semi-palmated.” Although hard to see, these half webs can be a field mark useful to separate Western and Semi-palmated Sandpipers from other stints.

Plumage Parts

The parts of a bird that produce the most “field marks” that birders use in field identification are plumage parts. It will be easier to learn these from the illustrations in the Bird Topography section of a field guide, so I will not try to teach all of them here. Nevertheless, it is especially important to understand how a bird’s wing and tail feathers are lain on, so I will spend some time describing that.

Imagine a plucked chicken while it is being prepared for roasting. Its entire body is covered with small “goose bumps,” the remains of follicles from which feathers once protruded. Now consider specifically the bird’s wing. Its trailing edge is rough with the remains of large holes that once held the quills of flight feathers, technically called “remiges.” The triangular portion of the wing farthest away from the body – i.e the hand portion – once held the primary remiges - long, stiff, flat flight feathers. A chicken has 10 primaries. Most birds have between 9 and 11 of them, although Ostriches have sixteen. Fifteen secondary remiges, also long, stiff, flat flight feathers, then protruded along the chicken’s ulna from the joint with the hand to the joint with the humerus. Some birds have more or less secondaries than a chicken does.

Now imagine the chicken with just the remiges attached to the wing. Other feathers are needed to cover the rest of the wing, including the spaces between the quills where they enter follicles. These feathers are called “coverts” because they overlap and cover the flight feathers. Before plucking, “primary coverts” covered the bases of the primaries. A series of coverts, the “greater coverts,”“ median coverts” and “lesser coverts,” covered the rest of the upper part of the chicken’s wing, including the forewing. “Underwing coverts” covered the under part of the wing.

The flight feathers of the chicken’s tail, called “retrices,” were similarly covered by “upper tail coverts” and “under tail coverts.” The remainder of the bird was covered by a variety of the smaller head, neck and body feathers birders describe as the scapulars, axillaries, mantle, nape, rump, breast, sides, belly, flanks, auriculars, supercilium, lores, malar, throat, etc. of a bird. The names of these plumage parts are illustrated in the Bird Topography section of the field guide, and every birder should take time to become familiar with them.

Molt

Once you have learned the plumage parts of a bird, you are ready to deal with the succession of plumage that occurs from immaturity to adulthood and from season to season. All birds pass through a series of molts from the first plumage, worn at hatching or acquired soon after hatching, to fully-adult plumage. Even when full adulthood is reached, all healthy birds replace every feather at least once a year. Some species molt two or even three times a year. Ptarmigan, which rely heavily on plumage camouflage, may even have four molts in one year.

Most species of birds have only a single annual molt. Where there is a second molt, it is sometimes complete (e.g. in Sharp-tailed Sparrows) but more often only partial. Molts are, of course, carefully synchronized with the reproductive cycle and with the seasons of the year.

There is much variation in the amount of time it takes different species to attain fully adult plumage. Horned Larks acquire it about three months after hatching – i.e. immediately after the post juvenile molt. Rose-breasted Grosbeaks acquire it by the first postnuptial molt – i.e., about 14 months after hatching. Herring Gulls go through a succession of summer and winter plumage, culminating in a fourth nuptial plumage about three years, seven months after hatching. Bald Eagles take at least five and sometimes as many as ten years to acquire the completely white head and tail. The male Twelve-wired Bird-of-Paradise takes at least seven years to acquire its fully adult plumage.

Molt is usually an orderly process. A complete molt usually begins with the loss of the innermost primaries on both sides. Then the other primaries fall out as their predecessors are being replaced. The process is gradual enough so that there is only a small gap between the remaining feathers, and the bird can still fly. When the molt of the primaries is completed, the secondaries follow, usually starting with the outermost and progressing inward. Meanwhile, body feathers are also being shed and replaced in an orderly manner.

A few birds drop all of their remiges together, making them flightless until they are replaced. Male Common Eiders do this, swimming away from shore in groups where land predators cannot reach them until they are able to fly again.

The adult plumage of birds that molt twice a year, which is true of most passerines, often comes in a brighter nuptial plumage and a less conspicuous fall or winter plumage. The duller fall or winter plumage is called "basic plumage" because the bird often wears it for the greater part of the year. The breeding plumage is called "alternate plumage." "Basic" and "alternate" are words you will hear often, so you need to remember them.

Ducks molt after breeding into an "eclipse" plumage, in which the plumage of the drake resembles that of the hen. Most ducks form pair bonds on their wintering grounds, so they lose the eclipse plumage in fall and regain the brighter nuptial plumage in which to begin courtship during the winter.

Some birds, including longspurs and House Sparrows, change their plumage appearance without actually molting. Instead, the dull outer portion of their feathering wears off as spring approaches, revealing more colorful, inner feathering appropriate for courtship.

When an advanced birder reports a bird as an "immature female" or a "second winter male," you can be sure that he or she has made some study of the molt sequences the particular species goes through. Molting at different ages and at different times of year are birds' way of making sure that the sport of birding never becomes too easy.

Ornithology 101
Part III – Behavior

by Robert G. Fisher

It is difficult to be a birder for long without wanting to know more about Ornithology. The text below is an attempt to provide on-line the information we think beginning and intermediate birders need to start learning the science of studying birds [1]. We call it "Ornithology 101" because it is just a beginning.

[1] I have drawn heavily on the following texts in preparing this course: Frank B. Gill, Ornithology, Second edition, W. H. Freeman & Co., 1994; J. Van Tyne & A. Berger, Fundamentals of Ornithology, John Wiley & Sons., 1961. Persons who want a more thorough grounding are encouraged to study the Gill text in conjunction with my written lectures.

III

Behavior

Birders usually watch birds doing something. Bird behavior includes feeding, roosting, courting, nesting, proclaiming a territory, fighting, evading attack, flocking, migrating and many other activities. In order to understand what he is seeing, the birder needs a basic knowledge of what birds do and how and why they do it.

