Phylum Chordata - Vertebrata
Birds

of all higher vertebrates, birds are probably best known

9700 species

→ 2nd most abundant vertebrate group

→ outnumber all other vertebrate groups except fish

smallest bird: bee hummingbird 1.8g (.06oz)

one of smallest warmblooded vertebrates

only slightly larger than a bumblebee

largest living *flying* bird:

is the wandering albatross with a 12 ft wingspan; weighs about 25 lbs

largest known flying bird:

a condor-like bird, ~6 MY ago

155 lbs (70 kg) with 21' (6.4M) wingspan

had to run downhill into a headwind to take off

largest bird: elephant bird of Madagascar is most massive bird that ever lived

2 M tall, 450kg(~1000 lbs)

also: tallest was extinct moas of New Zealand

flightless bird, related to emus

12 ft (3.6 M) to 550 lbs (250kg)

birds are found in all habitats:

forests, deserts, mountains, praries, oceans

some live in caves in total darkness

some can dive to 140’ to capture prey

birds are even found at the north and south poles

Origin of Birds

for over 50 MY amphibians and reptiles were the sole terrestrial vertebrates

before the Permian extinction, 250 MY ago, a branch of reptiles leading to birds an mammals arose

fossil evidence indicates that true birds evolved from feathered velociraptors (of Jurassic Park fame)

birds clearly evolved from dinosaurs

more similar to dinosaurs than dinosaurs are to turtles, snakes and lizards

earliest fossil of a true bird ***Archaeopteryx*** (=ancient wing) 150 MY ago

first fossil discovered in 1861 –2 yrs after Darwin's origin of species

rare find since delicate bones and feathers don't fossilize well

if not for impressions of feathers would be classified as a small dinosaur

following the rules of taxonomy they should be in same class (reptilia)

Archaeopteryx (=ancient wing)

~ size of crow
jaws had teeth
clawed fingers
reptilian skeleton
long reptile like tail

but

feathers may not be similar to modern bird feathers
no keel for flight muscles
→ probably didn't fly
bones not thin and hollow as in modern birds
brain comparable to reptile not to larger bird brain

by cretaceous, fossils clearly indicate birds that could fly

by end of tertiary (3 MY ago) many modern families were already in existence

some were up to 12 ft tall

recent genetic analysis indicates that the large flightless birds such as ostrich, kiwi & emu are the most ancient and most "dinosaur-like" birds

the most recent birds to evolve are the very specialized shorebirds, birds of prey, flamingos and penguins

Origins of Flight

flight has several advantages over other forms of locomotion:

→permits sudden and rapid escape from predators

→ easier to find food, water, nesting areas, mates, etc

→fast straight line travel from place to place

→inaccessible places become accessible; opens up new niches

→ facilitates migrations over long distances

flight had evolved at least 4 different times in history of life:

insects: 400 MY;devonian
reptiles: 200MY pterosaurs; late jurassic ,
birds: 150MY; coexisted with pterosaurs for~90MY
bats: 54 MY; (Eocene)

birds didn't evolve feathers & wings "in hopes" of achieving flight

→there had to be an advantage at each state

in its evolution

two major theories:

1. arboreal (gliding, trees down):

wings evolved in reptiles that climbed trees to hunt for insects

→ could glide to base of next tree

eg. used today by some woodpeckers

2. cursorial (running ground up):

wings evolved in running reptile
perhaps as stabilizers

eg. archaeopteryx evolved from a running reptile:
has running legs and feet, not perching

Body Form

in spite of the great diversity of birds they are amazingly similar in structure

birds evolved as flying machines

entire anatomy is designed around flight

small compact body; reduced weight; with all heavy organs close to center of gravity

