Birds

1) Aves
   a) Of all the modern animals birds can be easiest to identify, if it has feathers it's a bird, if it doesn't it's not a bird.
   b) All birds have forelimbs modified into wings
      i) Though these are not always used for flying
   c) All have beaks and lay eggs
   d) Even though not all birds fly, birds entire anatomy is designed around flight
      i) They have to have wings for lift
      ii) They need to reduce their body weight
      iii) They have to have a more efficient respiratory system to keep up with their high metabolic demand
      iv) They need to process an energy rich diet efficiently
      v) With the increased nutrients and metabolic demand they need an efficient circulatory system
      vi) Once flight evolved they needed a super-efficient nervous system to handle the complex senses that go along with flight.
2) Evolution
   a) Birds evolved about 147 million years ago during the Jurassic period
   b) Birds are basically just glorified reptiles
   c) They evolved from a group of two legged dinosaurs called **theropods**
      i) Theropods includes velociraptors, and similar dinosaurs
   d) Theropods had true reptilian characteristics, but one group of theropods began to develop different characteristics.
      i) Some developed filaments early on, later species developed feathers.
         (1) These developments were not for flight
         (2) The earliest forms probably developed to help with thermoregulation
      ii) We can also see the development of the beak followed by the loss of teeth.
3) Adaptations for flight
   a) Feathers
      i) Feathers are lightweight but their structure makes them incredible strong
         (1) Most feathers are called **contour** feathers
            (a) They have a hollow quill emerging from the skin
            (b) This turns into a shaft with barbs branching off of it
            (c) Each barb is like a mini feather branching off the center
            (d) Carbles overlap to make them more streamline and connect to each other by tiny hooks that keep the feathers together.
            (e) Like scales or hair, feathers are dead with no vascularization or nerves
            (f) Birds replace their feathers at least once a year through a **molt**
         (2) The remaining feathers are down feathers which lack the tiny hooks and puff out in order to keep heat in

b) Skeleton
    i) Flight is tough, gravity is relentless and pushing against air is hard
    ii) One way to help get off the ground is to be light
    iii) Bones of birds have evolved to be hollow with various air sacs in them
        (1) The frigate bird has a 7 foot wing span but is bones only weight 4 ounces (less than the weight of its feathers)
    iv) The remaining parts of the skeleton have become wider to accommodate muscle attachments
c) Muscular system
    i) The muscles associated with flight are proportionally huge
        (1) Pectoralis is the largest of the chest muscles that pull the wings down
    ii) The next biggest muscle is in the thigh but the feet are devoid of muscles
        (1) The feet have a special mechanism to lock in place when they are perched and asleep.
            (a) This is also the same mechanism that allows birds of prey to sink their talons into prey
d) Digestive system
    i) The digestive system is highly specialized and very efficient
        (1) In many predatory birds a whole mouse is digested in about 3 hours
        (2) Berries can pass in less than 30 minutes.
    ii) The mouth/jaw of the bird has evolved into a beak
        (1) Beaks are adapted for specialized use
            (a) Raven
            (b) Cardinal
            (c) Flamingo
            (d) Pelican
            (e) Woodpecker
    iii) Birds don't have a true stomach
        (1) Crop
            (a) Birds have a storage compartment to hold food until its ready to digest
            (b) Some birds produce a milk like substance in the crop that has high amounts of fats and proteins
                (i) This is used to feed young by regurgitating it.
        (2) Gizzard
            (a) The gizzard is a muscular part that is used for grinding food
                (i) Birds often swallow rocks and other hard objects to store in the gizzard
    iv) Digestion
        (1) The small intestine preforms the chemical digestion and absorption of nutrients
        (2) After food has passed through the small intestine it enter the large intestine
            (a) The large intestine absorbs water and a few nutrients.
            (b) At the junction of the small intestine and large intestine there is a structure called a **ceca**.
                (i) This holds bacteria and is used to break down plant material.