Feeding

Birders probably spend more time watching birds feeding than performing any other activity. A dowitcher probing mud, a Peregrine stooping at a flock of shore birds, a hummingbird at a flower, a loon diving on a lake, a warbler moving from branch to branch in a tree, a Turkey Vulture cruising over a field and an Eastern Towhee scratching in the leaves are all going about the business of finding food. Many birds spend most of their waking hours searching for food. As warm-blooded animals with high rates of metabolism, birds expend energy very rapidly. They feed to fuel that energy.

Some birds need to find food at truly amazing rates just to survive. It has been estimated that the Eurasian Goldcrest, a tiny bird, which closely resembles North America's Golden-crowned Kinglet, needs to find an insect larvae every two seconds throughout the day to avoid starvation in winter. Hummingbirds have similar needs for constant food replenishment.

Other birds go for weeks without eating at all in the harshest imaginable conditions. The Emperor Penguin lays her egg on an ice shelf miles from the ocean in the middle of the Antarctic winter. The male then balances it on his feet while she goes for food. He survives on a thick layer of fat accumulated before the fast, incubating the egg with a special brood patch of unfeathered skin on his belly. Weeks later, the female returns and regurgitates food she has gathered in the ocean for the now-hatched chick. The male still does not eat. Instead, he walks many miles to the ocean. There he fills up on krill and quickly restores his fat reserves.

Some birds, including shrikes, Acorn Woodpeckers, nutcrackers and tits (chickadees and titmice) store food. Shrikes impale their victims on thorns and barbed wire. Acorn Woodpeckers cram acorns into holes in dead trees. Nutcrackers and tits cache seeds.

Different species of birds are, of course, adapted to different feeding strategies in different ways. Beginning birders soon learn that the size and shape of a bird's bill is a primary identification feature. In addition to being an important field mark, it tells something about what kind of food the bird eats and how it gathers it. Bills are utilitarian feeding tools. The Woodcock's long bill enables it to probe the forest floor deeply for earth worms hiding in the soil. The Rose-breasted Grosbeak's heavy conical bill is perfect for crushing seeds and berries.

Unrelated species often have the same sort of bill to perform the same feeding function. Loons, grebes, herons, terns and kingfishers, each in a different order, all have similar spear point-shaped bills to spear fish. Mergansers and cormorants have serrated bills adapted to grasp wriggling fish and steer them down the gullet. Hawks and owls have hooked bills for tearing flesh. Northern Shovelers and American Flamingos have bills with grooves in them adapted for filter feeding.

Some birds have such specialized feeding habits that their bills are adapted to perform only one, unusual feeding function. This is true of a sickle-billed South American hummingbird whose bill is especially adapted to fit one kind of deep-cupped flower upon whose nectar it feeds regularly. Some Hawaiian honey creepers and African sun birds have similarly specialized bills.

Other bills perform multiple feeding functions. Most birders know that warblers have thin, sharply-pointed bills for capturing insects, while sparrows have heavier conical bills for eating seeds. Actually, many sparrows also subsist mainly upon insects during the nesting season, and their conical bills work just fine for collecting them. Later on, they use the same bills to eat seeds.

The bills of birds look rigid, but the upper half can usually be flexed to some extent at what is called the "nasofrontal hinge." They can be remarkably sensitive to both feel and taste. Bird's tongues are also adapted to perform a wide variety of feeding functions. Some, like the long tongues of woodpeckers, are adapted to probe cavities in wood or into the ground for insects. Many birds' tongues have rough processes on them to pick up specialized kinds of food and guide it down the gullet.

Not all feeding is done with bills. Raptors transport food to their nests with their talons. African sandgrouse soak up water in their breast feathers at water holes, fly to their chicks and allow them to drink from their breasts.

Alimentary System

No bird has teeth. Most birds swallow their food whole, although the crushing of seeds and berries by species with large, finch-like bills could be considered a rough form of mastication. In order to process food that has not been chewed, birds have specialized digestive systems. Most have a two-chambered stomach. One chamber, called the "proventriculus," is used for chemical digestion. The other, known as the "gizzard," grinds food mechanically.

Many birds have an additional chamber, called the "crop," in which food is collected and stored before being digested. Birds may use their crops to carry food to their young and regurgitate it. Or they may use them to take the food to a location where it can be further swallowed and digested. Some crops are both collecting and digesting organs.

Crops, proventriculi and gizzards vary greatly in size and shape, depending upon the kind of food a bird eats and how it is digested. The Lammergeier, or Bearded Vulture, of Africa and Asia, actually digests bones, so it relies heavily upon chemical digestion involving the secretion of powerful enzymes. Birds that eat grain and other seeds, like chickens and turkeys, need large gizzards with powerful muscles to pulverize their food mechanically. The digestive tracts of nectar-feeding species are arranged so that the nectar bypasses the stomach entirely and goes right into the small intestine.

As in mammals, digested food is assimilated into the blood stream through the walls of the intestines as it passes through them. In birds, the residue is defecated through the cloaca, an all-purpose orifice, through which pass eggs and urine as well as feces.

Sensory Systems

In order to find food and to perform other behaviors, birds have remarkable sensory systems. Many can hear sounds both higher and lower in pitch than the human ear can perceive. Some owls can track prey in total darkness by hearing alone. The cave-dwelling oilbirds of South America can navigate by echolocation. Some birds can see parts of the spectrum that are invisible to humans. Birds also have sensitivity to the Earth's magnetism and to minute shifts in gravity and barometric pressure that humans lack.