→center of gravity and propulsion systems are properly balanced

→ body is light yet strong enough for flight

Skin

bird skin is thin, light and flexible

→ the major functions of skin (insulation and protection from the elements is taken over by the feathers

loosely attached to body

directly attached to bone in several places

skull and beak

wing tips

legs

no sweat glands

single oil gland at base of tail
→ preening

skin over most of body is covered by feathers

on legs only: scales instead of feathers

on head and neck in some birds

→ combs and wattles

often brightly colored "ornaments" used for dominance or sexual signaling

other bare areas:

vulture head

→ keeps feathers clean while feeding on carcass

ostriches & relatives

→ unfeathered legs used for cooling after heavy exercise

arctic birds have NO bare areas

Feathers & Flight

wings and body covered by **feathers**

today, the single unique trait that identifies all birds

almost weightless but incredibly strong and tough

feathers smooth the surface and streamline the contour of the body

→ make flying more efficient

but origin of feathers was clearly not for flight

→ many dinosaurs apparently had feathers

feathers are **epidermal structures** derived from reptile scales

developing feathers closely resemble developing scales

scales elongate, edges fray

some dinosaurs clearly had feathers

feathers tend to grow in dense **tracts** with bare areas between

while growing feather has a blood supply

when fully grown blood supply is sealed off, and feathers are dead structures

feathers can be moved individually by muscles in skin (**arrector pili**)

a feather consists of:

shaft (=rachis)

quill part of shaft below vanes

vanes

barbs & hooked barbules overlapping extensions of vane
preening "zips" barbs and barbules back together

kinds of feathers

contour feathers
most of the visible feathers
→ smooth and streamline body surface

flight feathers = contour feathers that extend beyond the body and used in flight

primaries are the most critical in flying

→ their loss may prevent flight

down feathers (plumules)

soft tufts without rachis

lack vane, barbs fan out, not hooked together

hidden beneath contour feathers

especially on breast and abdomen of water birds
to conserve heat

filoplumes (decorative feathers & bristles)

hairlike, degenerative feathers; simple shafts or with tuft of bristles at end

some decorative → displays

eg. the phoenix fowl (a domesticated relative of chickens) has tail feathers up to 34 ft long

bristles →sensory

on head
around eyes
around mouth and nostrils

birds spend much time on feather maintenance:

preening → reconnects barbs & barbules

oiling → waterproofing

bathing

dust baths → to remove ectoparasites

feathers can be replaced individually as need or as a group by molting

Molting

feathers are shed regularly = **molting**

highly orderly process

(except for penquins who molt all at once)

frequency of molt depends on wear and tear and seasonal factors

most birds molt once/yr

usually late summer after nesting season

feathers must be shed gradually and symmetrically (matched pairs) to retain ability to fly

replacements emerge before next pair is shed

→ only ducks and geese are grounded during molting

→ wing clipping: removing critical flight feathers on one wing to prevent flight

Coloration:

among vertebrates, only tropical reef fish show the same intensity and diversity of color

a feather is naturally white

coloration due to:

a. pigments

chromatophores impart colored pigments during feather development

→ color deposited in barbules as they form

melanins: black, brown, dull yellow, dull red

carotenoids: bright yellow, orange, many reds

porphyrin: bright green, some reds

b. structural color

coloration due to refraction or scattering of light rays

→ all blues, most greens and some purples of animals

eg. blue jays, indigo buntings, bluebirds

eg. there is no "color" in blue jay feathers

eg. Tyndall blue → caused by light scattering (refraction) from keratin layers

eg. there is no 'color' in blue jay feathers

eg. iridescence →due to interference patterns of

light; light

interacting with bundles of hollow tubules inside feathers

color may change when viewed at different angles

eg. starlings & peacocks

color is used for:

camoflage

eg. in many species, juveniles and females are camouflaged with melanin pigments

eg. arctic birds white in winter, darker in summer

breeding/communication

eg. males breeding plumage often brightly colored

warning

eg. toxins similar to that of poison frogs has been found in skin and feathers of some brightly colored New Guinea species of *Pitohui*

Skeletal System

some of the most important flight adaptations are found in the skeleton

the skeleton is exceptionally **light and delicate** yet sturdy

frigate bird: 7’ wingspan→ skeleton = 4 oz
→ less than weight of feathers

vs humans 6’ skeleton (6-7’ armspan) weighs ~10 lbs

bones light and hollow with air sacs

Many bones are **fused** together to make them light, but still strong

skull is light, bones fused together, no teeth

many vertebrae are fused together (not neck) for more rigid support of body

pelvic girdle is also fused and joined to stabilize legs for landing

anterior skull bones are elongated to form **beak** (or **bill)** covered with hardened skin attached to skull
→modified lips

