Zoology - BIRDS

THINGS YOU NEED TO KNOW FROM THIS CHAPTER…

1. Classification of Birds
    a. What phylum do birds belong to?
    b. What class do they belong to?
    c. What are the 2 superorders of birds?
        i. How are birds in these groups different?
        ii. What are ratites?
    d. Memorize the 14 orders of birds from your notes and the example birds of those orders.
        i. I suggest that you make flashcards. Put the example birds on one side and the order names on the other. Then start practicing by flipping through them.
2. Diversity
    a. How many species of birds are there?
    b. What is the hallmark of birds (how can you tell just by looking that they're birds)?
    c. What are their forelimbs modified as?
    d. What is functionally equivalent to teeth in birds?
    e. Do all birds lay eggs?
    f. List the five adaptations necessary for flight.
3. What is the significance of the extinct *Archaeopteryx lithographica* species?
    a. What characteristics do birds have that are like reptiles?
4. What is the difference between Paleognathae and Neognathae birds?
    a. Which evolved first?
5. Feather structure
    a. Be able to define and identify on a diagram the following feather structures…
        i. Quill
        ii. Rachis
        iii. Barbs
        iv. Vane
        v. Barbules
    b. What does preening do for birs?
    c. What are the functions of the following feathers?
        i. Contour
        ii. Down
        iii. Filoplume
        iv. Powder-down
    d. What is the feather homologous to?
    e. What is molting?
        i. How does it usually occur?
        ii. Are there any exceptions to this?
6. What are pneumatized bones?

7. How is a bird skull and skeleton different than a mammal skull? (HINT: You should be able to think of numerous examples.)
8. What is a keel? Is it found in all birds?
9. What is the toe-locking mechanism?
10. What did ancestral birds primarily eat?
11. Do birds eat a lot compared to reptiles?
    a. Finish this statement by adding increases and decreases appropriately to the following blanks…
        i. As bird weight _____ food consumption _____.
    b. What is the gizzard, crop, and cloaca.
12. What is similar between the mammal and bird heart?
    a. What is strikingly different?
    b. Finish this statement by adding increases and decreases appropriately to the following blanks…
        i. As bird weight _____ heart rate _____.
    c. How are bird red blood cells different than mammals?
13. Describe the flow of air through birds.
14. What sense is the better developed in birds than in any other animal?
    a. What sense is typically poorly developed?
    b. Are there any exceptions to this?
15. How are bird ears and sense of hearing similar to mammals?
16. Give 3 examples of birds with phenomenal eyesight.
17. What were the driving forces behind the development of flight?
18. Defined the following terms related to flight…
    a. Lift
    b. Thrust
    c. Primaries
    d. Secondaries
    e. Downstroke
    f. Powered upstroke
19. What type of birds would have the following wings…
    a. Elliptical
    b. High-speed
    c. Soaring
    d. High-lift
20. Do all birds migrate?
    a. What are the advantages of migration?
    b. What stimulates migration?
    c. How do birds navigate during migration?
21. What are 4 advantages of flocking?
22. Describe the reproductive systems of male and female birds.
23. Are most birds monogamous or polygamous?
    a. Why?
24. What is the difference between precocial and altricial birds?
25. Give two examples of introduced, pest birds in the U.S.
26. What pressures are causing declining bird numbers?

CLASSIFICATION OF BIRDS

Phylum Chordata

Class Aves (** Only select orders, listed below, need to be memorized.**)

Superorder Paleognathae – Birds with primitive archosaurian palate. Includes ratites (unkeeled sternum – flightless birds).