Birds are highly visual. They have relatively large eyes. The eyes of eagles and owls are as large as human eyes, and their visual acuity is legendary. They can resolve images 2.5 to 3 times the distance humans can. I once saw a Bald Eagle leave its perch on a dead snag, fly in a straight line about two hundred yards to a point in the middle of a lake, grasp a fish the size of a Bluegill from the surface and return with it to its perch.

Birds' eyes are usually set on the side of the head. This gives them greater peripheral vision than humans, but it reduces depth perception and requires that they examine close objects one eye at a time. Binocular vision is atypical. Some birds have it to a limited extent, however.

Birds' ears are inconspicuously placed on the side of the head, usually hidden by feathers. Nevertheless, their hearing is often remarkably acute. Barn Owls' ears are placed asymmetrically so that they can more easily judge the distance from which a sound is coming. Barn Owls are one of several species that can hunt in total darkness by hearing alone.

Most birds have relatively small olfactory lobes, which has led some ornithologists to conclude that their senses of taste and smell are relatively undeveloped. Many birds evidently do not need much of a sense of taste or smell. However, other species rely extensively upon these senses. Turkey Vultures locate their food by smell. New Zealand Kiwis have exquisitely sensitive taste organs at the ends of their bills to aid them to locate food. Experiments have shown that most passerines have at least a rudimentary sense of smell.

Contrary to popular belief, birds have large brains relative to their body mass – 6 to 11 times larger than like-sized reptiles. Despite the reputation for stupidity that the term "bird brain" connotes, birds are comparatively intelligent. Some birds, especially crows and magpies, out perform mammals in laboratory learning experiments. Ravens and parakeets can learn to count to seven and can learn to identify a box of food by counting the number of objects in front of it. They easily excel over monkeys in counting experiments.

One of the most advance forms of learning – insight learning by observation and imitation – is regularly done by birds. Soon after the first English titmouse learned to pry the top off of a bottle of milk, other titmice soon learned to imitate, and the habit spread widely. Gulls learn to break clams open by dropping them on hard surfaces, particularly roads and parking lots. Lammergeiers break open bones by dropping them on rocks. An Egyptian Vulture can break pierce a large, hard-shelled egg by striking it repeatedly with a rock. The Galapagos Woodpecker Finch uses a thorn as a tool to pry grubs out of a crack. All of these behaviors are learned by observation and imitation.

Some birds have exceptional spatial memory. An individual titmouse may cache as many as 50,000 seeds and recover them as long as 28 days later. Clark's Nutcrackers hide an average of two pine seeds in each of 1400 to 2000 caches and recall their locations for as long as 8 or 9 months. The homing abilities of pigeons and Manx Shearwaters are legendary.

Communication

Virtually everything that a birder sees or hears about a bird relates to communication in one form or other. Many of the plumage and bare part characteristics of a bird appear as they do for the purpose of visual communication. Most bird sounds are made to communicate.

Birds need to communicate to one another and to other species of birds and animals for a variety of purposes. These include warning, informing, recognizing, attracting and hiding. Birds warn rivals to stay out of their territories and predators to stay away. They inform one another of danger, where food is and the locations of young or parents or other members of the flock. They communicate to recognize each other individually and to differentiate between their own kind and another species. They attract one another to mate, and they distract predators away from their young. Sometimes they use camouflage to communicate that they are absent when in fact they are present.

Birds are extremely visual animals, so a great deal of their communication is visual. A bird may display puffed out feathers to warn a predator not to attack. It may adopt a submissive posture to inform a mate that he or she is ready to mate or to trade responsibility for incubating the eggs. It may perform a ritualized greeting ceremony to recognize a mate. It may even build a bower of sticks decorated with blue and/or shiny objects to attract a sexual partner. These are merely a few of a nearly infinite number of different ways that birds display to communicate visually.

Although intelligent in their abilities to learn and remember, birds are also enormously instinctive, so much of their display is designed to cue automatic instinctive responses.. Innately performed, and innately understood, stereotyped displays avoid confusion.

Birds constantly compete with one another – for food, for mates and for territories. Much of their ritualized display appears to have evolved to enable them to compete without actual fighting. Bluff, taken seriously, minimizes the danger of crippling injury. Ritualized displays and responses are the avian counterpart of using diplomacy to achieve a political objective without going to war.

One example of ritualized competition is the famous “pecking order” of birds. Dominant individuals feed first. Subordinate individuals feed later in turn. A dominant individual adopts an aggressive display posture. The subordinate individual signals submission and gives way. If there is enough food, everyone gets some, and nobody gets hurt fighting over it.

Of course, as with people, not every individual bird always plays by the rules, and there are bird societies in which actual fighting, and serious injury, sometimes occur. Birds also steal from one another. Nevertheless, from an evolutionary standpoint, any activity that risks crippling injury also threatens gene survival. Behavior that minimizes that risk is usually selectively advantageous. That is why birds use it so often.

An interesting example of ritualized display is the aggressive posture by which male Red-winged Blackbirds maintain territories. Experiments have shown that the red epaulettes which give the bird its name are essential for the display posture to be taken seriously. Males whose red epaulettes are painted out lose their ability to maintain a territory. Defense of the territory is the key to mating success for male Red-winged Blackbirds because females of that species choose their mates, not for their personal qualities, but rather for the quality of the territory they defend. A male who can provide high quality real estate can attract a harem of up to 15 females. A male whose digs are on the wrong side of the tracks may have to batch it all summer.

Another important purpose of visual communication is species recognition. Closely related species need to tell one another apart to avoid hybridization, which usually involves a selective disadvantage, if not sterility. Birds do not always use the field marks in the bird guide to differentiate their own kind. For example, birders differentiate Iceland Gulls from Herring Gulls by their primary feathers. Iceland Gulls have white wing tips. Herring Gulls have black wing tips. A researcher at a colony in Baffin island where both species were present proved that the gulls themselves use other visual cues to tell one another apart. When he painted the primary feathers of Herring Gulls white or those of Iceland Gulls black, the birds still had no difficulty telling one another apart. Instead of looking a wing tips, the gulls told one another apart by the narrow ring of bare flesh around the eye, called the “orbital ring.” Herring Gulls have orange-yellow orbital rings. Iceland Gulls have purplish orbital rings. Herring and Iceland Gulls recognize their own species by looking each other in the eye.