since birds lose the use of their forelimbs their **beaks** are used as tools

long tubular beaks for nectar

sturdy wedge shaped to pry insects from bark

curved overlapping beaks to crack nuts and seeds

long upper beak that curves down over lower to tear flesh

neck is extremely flexible with more vertebrae than most vertebrates

most mammals have 7 vertebrae

birds have 11-25 vertebrae

the rest of the **vertebral column** is very rigid with vertebrae fused together for support

fused ribs and interlocking vertebrae provide additional attachment sites for flight muscles

the major flight muscles attack to large **keel** on **sternum**

collar bones are fused (**wishbone**) and connected to shoulder blade for additional support of wings

the pelvic bones are also fused and fused to vertebrae to provide a stable support for landing and walking

while the limbs of birds are made up of the same bones found in the limbs of all vertebrates they are modified in a characteristic way:

the **pectoral appendage** forms 3 major joints that support the flying feathers

humerus - first wing segment; upper arm of us

radius & ulna - second wing segment; lower arm of us

carpometacarpus and phalanges - third wing segment of bird; hand of us

the **pelvic appendage** has 4 major joints:

femur - only slightly moveable

→ acts as shock absorber for landing

tibiotarsus - upper "leg" of bird; lower leg and foot of us

tarsometatarsus - lower "leg" of bird; foot of us

phalanges - feet of bird; toes of us

5^{th} toe has been lost and first digit rotated 180^{o}

Movement

numerous muscles in neck provide tremendous agility

forelimbs modified into **wings**

breast muscles are the flight muscles

flight muscles (breast muscles) often very large % of body weight

eg. pigeon up to 50%

not so in gliders and soarers

main muscle mass is near a bird's center of gravity

wings have to be large enough to generate enough lift to support birds weight

→ direct relationship between body wt and wing area

largest bird that can fly is the great bustard *Otis tarda*

→22 kg (~10 lbs)

arched wing creates concave depression on underside

creates upward suction as wing passes through air

some birds fly in "V" formations:

when flying in flocks birds use each others energy like fish in shoals

takes advantages of leading birds slipstream; called drafting,

like bicyclists; helps conserve energy;

birds take turns at lead position

Kinds of Flight:

wings are designed to facilitate a particular kind of flight

launching

gliding and soaring

use up drafts to stay airborne

flapping flight

complex "figure-8" pattern

hovering

maneuvering

smaller faster wings

swooping

diving

swimming

Bird Flight:

some birds spend most of their lives in flight

eg. swifts

eg. alpine swifts spend up to 6 consecutive months alfot, not even resting after migration each year

eg. common swifts feed, communicate and mate in flight

only lands to sleep and nest

some swifts spend over 200 days each year in flight while migrating

average ~135,000 miles/yr (217,300 km/yr)

one recorded a nonstop trip of 310,000 miles (498,00 km)

cruising speeds are usually ~40 km/hr (25 mph)

peregrine falcon can reach 190 km/hr (120 mph)

many birds can hover at 0 mph

highest flying bird recorded:

Alpine Choughs, *Pyrrhocorax graculus* → 8200 M (26,902')

Feet

are nearly devoid of muscles

→ greater agility

→ very resistant to freezing damage

since mostly bone, tendons & tough skin

when perching, toes lock around branch

→ prevents bird from falling off while sleeping

Tail

early birds had long reptilian tail

modern birds have replaced tail with up to 1000 tail feathers; each under individual muscular control

Digestive System

first birds were probably **carnivores**

→ probably fed mainly on insects

head very flexible & versatile

Beak used like a tool or limb:

bird gave up "hands" millions of years ago and now use **beak/bill** in their place:

eg. catch bugs, shatter seeds, crush shells, drill holes, dismemeber carcasses, snare fish

eg. attack enemies, build nests, preen, impress mates and feed young

birds lives revolve around their beaks

beaks of birds are highly adapted for their feeding type:

eg. crows →generalized type has strong, pointed beak

eg. woodpecker→ straight, hard, chisel-like, creates forces of 10 g's when pecking a tree (humans can only survive 9g's for a few seconds); insert sticky tongue into hole to find insects