(ii) Plants are hard to break down into usable carbohydrates, so having a built in fermentation chamber is very useful.
(iii) This structure is present in all birds but much larger in herbivorous birds

(3) The waste exits out the cloaca in the form of uric acid

e) Circulatory systems
   i) Hearts are truly 4 chambers with a separate pulmonary system from the systemic system
   ii) Heart rates are fast compared to other reptiles and cold blooded organisms (birds are endotherms)
      (1) Heart rate is inversely related to body weight
         (a) Smaller you are the faster your heart
            (i) Turkeys – 93bpm
            (ii) Chicken- 250bpm
            (iii) Black capped chickadee- 500bpm while asleep!
   iii) Blood is **biconcave** shaped with a nucleus
      (1) Mammals also have this shape blood cell but without a nucleus
      (2) Birds appear earlier than mammals on the evolutionary tree and most likely evolved a more efficient respiratory system rather than ejecting the nucleus to help meet oxygen requirements.

f) Respiratory system
   i) The respiratory system is the most efficient in bids than any other organism
   ii) The biggest adaptation is the birds lung allows for continuous flow while others have a dead end alveoli.
   iii) Respiration works as follows:
      (1) During inhalation air is drawn into posterior air sacs
      (2) Then when the bird exhales that fresh air is pulled into the lungs
      (3) During the next inhalation the air in the lungs is drawn out into anterior air sacs
      (4) Finally that breath of air will exit during the next exhalation
         (a) This allows for only fresh highly oxygenated air to be brought into the lung and old deoxygenated air is sent out without mixing new and old.
   iv) This is so efficient it allows birds to maintain their high metabolic demands of flight and allows them to fly at higher altitudes where oxygen concentrations are lower
         (a) Bar-headed geese migrate over Mt. Everest (about 9,000 meters). This would be impossible for humans

g) Excretory system
   i) Birds have large efficient kidneys that filter water/salts out of the blood
      (1) Still not as efficient as mammals birds still retain salt glands
   ii) The waste is passed out the ureter directly into the cloaca (birds don't have bladders)
   iii) In the cloaca the uric acid combines with fecal waste and passed out.

h) Nervous system
   i) Birds have a highly developed brain with large optic lobes, cerebellum (processing center for muscles, sight, balance, and other things), and the cortex that plays a roll in cognitive thought.

ii) Birds have incredible sense of hearing and vision
(1) The **cochlea** is the structure in the ear that processes sound waves into nerve signals, it is very advanced allowing birds to have the best hearing in the animal kingdom
(2) Birds eyesight greatly surpasses other animals
(a) Their eyes are larger proportionally than other animals
(b) The eyes are immobile (birds turn their head not eye)
(c) They have **rods** (for dim light) and **Cones** (for color vision)
(d) A unique structure is called the **Pecten** this brings extra oxygen and nutrients to the retina
(e) Another unique thing is something called a **fova**
(i) Mammals and birds both have this structure on the retina but birds have 2
(ii) This area focuses light and has a high concentration of rods to increase sensitivity
(iii) This allows a hawk to spot a mouse in the grass at over 2 kilometers (almost a mile) away.
(f) Some birds can even see in the UV spectrum
(i) For birds like the humming bird it may be to help find flowers but others like ducks, kingfishers, pigeons it may be used for migrations.

4) Evolution of flight
a) Birds did not evolve wings to fly, flight was a byproduct of having wings
b) 3 hypotheses
i) Arboreal
(1) Started with life climbing trees for food/ or protection
(2) The most efficient way down is jumping this could be dangerous so the species with more feathers may have parachuted down
(3) Then the species with better feathers could begin to glide
(4) Finally a species would develop muscle to aid in flapping and thus fly
ii) Insect- net
(1) Using feathers on the arms to coral insect to be eaten
(2) This would favor broad long feathers that could lead to gliding and eventually flight
iii) Climbing
(1) To escape predators or capture prey being able to climb a steep hill would be to your advantage
(2) Using wings to aid is dashing up these hill would favor long broad feathers thus leading to gliding and eventually flight
c) Wings now come in different forms
i) Elliptical
(1) Best for maneuvering
(a) Woodpecker, flycatcher
ii) High speed wings
(1) Come to point for less air resistance
(a) Sparrow

iii) Soaring wings
(1) Long narrow wings for long flight
(a) Albatrosses
(2) Pass
iv) Passive soaring wings
(1) Land soarers that "hang" in the sky
(a) Vultures