Order Struthioniformes – ostrich of Africa
Order Rheiformes – rheas of South America
Order Casuariiformes – cassowaries & emus of Australia & New Guinea
Order Apterygiformes – kiwis of New Zealand

Superorder Neognathae – Birds with flexible palate

Order Ciconiiformes – storks, vultures, et al.
Order Anseriformes – swans, geese, ducks
Order Falconiformes – eagles, hawks, falcons, condors, & buzzards
Order Galliformes – quail, pheasants, turkeys, domestic fowl, et al.
Order Columbiformes – pigeons & doves
Order Cuculiformes – roadrunners et al.
Order Strigiformes – owls
Order Apodiformes – swifts & hummingbirds
Order Coraciiformes – kingfishers et al.
Order Piciformes – woodpeckers et al.
Order Passeriformes – perching songbirds

I. Diversity

A. Profile

1. Over 9,000 species have been described worldwide.
   a. Only fishes have more species among vertebrates.
2. The **feather** is the unique and essential feature or hallmark of birds.
3. Uniformity in Structure
   a. Despite 150 million years of evolution, birds are still readily recognized.
   b. Forelimbs are modified as **wings**, although not all are capable of flight.
   c. Hindlimbs are adapted for walking, swimming or perching.
   d. All birds have **horny beaks**.
   e. All birds lay **eggs**.
   f. The driving force for this uniformity appears to be the adaptations necessary for **flight**.
      1) Wings are present for support and propulsion.
      2) The respiratory system must meet high oxygen demands and cool the body.

3) Bones must provide a light but rigid airframe.
4) Digestion and circulation must meet the high-energy demands of flight.
5) And the nervous system must have superb sensory systems for high-velocity flight.

II. Origin and Relationships

A. History

1. The discovery of the fossil of ***Archaeopteryx lithographica*** in **1861** linked birds and reptiles.

a. The skull resembled modern birds but it had teeth rather than a beak.

b. The skeleton was reptilian with clawed fingers, abdominal ribs and a long bony tail.

c. Feathers were unmistakably imprinted along the wings.

2. Zoologists had long recognized that birds and reptiles shared many similarities.

a. Both have skulls that abut the first neck vertebra by a single **ball-and-socket joint**.

b. Both have a single middle ear bone, the **stapes**.

c. The lower jaw in both is composed of five or six bones; in mammals there is one mandibular bone.

d. Both birds and reptiles excrete nitrogenous wastes as **uric acid**; mammals excrete urea.

e. Both lay similar yolked eggs; the embryo develops on the surface by shallow cleavage patterns.

B. Relationships

1. Modern birds include **Paleognathae** with a flat sternum and **Neognathae** with a keeled sternum.

2. Flightlessness has evolved many times among many bird groups.

3. Smaller birds can revert to flightlessness on islands that lack terrestrial predators.

4. Larger flightless birds such as the ostrich and emu can outrun predators.

III. Form and Function

A. Feathers

1. Structure

a. The feather is a special bird adaptation that contributes to more power or less weight.

b. The hollow **quill** emerges from the skin follicle and continues as a shaft or **rachis**.

c. The rachis bears numerous **barbs**.

d. Up to several hundred barbs are arranged to form a flat, webbed surface, the **vane**.

e. Each barb resembles a miniature feather; numerous parallel filaments or **barbules** spread laterally.
f. With up to 600 barbules in each side of a barb, there may be over one million in the whole feather.
g. Barbules from two neighboring barbs overlap; they "zip" together with tiny hooks.
h. When separated, they are "zipped" back together by **preening**.

2. Types of Feathers
   a. **Contour** feathers provide the form of the bird; flight feathers extend off the wing in flight.
   b. **Down** feathers are under contour feathers; their barbules lack hooks and they function as insulation.
   c. **Filoplume** feathers are hairlike, degenerate feathers with a weak shaft and tuft of short barbs.
   d. **Powder-down** feathers on herons and their relatives disintegrate and release a talc-like powder to waterproof feathers.
3. Origin and Development
   a. The bird feather is homologous to the **reptile scale**.
4. Molting – most birds molt once a year, usually in late summer after the nesting season.
   a. The fully-grown feather is a dead structure; shedding or molting is an orderly process.
   b. Except in penguins, molting is a gradual process that avoids leaving bare spots.
   c. In many water birds, primary feathers are molted all at once and the birds are temporarily grounded, usually during nesting.