eg. hummingbird→ long tubular, ~20% birds feed on nectar

eg. seagull → basketlike sac below beak

contrary to conventional "wisdom" birds are voracious feeders due to **high metabolic rate**

hummingbird has the fastest metabolic rate of all birds

eg. 12x's MB of pigeon & 25x's MB of chicken

hummingbird may eat 100% body wt/day

crop:

in many birds there is an enlargement at lower end of the esophagus = **crop**

stores food to provide a continuous supply of energy during flight

used to store food for regurgitation to feed young

in pigeons, doves and some parrots: crop not only stores food but produces "bird milk"

breakdown of epithelial lining
much higher fat content than cow milk

→ feed young for a few days after hatching

gizzard:

modern birds have no teeth

grinding is done in gizzard

muscular with hard keratinized plates to help grind food

some birds "eat" pebbles to aid this process

some birds of prey form **pellets** of undigested material (bones and fur) and regurgitate them

eg. owl pellets

→ another way to reduce weight

birds have very efficient digestion

eg. shrike - can completely digest a mouse in 3 hours

eg. thrush - berries pass completely through GI tract in 30 minutes

Respiration

birds & mammals are **warm blooded** (homeothermic)

→ they maintain a constant body temperature independent of environment

flight is energy intensive; requires a consistently high metabolism

higher than land mammals (eg. 110º vs 98º F)

have fast heart rate

eg. hummingbirds 1000 bpm (humans 70bpm)

respiratory system is specially adapted to meet this metabolic demand

→ very different from other vertebrates

bird lungs are different than those of mammals:

→ bird lungs are relatively small

→ instead of microscopic **sacs** (=alveoli) that fill with air with each breath,

bird lungs contain microscopic tubes, open at both ends called **air capillaries** (=parabronchi)

→ in addition to **lungs**, birds have extensive system of **air sacs** in body

usually consists of 5 **air sacs** connected to **lungs**

branches throughout the body and enters larger bones

the **air sacs** comprise ~80% of the respiratory system and may completely surround the heart, liver, kidneys, gonads and intestine

air flows in only one direction in bird lungs compared to the two-way flow of mammals

→fresh air goes through lungs on inhale & exhale as it circulates through the air sacs and then through the lungs

in alveoli of mammals new air mixes with old in blind ended sacs

in parabronchi fresh air is constantly moving through tubes

doesn't get diluted with old air

→ much more efficient gas transfer

new studies indicate that some reptiles (alligators) also have a similar one-way flow of air through lungs; as perhaps did dinosaurs and ancestors of birds from when O_2 levels were ~half what they are today

air sacs and **lungs** often make up 20% of body volume (humans lungs=5%)

these air sacs also serve as an **air conditioning system**

→ cool bird during vigorous flight

eg. pigeon produces 27x's more heat flying than at rest

bones with air sacs help to **lighten weight** of bird

even provides a little **buoyancy**
→ hot air rises

The main breathing muscle in mammals is the **diaphragm** which contracts to draw air in and relaxes to push air out of the lungs

birds do not have a diaphragm, instead they use muscular contractions to expand and compress the ribcage for inspiration and expiration

much like reptiles

the "wishbone" of birds also compresses one of the airsacs to increase ventilation while in flight to improve the efficiency of air flow

Circulation

similar to mammals:

- 4 chambered heart
- 2 completely separate circuits: pulmonary & systemic

heart is relatively large

very fast heartbeat (humans ~70-75bpm at rest):

- eg. turkey 93 bpm
- eg. chicken 250 bpm
- eg. blackcapped chicadee 500 bpm
  - → exercise to 1000 bpm

actual blood pressure is similar to mammals of similar size

Nervous System & Senses

brain is same relative size as mammals

while most birds seem to operate mainly on instinct and preprogrammed behaviors, birds are the first

nonhuman vertebrates to be shown to have instinctive tendencies to make and use tools

eg. New Caledonian crows use twigs to poke food out of crevices (without being shown)

several other birds such as woodpecker finches and burrowing owls also routinely use tools but it's not known if their skills come from copying other birds or are innate

cerebellum is relatively larger than in mammals or reptiles

→ coordination of flight muscles

a. eyes are perhaps the most important sense organ

birds eyes are disproportinately larger than in other vertebrates

eg. the eye of the ostrich is ~2" diameter; the largest of any vertebrate

eg. the eyes of most large birds; eg hawks and eagles are larger than human eyes

also disproportionately large compare orbits in skulls

no eye muscles

→ all space is filled with eyeball

can't move eyes to track objects

→flexible neck compensates

plate-like **sclerotic ring** strengthens and focuses eyes

pecten is a thin, greatly folded tissue extending from the retina toward the lens.

unique structure in birds eyes

supplies nutrients and oxygen throughout the vitreous humor

this reduces the number of blood vessels in the retina that obscure the rods and cones.