5) Migrations
a) Many birds migrate great distances to breed and find food.
b) Migrations are triggered by changes in day length
i) Birds are very sensitive to sunlight
ii) They use it to know when to migrate and what direction to go
c) The longest migration is by the artic turn
i) It breeds at the north pole during June/July then travels to the south pole (11,200 miles away) during the southern hemispheres summer (January/ February)

6) Reproduction
a) Male usually lack a penis so to fertilize they have to bring cloaca surfaces together.
b) Oddly only the left ovary works in most birds the right never forms (probably a way to reduce weight)
i) When an egg is released from the ovary it travels down the oviduct where it is fertilized
ii) From there **albumin** is added (egg white) and finally a specialized shell gland adds the hardened shell around the egg
c) Mating can be **monogamous** (one partner) or **polygamous** (multiple partners)
i) Monogamy is almost inexistent in most animal species with the exception of birds
ii) 90% of birds practice some form of monogamy
(1) The most common type is seasonal monogamy
(a) Since mating only happens once a year for many birds they will mate with one partner that year. Then the next year they may mate with another partner.
(b) This works well because unlike mammals or other groups both male and female are equally adapted for parental care and the work can be devided.
(2) True monogamy does happen in birds such as swans, geese, penguins, and a few other non-migratory birds.
(a) More research has found that this is becoming less and less true it appears many males may mate with multiple females but only help one female raise their offspring
(b) Its not just the males, females can lay multiple eggs at a time and these eggs can be fertilized by more than one male. Studies have shown that it is very rare to find all the eggs fertilized by the same male.
d) Nesting
i) Most birds have some form of nest to incubate eggs
ii) Some build incredibly elaborate nest
(1) Orioles
(2) Hummingbirds

iii) Some birds are **nest parasites**.
(1) The brown-headed cow bird, and kookaburras lay their eggs in smaller species nest so that when they hatch the other species feeds them as if they where her own and that offspring being much more vocal and large outcompetes the others.
(2) Wood duck do something similar except they lay eggs in other wood duck nests so that that duck raises their offspring

7) Species of interest
a) Starlings and house sparrows
i) These are the most abundant species on earth (including the US and GA)
ii) In 1890, 60 of each species were released into central park New York in an effort to bring every bird mentioned in Shakespeare plays to America (I know it's a dumb as it sounds), these few birds quick spread across the country.
b) Dodo bird
i) They were tasty! Now extinct
c) Passenger pigeon
i) These were once so common in the south that they literally blackened out the sky.
ii) But apparently they were really easy to kill and were hunted to extinction the last one dies in captivity in 1914
d) Ostrich
i) Native to Africa is the largest bird in the world (2.5 meters tall)
ii) They are flightless but incredibly fast
e) Crows/ravens
i) Supper smart!
ii) Have been shown to be able to count
iii) Can not only use tools to solve problems but can create tools to solve problems
iv) They can learn from their environment
(1) Crown will wait at red lights with oysters and put them under car wheels
(2) The car crushes them and then on the next red light the crow goes and gets the crushed oyster to eat
(3) They have figured out automatic doors at grocery stores so they can open them go in get a snack and leave
f) White pelicans
i) Cooperate to hunt fish
ii) They make a horse shoe to coral fish then scoop them up with their beaks to eat
g) Lyre bird
i) Shows the extreme abilities of bird communication by not only mimicking other bird calls but also chain saws, car alarms and anything else it hears
h) Parrots
i) Talking little guys