Birds also communicate acoustically. Birds have the greatest sound-producing capabilities of all vertebrates. Their principal organ for vocalization is called the "syrinx," a specialized voice box that can create loud sounds of great complexity. Birds use vocal communication for nearly all of the purposes for which they use visual displays. Sometimes they communicate both vocally and visually at the same time.

Birds are known especially for their ability to sing. People often assume that they are singing to attract a mate, but much passerine bird song is actually used to define a territory. The bird, usually a male, travels the boundaries of his territory and sings, thus notifying rivals of their location and warning them to stay away.

Acoustic communication is not limited to song. Birds also use a wide variety of calls and chips to communicate. Woodpeckers communicate by drumming on hollow logs. Male Ruffed Grouse make a drumming sound with their wings. American Woodcocks make a chirping sound with their wings during an areal display. Wilson's Snipe make a different winnowing sound with their wings in flight. The "booming" sound made by the air sacs of Greater Prairie Chickens on the lek, which sounds to me like blowing across the open neck of a glass bottle, is hardly "song." But it is an important form of acoustical communication.

In addition to defending territories, birds use acoustic displays for courtship, alarm, flock cohesion, and individual and species recognition. Sprague's Pipits, Horned Larks and Cassin's Sparrows, all grassland birds, court by singing in flight. Great Horned Owls court by hooting duets back and forth. The scolds of jays warn of the presence of a predator. Flocks of song birds call to one another as the migrate at night. In some large seabird colonies, parents locate their chicks among tens of thousands of individuals by recognizing their distinctive voices. Most species vocalize to facilitate the attraction of mates, to maintain the pair bond and for social cohesion.

Reproduction

A species has two responsibilities to avoid extinction – survival and reproduction. When some individuals of a generation survive, reproduce and raise their offspring to reproductive maturity, the species lasts, at least for another generation. In evolutionary terms, reproduction is as important a task as survival itself.

Birds reproduce sexually. Females usually have only a single ovary, which produces eggs. Males have two testes, which produce sperm. In most bird species, males do no have a penis. Instead, sperm is transferred from the male to the female's body by a "cloacal kiss" in which the male ejaculates into the female's body when the opened cloacae of both birds come briefly into contact. Although it may take longer to position the two cloacae, the actually copulatory act often lasts only a second or two. Swifts copulate in midair.

There are, of course, differences in copulatory behavior from one species to another. Arctic Warblers copulate for as long as twenty-five minutes, during which the male inseminates the female repeatedly just prior to and after egg laying. Other species, of which Smith's Longspur is an extreme example, copulate repeatedly. Female Smith's Longspurs are the nymphomaniacs of avian society. They solicit copulations from multiple males and experience an average of 365 copulations before egg laying. A few species of birds, including chickens, turkeys and waterfowl, have penis-like intromitting organs. The waterfowl penis probably evolved to transmit sperm under water.

After being fertilized in the ovary, the egg passes through an oviduct to the cloaca. On the way, albumen ("egg white"), shell membranes and pigmentation are added in succession. The final stage of egg production is the formation of a hard shell. When all layers, membranes and the shell have been added, the egg is ready for laying. Most birds lay eggs every day, or every other day. A few species, usually those which lay very large eggs, take as long as seven or eight days between layings.

Clutch size varies greatly from species to species. Some species lay only a single egg each breeding season. Others, like the Eurasian Blue Tit, may have as many as 19 eggs in a clutch, and the species may breed more than once in a single year.

Scientists recognize two basic reproductive strategies in animals of all kinds, including birds. The so-called “r strategy” is to produce large numbers of young, only a small percentage of which are expected to survive. So-called “k strategy” animals reproduce at a much slower rate, but once adulthood is achieved, tend to live for many years. They depend upon a long life and a relatively high survival rate for the species’ continuance.

Chickadees are “r strategy” birds. It has been estimated that 75% of all Black-capped Chickadees hatched die in their first year of life. Thereafter, 70% die each year. At that rate, of 100 individuals hatched, only 2.25 will survive three years.

California Condors are “k strategy” birds. A California Condor that reaches adulthood can expect to live 25 years or more unless some unnatural event, like collision with a power line or eating a poisoned carcass, does it in sooner. Unfortunately, a small increase in mortality may tip the balance against a “k strategy” species and head it toward extinction. One reason that remnant Pleistocene species like Whooping Crane and California Condor have had such a difficult time is that they are “k strategy” birds whose morality rates have been altered, first by major climatic change, then by additional perils created by human beings.

There are, of course, intermediate strategies between “r” and ‘k.” Many species have two, three or four eggs in a clutch. Some, like Sandhill Cranes and many raptors, have two young each year but expect only one to survive.

Clutch size can also be influenced from year to year by the abundance of food, or by other factors affecting the amount of energy reserve in the adult’s body from which eggs are formed. Snowy Owls have larger clutches in years when lemmings are abundant than they do when the lemming population crashes. Snowy Owls invade from the north for two reasons after a lemming crash. There is a food shortage because lemmings are in short supply. There is also a surplus of owls left over from the period of lemming abundance. Thanks to the feast and famine cycle in the Arctic, we have the privilege of seeing Snowy Owls way below their normal range every four years or so. Unfortunately for the owls, however, many of the invading owls, and some of those who stayed behind, starve. Thus are the Snowy Owl and lemming populations kept in a rough sort of balance from year to year.