With fewer blood vessels to scatter light coming into the eye vision is enhanced

predatory birds such as eagles and hawks have the largest and most elaborate pecten of all the birds. and the best vision of all animals

generally:

predatory birds have eyes in front of head

→ **stereo vision** = depth perception

some birds of prey have 2 **foveas** (areas of greatest visual acuity - mammals have one)

equivivalent to a camera having both a telephoto and a macro lens

visual acuity of hawk is 8x's that of humans

best vision in animal kingdom:

→ can clearly see crouching rabbit >1 mile away

vegetarian birds have eyes that look out to sides

→ greater field of view

eyes have **nictitating membrane** (reptile trait)

in some water birds this membrane acts as a "contact lens" to help birds focus underwater

a few birds (eg zebra finches) can see UV light

b. hearing is also well developed in birds

they can hear the same range of sounds as we do yet their ear structure remains reptilian:

have retained single middle ear bone (**columella**)

do have short outer ear canal

but better **cochlea** (not coiled as in mammals, but long and straight; banana-shaped)

birds can replace damaged hair cells (we can't)

In some their hearing ability improves during mating season and declines the rest of the year

night predators such as owls have asymetric ears (not the feathery "ear" tufts) improving their ability to locate prey in the dark.

great grey owls, which hunt in the daytime can locate a mouse beneath the snow with precision

a few birds (oilbirds & swiftlets) can use **echolocation** in the dark to avoid objects

bird ears are not as effective as mammal ears for sonar

not as good as bats, not used for hunting

c. Sound and Communication

bird songs are some of the most recognizable and endearing characteristics of birds; used to find mates, mark territories and other kinds of communication

most birds have a larynx (voice box) but don't use it to generate sounds

they do have a **syrinx**

a cartilaginous chamber at the base of the trachea with muscle controlled membranes which they use to make familiar bird songs

membranes on each side can produce separate sounds to generate chords or harmonies when singing

one species, the club-winged manakin of Ecuador creates a courtship sound by knocking his wings together over his back to go with his song

→ no other vertebrate produces this kind of sound, although stridulation is common in insects

c. **smell**, we used to think birds lacked sense of smell now we know they have very refined sense of smell (some as good as mammals)

used to find food, breeding colonies, their individual nests and recognize their partners

vultures & petrels probably have some of the best smell receptors; songbirds the worst

d. **taste** not very well developed

hundreds of receptors located on upper and lower jaws

mammals have 10,000's mainly on tongue

e. **touch**

the bills of ducks & wading birds contain very sensitive touch receptors

as they dabble in muddy water or probe for hidden food they can distinguish between what's edible and what's not

touch also plays an important role in social relationships that promotes bonding

many spend hours preening each other (as in primate grooming)

Excretion

kidney is similar to that of reptiles

contains **nephrons** which filter blood and remove metabolic wastes

water is conserved by excreting insoluble **uric acid** as main nitrogen waste

takes 20x's more water to get rid of urea than to get rid of uric acid

metabolic wastes are passed directly to **cloaca**

birds have no bladder

water is reabsorbed in cloaca

the white, paste-like uric acid that remains is eliminated along with feces through the **vent**

like reptiles, marine birds have **salt glands** that empty through nostrils to get rid of excess salt

Life Cycle

some birds live over 70 years (eg. Andean condors)

reproductive strategy for most birds is to have a few offspring at a time and provide lots of care initially

usually both males and females contribute to care.

