Nervous System: Brain and Senses

Structural parts of brain similar in all vertebrates but they differ in their complexity and organization.

Bird brain is organized differently

I. Overview

A. Systems

Nervous system consists of

- Central Nervous System – brain and spinal cord

• Peripheral Nervous System – cranial & spinal nerves, autonomic nerves, and sense organs

B. Functions

- obtain information about internal and external environment
- analyze and respond to information
- store information
- coordinate outgoing motor impulses to skeletal muscles and viscera

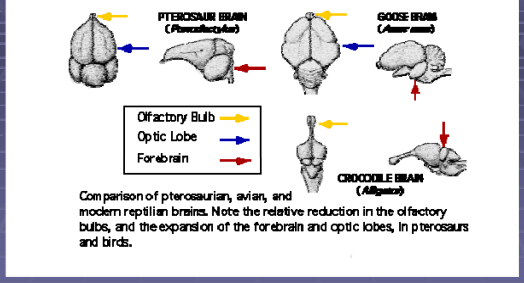
II. Brain

A. Characteristics

Because of shared ancestry

brains of reptiles and birds are similar

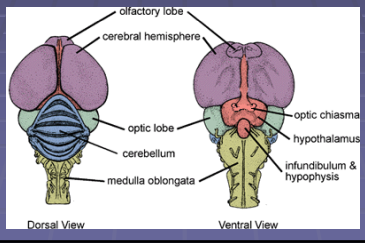
- larger cerebral hemispheres
- larger cerebella
- larger optic lobes
- smaller olfactory bulbs



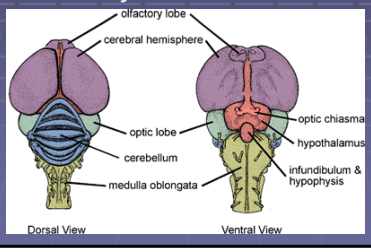
Comparison of pterosaurian, avian, and modern reptilian brains. Note the relative reduction in the olfactory bulbs, and the expansion of the forebrain and optic lobes, in pterosaurs and birds.

B. Generalized Anatomy

- medulla – part of brainstem, helps control heart rate, respiration, blood pressure
- optic lobe – part of midbrain, large in birds



- cerebellum – coordination of skeletal muscle activity, large in birds
- cerebrum – 2 hemispheres plus olfactory lobes, sensory information relayed here, learned information stored, send motor nerves to body



Cerebral hemishpheres consist of 2 regions

dorsal - Pallium

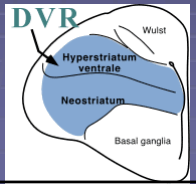
ventral – SubPallium

all vertebrates have cerebrum based on same basic plan

Changes due to loss, fusion or enlargement of various regions

Reptiles – Pallium has dorsal ventricular ridge (DVR)

Birds – DVR expands further and includes hyperstriatum plus wulst (unique to birds, serve as center of learning and intelligence)



Mammals – do not have enlarged DVR but Pallium is enlarged (cerebral cortex)

Requirement for sophistication in

- sensory processes
- motor control
- behavior

selective forces driving development and volume of DVR

DVR best developed in

- Crows, Magpies, Jays
- Parrots

Least developed

- Pigeons, Doves
- Quail, Chickens

C. Memory

Birds remember where and when food cached

Clayton and Dickinson 1998

Nature 395:272-278

Episodic Memory

1st demonstration in

animals other than

humans

Type referred to as “mental time travel” it involves mental images of past events

“Where did I put my keys”

– visualize yourself night before walking into house

Making decisions based on timing of past events critical for episodic memory

Allowed Scrub Jays to cache favorite food (waxworms) on 1 side of sand tray

Peanuts cached on other

Jays retrieved wax worms if less than 4 hours old

Learned wax worms decompose

avoided older waxworms in favor of peanuts

D. Single Hemisphere Sleep

Birds are able to sleep with ½ brain active

Brain hemispheres alternate sleep

(Rattenborg et al. 1999. Nature 397:397)

Eye controlled by "sleeping hemisphere" droops shut, eye controlled by alert hemisphere is open.

Evident in flocks

Predict extra vigilance in end of row sleepers.

End birds tended to keep eye open on side away from flock mates. Birds toward center no preference.

Only been identified in birds, aquatic mammals (dolphins, whales, seals, manatees).

Why?

III. Sense Organs

A. Tactile

Touch receptors (Herbst corpuscles) abundant in bills of some birds

Waterfowl

Shorebirds

Tongues of woodpeckers

Piersma et al. 1998. Proc. Royal Soc. London B. 265:1377.

Red Knots

Locate shellfish in wet sand by probing bill ~ ½ cm into sand

Hid small stones in sand (simulating shell fish)

Knots could not find them in dry sand.

- must be due to differences in currents of water in wet sand between particles.

Knots have 10 – 20 Herbst corpuscles sensitive to differences in pressure.

When bill inserted into wet sand creates a pressure wave because of inertia in water between sand particles and stones.

Rapid up and down movements of bird's bill packs the sand, displacing interstial water, causing residual pressure surrounding object to increase.

Knots can not distinguish between shellfish and stones – thus

they never are found foraging in sand with stones!!

B. Olfaction

- based in surface epithelium of olfactory cavities
- traditionally thought limited
- most probably can smell to some extent
- well developed sense in

Turkey Vultures, Kiwis, Albatrosses, Petrels

C. Taste

compared to other vertebrates – have few taste buds

Chicken – 24

Starling – 200

Mallard – 375

Lizard - ~550

Humans – 9,000

Catfish – 100,000

- located on back of tongue and floor of pharynx
- some have well developed sense of taste

Sanderlings & Dunlins can distinguish between sand where no worms had been present and sand where worms were present!

Hummingbirds can distinguish solutions with different sugar concentrations

- many species can tolerate high acidic and alkaline solutions (can tolerate unripe fruit)