Birds’ eggs come in many sizes, shapes and colors. Although the eggs of the smallest birds are tiny, they are usually larger in relation to the size of the parent than those of larger species. An exception is the Brown Kiwi of New Zealand. It lays two, sometimes three, eggs that are 25% of the females own mass, four weeks apart.

Petrels, turacos, owls and kingfishers have nearly spherical eggs. Murres and other cliff nesting species have severely pointed eggs because that shape limits the likelihood that an egg will roll off the cliff. Grebes, pelicans and bitterns have ellipsoidal eggs. Spherical eggs maximize shell strength and the conservation of heat. Pointed eggs fit together in the nest and reduce the area that a brooding parent needs to cover with his or her body.

Generally, birds that lay eggs in burrows or otherwise keep them out of sight lay pure white eggs. Eggs in open nests are camouflaged with different colors, streaks and speckles. Parasitic Eurasian Cuckoos lay eggs that mimic those of their hosts. Individual cuckoos that parasitizing a particular host species mimic the eggs of that species; individuals that parasitize a different host mimic its eggs, and so forth. Individuals cannot vary the color of their eggs, so it must be inferred different portions of the cuckoo population have evolved to parasitize different host species.

Mating

Birds use a the following mating systems to reproduce:

Monogamy: There is a prolonged and exclusive pair bond with a single member of the opposite sex. Birds are among the most monogamous of all animals. Ninety per cent of all bird species are at least seasonally monogamous – i.e. they form a single pair bond for the duration of a breeding season. A much smaller percentage mate for life. Lifetime mates include parrots, albatrosses, eagles, geese and pigeons. As in humans, some of those who start out to mate for life fail to go the distance. Some pairs last. Others separate. Ornithologists view monogamy as the most practical mating system. A pair can raise more young and give those they do raise more parental attention than single parents can. Attendant males also defend territorial space, which insures adequate food supplies for female and young. Sometimes they also assist in nest building, feeding and/or incubation.

Polygamy: Pair bonds are formed with multiple mates of the opposite sex. Only three per cent of bird species practice polygamy.

Polygyny: Polygamy where the male pairs with two or more females. About two per cent of bird species are polygynous.

Polyandry: Polygamy where a female pairs with several males. Each male may tend a clutch of eggs. If a female lays full clutches for successive males, the polyandry is said to be "sequential." If she has two or more mates at once, it is called "simultaneous." Less than one per cent of birds are polyandrous.

Polygynandry: Avian "swinging." A female pairs with several males, each of whom also pairs with several females. Only a few species engage in this rare form of polygamy. These include flightless ratities (Ostrich, rheas, Emu), tinamous, Smith's Longspurs and Hedge Accentors. Male ostriches and tinamous incubate mixed clutches of eggs from several females, which deposit eggs at different times with different males.

Promiscuity: Distinguished from polygamy by the brevity of its duration, this mating system characterizes about six per cent of all bird species. Lekking species in which males display to attract females and mate indiscriminately with any female who selects them are promiscuous. Hummingbirds, manakins, grouse and some shore birds are promiscuous.

It is interesting to note that Arctic breeding sandpipers in the Family Scolopacidae use most of the diverse mating systems. Some are monogamous, others polygamous or promiscuous. Phalaropes are famous for being polyandrous. Not only do the males incubate the eggs, the females defend territories and are brighter colored. Spotted Sandpipers are also polyandrous. Woodcocks and Ruffs are promiscuous.

Ruffs are an especially interesting sandpiper species. Male Ruffs have varicolored neck feathers. Males with darker ruffs tend to congregate in the center of the lek and are preferred by the females. Males with lighter ruffs display in less advantageous positions on the periphery and steal sexual encounters with females entering and leaving the lek. One might ask why any males with the disadvantageous lighter ruffs would persist in the gene pool. Apparently, they perform a function in attracting females to the lek. Although females disfavor light ruffed males, they favor leks that have light ruffed males on their periphery. The light-ruffed males apparently steal enough quickies from the females to pass their genes along together with those of the preferred dark-ruffed males.

Another interesting phenomenon is the so-called "exploded lek," in which males display out of sight of one another, but usually within earshot. Pectoral Sandpipers are an exploded lek species.

Birds also engage in the avian analogues of rape and adultery. Forced copulation is especially common among waterfowl. Philandering is even more common. Studies of Purple Martin colonies show that older, more experienced males in a Purple Martin "apartment house"get a much higher percentage of the action, and sire proportionately more of the young, than younger males.

Ducks and other waterfowl have somewhat unusual breeding systems. They form monogamous pairs in winter and cheat in summer. Hen ducks generally return to the places where they were hatched and raised. A hen's ability to build up fat reserves for migrating and nesting is made more efficient by pairing with a drake, who will protect her on the wintering grounds. Therefore, she selects a mate and initiates pairing during the winter. A drake cannot follow two females back to different home areas. Nor can he control a high-quality territory in the nesting area. Therefore, he needs to pair with a hen who selects him and to follow her to her breeding ground. Once there, however, his chances of passing on his genes are enhanced if he also engages in extra-pair copulations and/or fertilizes one or more re-nesting females. So he cheats.

Nesting and Parental Care

All birds must incubate their eggs or provide for their incubation. Most bird species also care for their young after they are hatched. Incubation is usually done in some sort of nest. Nests vary from no structure to elaborate woven dwellings and gigantic structures.

The least elaborate nesting arrangement is that of the Emperor Penguin, which balances the single egg on top of the feet, incubating it from Antarctic winter temperatures by a brood patch of bare skin with which it is in constant contact. The nests of gulls and terns are often hardly more than shallow depressions in sand or gravel.

The most elaborate nesting arrangements may be those of the megapodes, or mound-building Malleefowl, of Australasia. They build mounds to use heat from the sun, volcanic steam or decomposing vegetation to incubate their eggs. Some of their mounds are as much as 36 feet in diameter and 16 feet high.