Reproduction, Nesting & Egg Laying

birds are **dioecious** with **internal fertilization**

to save weight:

→in males testes enlarge only during mating season

→females only have left ovary; not paired

Courtship

courtship in birds involves

→ marking and defending a territory

→ and sometimes elaborate rituals to entice a female into the territory

selection of territory usually occurs a few weeks before nesting season

male selects nest location

solitary species defend fairly large area

gregarious species that nest in colonies defend a very small area

sometimes this seasonal instinct to defend territory becomes obsessive

eg. robin or cardinal that returns day after day to struggle futily with its reflection in a window pane

courtship rituals

males are sometimes very colorful during breeding season, dull rest of time

many develop seasonal ornamentation

eg. inflated skin pouch on throat

courtship almost always involves singing to a potential mate

sometimes also involves elaborate dances

eg. lyrebird - to attract a mate:

male will stand on a small mound of dirt and spreat his decorative tail feathers up over his head

he then sings both his own songs and mimicks other bird's songs

he will even mimic the noise of a nearby car

as he sings he jumps about

eg. frigatebird

male has a throat sac that it can inflate over a period of 20 minutes into a heart shaped balloon

he then waggles his head from side to side, shakes his wings and calls the female

a female frigatebird will mate with the male with the largest and shiniest balloon

during sex the male will "sweetly" put its wings over the females eyes … to make sure she doesn't get distracted by a better offer

eg. Long tailed Manakin (of Costa Rica)

males work in pairs who begin perched on a branch near the ground

they both call a whistle-like call for females

a female lands on the branch indicating she is ready to be courted

both birds launch into a prolonged acrobatic display

they step daintily and hop, they somersault and leap-frog, they take turns hovering in the air, all while calling to the female

as the tempo picks up the males emit a buzzing sound and the female becomes even more excited

at the critical point the leading male utters a shrill cry

this is the lesser male's cue to make himself scarce

following a brief dance the male quickly mounts the female

eg. bowerbirds

19 sp in Australia and New Guinea

no other bird has developed its breeding and mating behaviors to such a degree

the key to successful mating is construction of a "**bower"** → a performance arena used only to entice a female, not a nest for eggs

the least colorful males produces the most elaborate bowers

it apparently takes the young males several years to learn how to build one

each bower consists of a mat of mosses and ferns, decorated with shells, feathers, pieces of fruit, etc

often includes an 'avenue' bordered by walls of sticks

some bowers form a coneshaped hut several feet tall with a door and a 'front lawn' decorated with fruit and flowers

once the bower is completed the male defends it and entices females with complex calls and dances

if the female is impressed she will mate then leave to build a nest and lay eggs

the male promptly begins advertising for a new partner

---

most birds have no transfer organ →press cloacas together

a few birds have erectile penis with external groove to guide sperm into females cloaca

a few bird species are monogamous for life

eg. swans, geese, eagles, owls

most birds are monogamous while mating

but after mating or rearing their chicks, they go their own ways

however new genetic data shows that many female birds once thought monogamous are actually quite promiscuous bearing offspring from several fathers

Nests

some of the most obvious and characteristic features of birds are the nests they make to lay eggs and care for their young

nests vary from simple depressions or accumulations of materials on the ground to large communal nests for 100's of birds

some of the most elaborate nests are associated with some swallows and weaver finches

nests typically take 2 to 7 days to construct

cavity nests in trees can take up to 4 weeks to excavate

the most elaborate nests can take months

nests vary in complexity based at least partly on their flying skills

eg. typical nest of smaller bird is cup shaped "basket" lined with finer material

eg. barn and cliff swallows mold nests of mud from softened pellets

eg. largest bird nest is that of bald eagle

→ to 10' wide, 20'long and 5,500 lbs
(the weight of almost 3 cars)