B. Skeleton
1. Bone Weight
   a. Compared with the *Archeopteryx*, modern birds have light, delicate bones laced with air cavities.
   b. These are termed **pneumatized bones**; they are nevertheless strong.
   c. The total weight of a bird's feathers may outweigh its skeleton.
2. Bird Skull
   a. Bird skulls are so specialized that it is difficult to see the diapsid condition.
   b. The skull is fused into one piece; the braincase and orbits are large to hold a larger brain and eyes.
   c. While the skull is lighter, the legs are heavier than in mammals; this lowers the center of gravity.
3. Vertebral Column and Appendages
   a. The bird vertebral column is very rigid; vertebrae are

fused except for the cervical vertebrae.

b. Except in flightless birds, the sternum bears a large **keel** for anchorage of **flight muscles**.

c. Bones in the forelimbs are highly modified for flight, with some bones reduced in number or fused.

C. Muscular System

1. A **toe-locking** mechanism prevents a perching bird from falling off a branch while asleep.
2. As many as 1,000 muscles may control the tail feathers for steering in flight.

D. Food, Feeding and Digestion

1. Insect Eaters (**Insectivores**)
   a. In their early evolution, birds were carnivorous, primarily feeding on the great variety of insects.
   b. Modern birds have specialized to hunt nearly all types of insects in most habitats.
2. Other Diets
   a. Other animals joined the diet of birds, including worms, molluscs, crustaceans, fish, frogs, etc.
   b. Nearly one-fifth of birds feed on **nectar**.
   c. The beaks of birds often reveal their food habits and vary between seed-eaters, insect-eaters, etc.
   d. A woodpecker has a straight, hard, chisel-like beak to expose insect burrows; its long, flexible, barbed tongue seeks out the insects in the wood galleries.
3. Food Quantity
   a. Contrary to the saying “to eat like a bird” meaning “to eat little,” birds are voracious feeders.
   b. Birds have a high metabolic rate and small birds need even more food per body mass.
   c. A hummingbird uses oxygen 12 times faster than a pigeon and 25 times that of a chicken.
   d. A hummingbird eats **100%** of its body weight each day, a blue tit about **30%** and a chicken, **3.4%.**
   e. Because birds lack teeth, foods that require grinding are cut apart in the **gizzard.**
      1) Birds may also swallow pebbles or grit to assist in grinding in the gizzard.
   f. Many birds have a **crop** that serves to store food at the lower end of the esophagus.
   g. The crop of pigeons, doves and some parrots, also produces a lipid- and protein-rich “milk.”
   h. The end of the digestive system is the **cloaca**, which also receives the products from the genital ducts and ureters.

E. Circulatory System

1. The **four-chambered** heart is large, with strong ventricular walls.

2. Birds share with mammals a complete separation of respiratory and systemic circulations.
3. The **right aortic arch**, instead of the left as in mammals, leads to the dorsal aorta.
4. The heartbeat is relatively fast compared to mammals and is inversely proportional to size.
    a. A turkey heart beats **93** times per minute.
    b. A chicken heart beats **250** times per minute.
    c. A small black-capped chickadee heart beats **500** times per minute.
5. Bird red blood cells (erythrocytes) are nucleated and biconvex.

F. Respiratory System

1. The bird respiratory system differs radically from the lungs of both reptiles and mammals.
2. Bird Lungs
    a. The finest branches of the bronchi do not terminate in alveoli but are tube-like **parabronchi**.
    b. Air sacs extend into the thorax, abdomen, and even the long bones.
    c. A large portion of the air bypasses the lungs and flows directly to the air sacs on inspiration.
    d. On expiration, this oxygenated air flows through the lungs; therefore there is continuous air flow.
    e. Thus it takes **two** respiratory cycles for a single breath of air to pass through the system.
    f. This is the most efficient respiratory system of any vertebrate.
3. An air sac system helps cool a bird during vigorous exercise when up to 27 times more heat is produced.