Nesting strategies vary greatly depending upon the primary needs of the eggs and young. Ornithologists generally classify young birds as either "precocial" or "altricial." Precocial young birds are born with their eyes open, covered with down and able to run around and feed themselves almost immediately after hatching. Altricial young hatch naked; their eyes are closed for a period after hatching, and they are totally dependant upon their parents to feed them and protect them from the elements. Ducks and chickens have precocial young. Robins and many other song birds have altricial young. Parents of precocial youngsters need a nest structure that will facilitate incubation until hatching. Parents of altricial youngster usually need a structure that will also enable them to protect and care for their youngsters until substantial further development has occurred.

Of course, nests also vary with the materials at hand. Adelie Penguins build nests of pebbles, essentially the only nest building material available on the barren Antarctic hillsides where they place their colonies. Cavity nesters need cavities in which to nest. Burrowing nesters, like various alcids, petrels and shearwaters, need soil that is loose enough to dig a burrow. Mud nesters need mud; stick nesters need sticks, and so forth. Some swifts use saliva to construct nests. Others birds use excrement. Some grebes use buoyant reeds to build floating nests. Many birds construct nests of sticks or leaves or other vegetation. Some use spider webs. Some birds, like Great Horned Owls and Eastern Bluebirds, do not construct nests. Instead they use nests previously constructed by other species. Great Horned Owls frequently take over old Red-tailed Hawk nests. Bluebirds use cavity nests excavated by woodpeckers.

Protection of the eggs and young from getting too cold or too hot are among the primary goals of nesting. These objectives are achieved in a variety of ways. Ducks insulate their nests with down that they pluck from their breasts. Killdeer, and many other species that nest in shallow depressions in open situations, shelter their eggs, and to some extent their precocial young, from adverse weather with their bodies.

Perhaps the most important factor in most nesting strategies is protection of the eggs and young from potential predators. A variety of nesting techniques achieve that objective. One of the most common means to protect young from predators is to place the nest out of reach. Fulmars, Black-legged Kittiwakes and murres place their eggs and young out of reach by nesting on inaccessible cliffs. Albatrosses and pelagic terns avoid four footed predators by using remote islands in the sea. Placing a nest in a tree puts it out of reach of many predators.

Snow and Canada Geese migrate to the Arctic to nest where only those few predators that can survive an Arctic winter can reach them. The Canada Geese that poop on golf courses probably would not nest successfully in latitudes populated by racoons and skunks but for the human practice of placing wash tubs in the middle of farm ponds where those predators cannot reach them. Species that nest in burrows place their eggs and young out of reach and/or out of sight of marauding birds.

Predation can also be avoided by camouflaging the nest or by placing it where specific plants or animals discourage predators from approaching it. Cactus Wrens nest amid thorns of Cholla cacti that most mammals cannot negotiate. Some birds nest in close proximity to ants or wasps to discourage predators from coming too close. Yellow-rumped Caciques, a tropical blackbird indigenous to Amazonia Peru, use three defenses against predators simultaneously. First, they nest on islands and near wasp nests. The wasps protect them from monkeys and other arboreal mammals. Caimans and otters protect them from snakes that might swim to the islands on which their colonies are located. Second, living in colonies enables them to mob predators as a group. Finally, they construct elaborate hanging nests and do not use all of them. Mixing active nests with abandoned nests camouflages the active nests.

Nesting colonially is a a common strategy for dealing with predation. Some seabird colonies number in the millions. Although some predators may attack the colony, the sheer numbers of birds in them overwhelms the few of predators who are able to reach them. Those few predators may have a field day, but the losses they inflict on the colony are a tiny percentage of the total number of birds there.

There are drawbacks to large colonies, however. They may increase the spread of diseases and parasites. They may attract flying predators. They sometimes exhaust food supplies. The last is especially true of some seabird colonies in El Nino years.

Birds also have widely varying strategies for caring for their young. Many birds, including most passerines, do not incubate their eggs fully until the entire clutch has been laid. As a result, the earlier eggs do not start to develop until the clutch is complete. This sort of incubation, which is called “synchronous,” assures that all of the young will fledge at the same time. Other species are “asynchronous.” Their young develop at different rate. The young in a Barn Owl family will often be of different sizes. The largest will be the hatchling of the first egg laid, the next largest of the next and so forth. When food is abundant, the entire family of Barn Owls will eventually fledge. When it is limited, as it often is, the strongest chicks will survive, and later hatched chicks will perish before they consume too much of the limited food.

The amount of parental care varies greatly from species to species. Birds that have altricial young are often monogamous because the young need to be fed and protected by both parents as they develop. Parents of precocial young may or not feed them. Terns bring fish to their precocial young. Young gallinaceous birds like grouse and pheasants soon find insects for themselves. In either case, however, parents of precocial young lead them to food and away from danger and protect them from predators. Examples of parental leadership are the little ducklings or chicks that follow a hen duck or Wild Turkey around. They form a bond with the parent known as “imprinting.” Young geese can be imprinted to a human biologist instead of a parent goose. Example of protection from predators are the terns that “dive bomb” visitors to a tern colony and the “broken wing act” or distraction display used by an adult Killdeer to lead a potential predator away from the young.

Not all birds care for their young until they can fly. Atlantic Puffins feed their young oily fish in the burrows in which the nest until they are very fat. Then they desert them. After living on their fat reserves for a while, the young emerge from their burrows and put to sea on their own.

One group of birds that do not care for their young are parasitic species. There are two kinds of parasitic bird species, “intraspecific brood parasites” and “obligate brood parasites.” Intraspecific parasites lay eggs in nests of their own kind to be raised by the host parents. European Starlings commonly lay eggs in Starling nests other than their own. When parasitism is “intraspecific” the family unit consists of both natural and adopted children of the same species, and adults of the parasitic species raises the young. When it is "obligate," host parents raise the young of other species, and adults of the parasitic species do not provide parental care to any young.