→ the same nest can be used for decades

most birds void outside of nest

types of nests:

scrape nests – simple depressions in the ground or litter

eg. penguins, shorebirds, gulls, terns, nighthawks, vultures

burrow nests – burrows dug in the sides of cliffs are very effective at protecting eggs and young from predators

eg. bank swallows, kingfishers, burrowing owls

cavity nests – nests excavated in trees or cacti are used by numerous birds

eg. woodpeckers, owls, parrots, some waterfowl

platform nests – relatively flat nests that may be on the ground, in a tree or across the tops of vegetation in shallow water

eg. western grebe

cupped nest – some of the most commonly seen nests, usually in branches of trees and shrubs and supported from below or suspended from branches; there are many variations in this kind of nest

eg. many "passerines" & hummingbirds

Eggs

all birds lay eggs (=oviparous)

not sure why they never evolved to bear live young (=viviparity)

live bearing did evolve in ***all*** other vertebrate groups:
fishes
amphibians - at least twice
reptiles - 100's of separate times
mammals - once

one argument is that it would be difficult for a pregnant bird to fly

but: bats can

another idea is that bird's body temperature is usually a few degrees higher than the body temp of mammals and that temperature is lethal to the eggs

birds typically incubate their eggs at ~37º C (98.6º F)

all bird eggs have hard shells with lots of microscopic pores

shell is soft when formed & hardens before being layed

egg size & shape

largest: known bird egg is from extinct Elephant bird (*Aepyornis*) of Madasgascar

13" long, 9.5" dia; 2 gallon volume

smallest: some hummingbird species <1/4th "

abnormal eggs:

a. runt egg

→yolk smaller than normal

→ parasite or debris in oviduct triggers egg fomation missing yolk all together

b. double yolk
rarely 3 yolks

c. egg within an egg

enforced return up the oviduct

Parental Care

usually female incubates eggs

12-30 days needed for incubation

incubating birds develop "incubation patches"
loss of feathers
thickening of skin
greater blood supply to area to maintain temp

in hot areas birds must shade eggs

after hatching young are fed by **regurgitation**

some birds (pigeons, doves, flamingos and some penguins) produce **crop milk**

secretions with a "cottage cheese"-like consistency, very high in proteins and fats

much higher fat content than cow milk

produced by both male and female birds to feed the young for the first few weeks

Migrations

regular extensive seasonal movements of birds between summer and winter regions

origins: more northerly birds were forced south as winters got colder

enables bird to live in optimal climate all the time
generally breed in northern latitudes
overwinter in southern latitudes

as north and south ranges moved further apart due to continental drift the migration routes got longer and longer

just less than half of all birds migrate

(for 1000's of years thought most hibernated)

Why Migrate?

migration increases the amount of space available for breeding

→ reduces aggressive territorial behavior

avoids climate extremes favors homeostasis

→ less energy needed to maintain internal stability

north in summer

→ long summers, abundance of insects to rear young, not many predators

much variation in methods of migration

→ most birds migrate at **night**,

esp smaller birds

mainly before midnight and immediately before dawn

→ protection from predators

→ can spend day feeding

some larger birds migrate in day

eg. hawks, shore birds, black birds, pelicans, bluejays

→ most fly at <3000'

very rare to find one >5000'

→ most travel at 20-50 mph

some 80-100mph

ancients thought they migrated in 1 night
→ would have required speeds of 180-240 mph

→ main timing factor is **changes in day length**

Arctic tern has longest migration route:

nests from Mass to Greenland and Alaska

spends winters off shores of Anarctic near Falkland Islands

→ experiences more hours of daylight than any other bird
only crossing the equator does it esperience long nights

navigation cues:

birds use a variety of navigation clues including sun and stars and olfactory cues. Some can even use the earth's magnetic fields

1. visual

   follow familiar migratory routes

   most migratory birds have **well established routes**

2. earth's gravitational field

   some birds have crystals of magnetite around their eyes and in their nasal cavities of upper beak

3. celestial cues

4. sun's position in sky & 'time sense'

Classification of Birds

birds today are divided into 2 major groups with 27-28 orders:

1. flying birds
   largest group of these are **perching birds**
   → comprise >1/2 of all bird species