G. Nervous and Sensory Systems

1. A bird's nervous and sensory system must accommodate the problems of flight and a visual lifestyle.
2. The bird's brain has well-developed cerebral hemispheres, cerebellum, and midbrain tectum.
3. The cerebral cortex, a chief coordinating center in mammals, is thin, unfissured and poorly developed.
4. Sense of **smell** is poorly developed except in flightless birds, ducks and vultures.
5. Birds have good hearing and superb vision, the best in the animal kingdom.
6. The bird ear is similar to the ear of mammals.
    a. The external ear canal leads to an **eardrum**.
    b. An inner ear has a short **cochlea**; it allows birds to hear about the same range of sound as humans.
    c. Bird ears do not hear as high a frequency as do humans but surpass us in ability to distinguish differences in pitch

and intensities.

7. The bird eye is similar to the mammal eye but it is relatively larger for a given body size.
    a. A bird eye is less spherical and almost immobile; a bird turns its head rather than its eyes.
    b. Vegetarians must avoid predators and they have eyes placed to each side to view all directions.
    c. Birds of prey have eyes directed forward to provide better depth perception.
    d. A hawk has eight times the visual **acuity** of a human and can see a rabbit over a kilometer away.
    e. An owl's ability to see in dim light is more than **ten times** that of a human.
    f. Many birds can see partially into the **ultraviolet** spectrum, seeing flower nectar guides.

I. Flight
    1. History
        a. The early airspace was an unexploited habitat with flying insects for food.
        b. Flight also provided rapid escape from predators and ability to travel to better environments.
        c. There are two hypotheses on the evolution of bird flight.
            1) Ground up
            2) Tree down
        d. Feathers preceded flight and arose for thermoregulatory purposes.
    2. Flapping Flight
        a. Flapping flight requires a vertical **lifting** force and a horizontal **thrusting** force.
        b. Thrust is provided by **primaries** at the wing tips and lift is provided by the **secondaries**.
        c. Greatest power is provided by the **downstroke**.
        d. The **powered upstroke** is essential for hovering and fast, steep takeoffs.
    3. Basic Forms of Bird Wings
        a. **Elliptica**l Wings
            1) Birds that must maneuver in **forested habitats** have elliptical wings.
            2) Elliptical wings are slotted between primary feathers to prevent stalling at low speeds, etc.
            3) The small chickadee can change its course within 0.03 seconds.
        b. **High-Speed** Wings
            1) Birds that feed on the wing or make **long migrations** have high-speed wings.
            2) These wings sweep back and taper to a slender tip;

this reduces “tip vortex” turbulence.
3) They are flat in section and lack wing-tip slotting.

c. **Soaring** Wings

1) Albatrosses, gannets and other oceanic soaring birds have wings with long, narrow wings.
2) The high-aspect ratio of long, narrow wings lack wing slots and allow high speed, high lift and dynamic soaring.
3) They have the highest aerodynamic efficiency of any design, but are less maneuverable.
4) These birds exploit the highly reliable sea winds, and air currents of different velocities.

d. **High-Lift** Wings

1) Vultures, hawks, eagles, owls and other **birds of prey** that carry heavy loads have wings with slotting, alulas and pronounced camber.
2) This produces high lift at slow speed.
3) Many are land soarers; their broad, slotted wings allow sensitive response for static soaring.

IV. Migration and Navigation

A. Migration

1. About half of all bird species migrate.
2. They can move between southern wintering regions and northern summer breeding regions.
3. They can exploit seasonal changes in abundance of insects and avoid bird predators.
4. Appearing one time a year prevents buildup of specialized predators.