Cowbirds and Old World cuckoos are the most familiar obligate brood parasites. By letting host parents raise their young they are able to lay more eggs. By not putting all of their eggs into one nest, they improve the chances that some offspring will avoid predation.

Some species of birds are not parasitic, but they do utilize other birds to help with the parenting. This is called "cooperative breeding." Florida Scrub Jays are an example. The basic social unit consists of a breeding pair with up to six helpers. The pair defends a territory. The helpers, which may be offspring from a previous year, assist in feeding and protecting nestlings. Harris Hawks are another example. Although unpaired family members do not feed young, they assist in group hunting. African Bee-eaters also help out. It has been estimated that about 200 species of birds utilize helpers in one form or other.

Migration

A great deal of the sport of birding depends upon migration. If birds did not move around, it would not take long to see all of the species in a given birding area. It is the possibility of seeing new birds in the same places that makes the listing game interesting and challenging.

Why do birds migrate? There are many answers to that question. Some birds obviously leave areas because food is exhausted and/or seasonal change makes them inhospitable. Insect-eating warblers that breed in the boreal forests of northern Canada must leave when cold weather drives the insects into hibernation. Waterfowl leave when lakes and rivers freeze up. Birds also may leave an area when it becomes too wet or too dry, when ocean currents take marine food elsewhere or when a seed crop fails.

Perhaps seasonal change explains why birds that summer in the boreal forest travel to the tropics to winter. But why do they come north again to breed? There may appear to be a simple answer in the case of one species or another, but there is no general reason why all species migrate. The reasons vary from species to species and from place to place. Indeed, there are some species, which have both migratory and non-migratory populations. These include Sandhill Cranes, which have a resident populations in central Florida, while other populations migrate long distances. Another example is the Common Ringed Plover of Eurasia. Some Common Ringed Plovers migrate from the Arctic to southern Africa, while others are resident all year in the British Isles.

Much migration probably has a historical explanation. Climatic change has altered species' ranges over centuries and millennia. One possible scenario goes as follows. Birds that now breed in northern boreal forests bred farther south when the ice cap covered the northern half of North America. When the ice cap retreated, those bird species advanced northward to occupy niches that opened up where the ice had been. They continue to return to their historic wintering grounds when cold temperatures return each winter.

The above scenario is probably much too simplistic. The range of a bird species can change dramatically in a decade, so all sorts of possibilities may have occurred in the ten or twelve millennia since the ice cap started to retreat. Indeed, new species may have evolved during that time period. Nevertheless, there is considerable evidence that birds do retrace historic migration routes after breeding. Examples are the eastern North American populations of Arctic Tern and Northern Wheatear. When breeding ends, neither species migrates due south. Instead, both first go east to Europe and then go south in the Old World. Arctic Terns that breed as far south as northern Maine and the maritime provinces of Canada may actually go north first before turning east to head for their long journey down the west coasts of Europe and Africa to their eventual destination 12,000 miles away.

We tend to think of many of our North American migrants as temperate species that winter in the tropics. They could just as easily be considered tropical species that come north to breed. The latter is probably the more realistic characterization, since many of them spend more time in the tropics than they do in temperate latitudes.

Not all migration is from north to south. Some species migrate up and down mountains. Cory's Shearwaters travel from east to west to summer in the eastern Atlantic. Some birds move into shallow lakes and marshes created by a rainy season, then move away when they dry up during the dry season. Herons are famous as "dispersal migrants." They go in all directions when the breeding season ends. Many of the egrets and Little Blue Herons that we see in Missouri in late summer are dispersal migrants that actually came north after breeding. Nevertheless, they will eventually go south again when cold weather comes.

Seasonal migrants do not always take the same routes on the return trip as they did in spring. Several shore bird species migrate up the center of North America in spring, but travel over the eastern Atlantic in fall. These include nearly all Hudsonian Godwits and most American Golden-plovers and White-rumped Sandpipers. One bird with a particularly interesting fall migration pattern is Blackpoll Warbler. They fly southeast over the Atlantic Ocean in fall, counting on tropical east-to-west tropical trade winds to blow them back to South America, where they spend the winter.

Migrating large distances requires considerable energy, which birds store in the form of fat. Some birds that travel long distances in one flight actually add as much as fifty per cent of their total body weight in fat when getting ready to migrate, then lose virtually all of it during the trip. Other species migrate shorter distances, stop and fatten up for a while, then continue on for another relatively short flight, gradually working their way to their destination.

Eskimo Curlew was one of the shore birds that migrated through central North America in spring, then made a long transoceanic flight to its Argentine wintering grounds in fall. One reason the species may be extinct is that it counted on grasshopper eggs deposited in Great Plains prairies to fuel its northward journey. Plowing of large portions of its traditional spring migration route eliminated the abundance of grasshopper eggs there. Market hunting may have depleted the Eskimo Curlew population to very small numbers, but the diminution of its primary source of fuel for the northward migration probably prevented a comeback once protection measures stopped the hunting.

Most song birds migrate at night. Winds often die down after dark. It is cooler then, and the risk of predation by hawks and gulls is minimized after dark.. Hawks, cranes, pelicans and other soaring birds migrate by day, when the heat of the sun creates thermal uplifts upon which they can ride. Swallows migrate by day because they can feed on the wing while migrating. Many waterfowl and shorebirds migrate both by day and by night.