2. flightless birds (ratites)

   originally from flying forms

   flightlessness almost always evolved on islands with few predators

   lost use of wings; keel and flight muscles degenerate

   → lived with few predators in isolated areas

   tendency to become quite large

   eg. moas of New Zealand to 500 lbs

   eg. elephant bird of madagascar is largest bird that ever lived

   2 M tall, 450kg(~1000 lbs)

   developed very powerful legs

   → can achieve very fast running speeds

   eg. emu ~ 30 mph,

   eg. ostrich ~ 42 mph and up to 60 mph

swimming birds:

most have webbed feet

- birds with webbed feet for paddling have legs far back on body and tend to be clumsy walkers

those that dive skillfully are usually not very good fliers

some chase prey underwater by paddling with wings

some very effective swimmers

- eg. gentoo penquin → 22mph

Bird Ecology

1. pollination

eg. hummingbirds
- do not have a highly developed sense of smell
- but do have excellent sense of vision
- frequently bright red or yellow flowers
- little if any odor
- fused petals with nectary
- produce copius quantities of nectar
- long floral tubes prevent most insects from reaching the nectar
- eg. fuschias, petunias, morning glories, salvias, cardinal flowers, trumpet creepers, columbines, penstemons

2. disperse seeds

eg. edible fruits
- attracts birds or mammals
- may eat whole fruit or spit out pits
- if swallowed seeds resistant to digestive juices
- squirrels and birds bury fruits and seeds
- nuts stored underground are forgotten

eg. passively carried by birds
- hooks or spines to catch in feathers
- in mud on feet of birds, etc.
- burs, beggars ticks, devils claw, etc.

3. pest control

eg. Birds eat many things: beetles, flies, spiders, earthworms, rotting fish, offal, poison oak berries, weed seeds, etc

eg. raptors & owls - eat mice, rats, snakes

Human Impacts

1. meat and eggs

20 B birds are used for food (world/yr):

chickens	20 B/yr
turkeys	304 M/yr
ducks	773 M/yr
geese	209 M/yr

US exports:

120,000 tons of wings to china
2 M tons of leg quarters to Russia

US also processes:

1.6 M tons of **feathers**/yr
→ ground u into feather meal as animal feed or plastic fortifiers

intestines go to rendering plants where they are ground up and used in pet foods and fertilizers

US exports ~50,000 tons to South Africa

~330,000 tons of **feet**/yr exported to China

scientists have recently bred a "featherless chicken

→ grows faster
→ don't need to pluck it

~ 91 Billion eggs produced US each year

2. extinct or endangered species due primarily to human activities

2/3rds of bird species are declining in numbers

eg. about 20% of world's bird species have gone extinct in historic past

eg. Passenger Pigeon (Ectopistes migratorius)

inhabited eastern N America

200 yrs ago was the world's most abundant bird

→ 3-5 Billion

→once accounted for ~1/4th - 1/3rd of all N Am birds

→ 1830's Audubon saw a single flock estimated at 10 miles wide and 100's miles long (~1 Bill birds)

were easily slaughtered for meat (pigeon pie)

→ they wouldn't fly away if threatened

over 20 yrs of hunting and habitat loss at end of 1800's the population was decimated

last wild bird was shot in 1900

last individual (Martha) died at the Cincinnati Zoo in 1914

eg. Ivory Billed Woodpecker

3. Other direct effects of humans on birds

100 M – 1 B birds are killed by glass collisions/yr in US

140,000 – 328,000 birds die from wind turbines/yr in US

500,000 - 700,000 birds are killed by getting tangled in fishing nets and hooks/yr world

4. Introduced pests

eg. starling

eg. house sparrow

eg. brown tree snake → Guam 1950 caused extinction of 9 of 18 native bird species; 3 sp of bats and several lizards

5. Domesticated Birds and Bird as Pets

some birds have been truly domesticated:

eg. chickens, turkeys, geese, ducks, pigeons

a few are semidomesticated

eg. hawks and falcons

earliest domestication ~1700 BC in Persia

Europe ~300 BC

12% of pet sales are birds (19% dogs; 5% cats)

??5 M live birds are sold worldwide
4.2-13 M US/yr ??world??

in US (1980's): 500,000 birds sold as pets

European Countries →buy 3/4th 's of live birds

illegal trade:

bird collectors will pay $10,000 for a rare hyacinth macaw from Brazil

$12,000 for a pair of golden-shouldered parakeets from Australia

mortality rate of live animal trade is enormous:
~50 animals caught or killed for every live animal that gets to "market"

6. bird watching

more lucrative than bird hunting

7. hunting

91 M birds are hunted each year worldwide
21 M waterfowl
→ 2injured/ 1 taken

500,000-700,000 seabirds killed as bycatch

8. research

5 M birds are used for research each yr

9. wildlife photography, art