B. Stimulus for Migration

1. The long days of late winter and early spring stimulate development of gonads and fat.
2. Long day length stimulates the anterior lobe of the pituitary.
3. Release of pituitary gonadotropic hormone sets in motion a complex series of physiological and behavioral changes resulting in gonadal growth, fat deposition, migration, courtship, mating behavior and care of young.

C. Direction Finding in Migration

1. Experiments suggest birds navigate chiefly by **sight**.
2. Birds recognize topographical **landmarks** and follow familiar migratory routes.
3. This pools navigational resources and also experience of older birds.
4. Birds also have a highly accurate innate sense of time and an innate sense of direction.
5. Research indicates they can navigate by the **earth’s magnetic**

field; this may be related to magnetite found in the neck musculature of pigeons.

6. Sun-azimuth Orientation

a. German ornithologists used special cages to show birds navigate by sun at day and stars at night.

b. Planetarium experiments revealed they use the **sun** as a compass; an internal clock tracks position.

c. These experiments suggest use of the **North Star** as an axis at night.

V. Social Behavior and Reproduction

A. Cooperative Behavior

1. Sea birds often gather in huge colonies to nest and to rear young.
2. Birds that isolate during breeding may congregate for migration or feeding.
3. There are many advantages for flocking together:
   a. mutual **protection** from enemies
   b. greater ease in finding **mates**
   c. less opportunity for an individual **straying** during migration
   d. mass **huddling** for protection against low night temperatures during migration.

B. Reproductive System

1. Bird testes are very small until the approach of the breeding season, when they may enlarge 300 times.
2. Males of most species lack a penis; mating involves bringing cloacal surfaces in contact known as **cloacal kissing**.
3. In most birds, the **left ovary** and **oviduct** develop and the right ovary and oviduct degenerate.
4. The expanded end of the oviduct, the **infundibulum**, receives the discharged eggs.
5. Special glands add **albumin** or egg white to the egg as it passes down the oviduct.
6. Farther down the oviduct, the shell membrane, shell, and shell pigments are also secreted.
7. Fertilization must therefore take place in the upper oviduct before albumin and shell are added.
8. Sperm remain alive in the oviduct for many days after a single mating.

C. Mating Systems

1. Over 90% of bird species are **monogamous**; they only mate with one partner each breeding season.
2. A smaller number **are polygamous**; individuals mate with two or more partners each breeding season.
3. The reason birds have a high monogamy rate, compared to mammals, is two-fold…

a. Baby birds lack a built-in food supply and require the parental care from both parents to provision the young.

b. Bird Territories

1) A male sings often to announce his presence to females and drive away males.

2) Females wander about to select a male that offers the best chance of reproductive success.

3) Usually a male can defend an area that provides just enough resources for one nesting female.

D. Nesting and Care of Young

1. Nearly all birds lay eggs that must be incubated by one or both parents.

2. **Precocial** birds are able to feed and run or swim as soon as they are hatched.

3. **Altricial** birds are naked and helpless at birth and must be fed in the nest for a week or more.

4. Nesting success in altricial birds is very low; sometimes barely **20%** of nests produce young.

5. Causes of nesting failure include **predators**, **nest parasites** and other factors.

VI. Bird Populations

A. Factors

1. Humans have introduced birds to new regions; the **starling** and the **house sparrow** are both abundant now in the United States.

2. Since the dodo went extinct in 1695, more than 80 bird species have also become extinct due to human influence.

3. Causes of bird extinction include **habitat destruction** and **hunting**.

4. Modern hunting interests have helped recover wetlands; no legally hunted birds are endangered.

5. Recent Decline of Songbirds

a. Some songbird species that were abundant 40 years ago are in decline.

b. **Agriculture** has utilized once-fallow fields.

c. **Fragmentation** of Forests in the United States exposes nests to nest predators.

d. **House cats** are formidable predators that kill many songbirds.

e. The loss of tropical forests also deprives about 250 migratory songbirds of their wintering homes.