Various factors stimulate migration. Birds have internal clocks that stimulate physiological changes that precede migration, such as the enlargement of gonads before migration to the breeding grounds. Most species have evolved to follow regular annual cycles of molt, migration and breeding timed to coincide with favorable conditions. Different populations of the same species may have different annual cycles depending upon conditions in their particular ranges. Southern-ranging subspecies come into breeding condition first, while those that migrate farther north do not get ready until seasonal change readies the breeding ground to receive them. The actual stimulus to move may involve a combination of factors, including physiological readiness to migrate, changes in the amount of daylight, temperature change and/or favorable conditions for travel. The timing of fall migration, which is often more protracted than the trip north in spring, may depend more on stimuli of cold fronts and favorable winds. The rate of progress of migrants often depends upon their success at finding food at stopover places to fuel the next leg of the journey.

Males generally migrate first in spring. They need to arrive on the breeding grounds before the females so that they can establish and defend territories by the time the females arrive. Adults often precede juveniles on the southward trip. Once the adults have completed their parenting responsibilities, there may no longer be any reason for them to linger at the breeding grounds. Young of the year may need to linger to polish up their skills of feeding and flight before embarking. Of course, there are many species in which young and adults migrate together, either in family groups or in flocks.

There are many examples of amazing navigational feats by birds, but exactly how they do it has puzzled scientists for generations. There is evidence that they use some or all of the following methods:

Visual landmarks: Both diurnal and nocturnal migrants tend to follow watercourses, coastlines and mountain ranges and to avoid crossing large bodies of water unless winds are favorable. The tendency of birds to follow natural landmarks and to avoid water crossing produces a funneling effect that makes certain locations birding hot spots in season. Hawk Mountain, Pennsylvania, Cape May, New Jersey and Duluth, Minnesota are all famous birding spots into which migrants are funneled in fall. Point Pelee, Ontario and High Island, Texas are famous landing places where birds exhausted by long over water flights congregate in spring. Reference to visual landmarks is undoubtedly a major factor in much bird navigation.

Solar compass: Experiments have shown that Starlings, homing pigeons and other species use the sun to orient themselves.

Stellar compass: Planetarium experiments have shown that nocturnal migrants can get directional information from the stars.

Geomagnetism: Birds evidently have a sensitivity to the earth's magnetic field that humans lack. Experiments in which electric caps that produced a magnetic field were fitted to the heads of homing pigeons demonstrated that they respond to magnetic impulses. When the electrical current was changed so that the magnetic field reversed, the pigeons went in the opposite direction!

Olfaction: Storm-petrels and pigeons apparently locate their nests at least partly by smell. Experiments in which the sense of smell was impaired demonstrated that impaired birds did not find their nests as easily as control individuals.

Apparently, birds' ability to navigate is partly learned and partly innate. When scientists capture birds and release them a different locations, young birds often go south in the same direction they would have used had they embarked from the point of capture. Older birds are more likely to recognize and correct for the displacement, which indicates that they learned something on a previous trip that the young birds had no prior opportunity to learn.

Social Behavior

The social behavior of birds varies widely from species to species. It also depends upon the conditions in which birds find themselves. Examples of different kinds of avian social behavior include defending breeding territories, defending winter feeding territories, flocking to migrate, flocking to minimize predation, colonial nesting and cooperative predation.

Maintaining a territory is one of the most basic social activities of birds. The usual purpose of a territory is to insure a supply of food to the territorial owner. But a territory may just be a matter of insuring that another individual will not come too close. Sea birds that nest in gigantic colonies defend territorial space around their nests. Anyone who invades that space risks a peck. In some cases, the defending bird will do more than that, chasing the offender around the colony. A Golden Eagle's breeding territory may include many square miles. A Sooty Tern's nesting territory may be only a couple of feet in diameter.

Birds often defend breeding territories. Here, the objective is to provide enough food for the mate and the young. A breeding territory may also be a way to attract and keep a mate.

Many species also defend winter feeding territories. A winter feeding territory has to provide more fuel for the bird than the energy expended to defend it. Sanderlings demonstrate this principle in action. A wintering Sanderling may defend a particular stretch of beach if there are a moderate amount of the isopods upon which it feeds there. If isopods are scarce, the territory is not worth defending. The Sanderling may poke around looking for food there from time to time, but it will not establish a territory. If isopods are abundant, whole flocks of Sanderlings will arrive to feed upon them, and it will be impossible for one bird to establish a territory. Sanderling territories will be maintained along that stretch of beach only if the volume of prey species is intermediate between abundance and scarcity.

Flocking is obvious social behavior. Many birds migrate in flocks. Not only may they minimize predation that way. The flock may be a means for experienced individuals to help inexperienced youngsters find their way. Flocks operate in several ways to minimize predation. The flock acts as a system to warn its members when a predator is present. But a flock may also make predation itself more difficult. A predator such as a Peregrine needs to home in on a particular individual, pursue it and strike it to knock it out of the air. A wheeling flock of shore birds presents a confusion of shifting target, which makes it difficult for the predator to target any individual. Thus, the whole flock often gets away.

Flocks also help individuals find food. Warblers and other passerines often migrate and feed in loosely organized flocks containing different species. Members of mixed-species flocks share information about food and predators by chips, calls, scolds and visual displays. Tropical flocks, especially those that follow ant swarms, may contain 60 birds of 30 different species, whereas flocks in temperate areas are more apt to contain 10 to 15 birds of 6 or 7 different species.

The same advantages that lead to feeding flocks also encourage colonial nesting. Members of the breeding colony can aid each other to find food. Terns often head out to see in the direction from which returning individuals have brought fish. They can warn. They can mob predators. And they can overwhelm predators with sheer numbers, thus ensuring that mortality due to predation will be small on a percentage basis.

Finally, birds do act cooperatively. We have previously mentioned the communal hunting of Harris Hawks and the communal nesting of Florida Scrub Jays. Pelicans also hunt cooperatively, corralling fish by swimming together in lines.