DURING THE EVOLUTION OF THE VERTEBRATE BRAIN, THE MIDBRAIN DECREASES IN SIZE, WHILE THE FOREBRAIN INCREASES

The brain of the earliest vertebrates was probably just a modest enlargement of the anterior end of the spinal nerve cord, but vertebrate evolution is marked by **cephalization**, the tendency for the sense organs and neural control to be concentrated in an anterior head. The brain becomes the coordinating center and gradually assumes control over the rest of the nervous system. The anterior end is usually the first to encounter new environmental stimuli. Consequently, natural selection favored development of the major sense organs in this region, which, in turn, led to the enlargement of the anterior end of the spinal cord.

The ancestral vertebrate brain and the partly developed brains of all vertebrate embryos consist of three irregular swellings at the anterior end of the spinal cord. These three regions, designated the **forebrain**, the **midbrain**, and the **hindbrain**, underwent much modification in the course of evolutionary development of the more complex vertebrates. Often specially thickened areas form in their walls and distinctive enlargements and outgrowths occur in other places. Despite these changes, however, the original three divisions of the brain can still be recognized even in the mature forms of the most elaborated vertebrates, including humans.

The trend in vertebrate evolution has been toward more complex neural pathways within the central nervous system, and increasing dominance by the brain. And because active animals require accurate sensory information about the environment around them, natural selection favored the elaboration of the sense organs and the development of complex neural networks within the brain to process and integrate the sensory information. The brain became an area for analysis and integration. With this enhanced integrative skill came the ability to perform more complex and more flexible behavioral patterns.

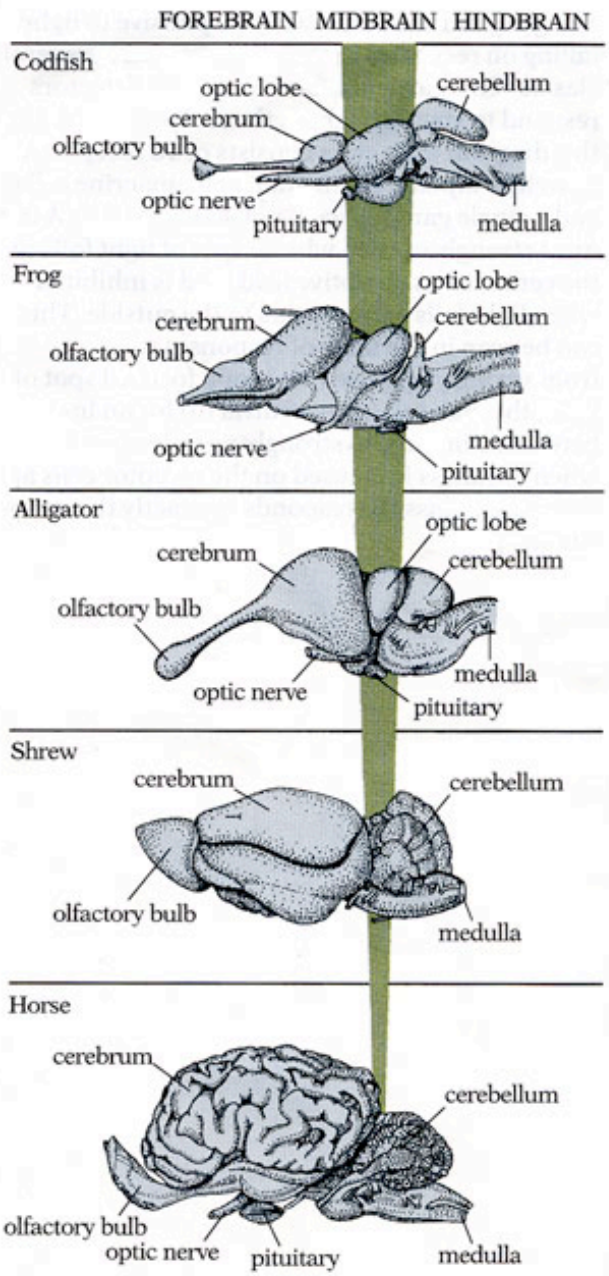
Very early in its evolution, the vertebrate brain underwent modifications that set the stage for later evolutionary trends. Briefly, the modifications were these:

1) The hindbrain became divided into a ventral portion, called the **medulla oblongata**, and a dorsal portion, the **cerebellum**, and the anterior **pons**. The medulla became specialized as a control center for some autonomic and somatic pathways concerned with vital functions (such as breathing, blood pressure, and heartbeat) and as a connecting tract between the spinal cord and the more anterior parts of the brain. The pons is above the medulla and also acts as a connecting tract. The cerebellum enlarged and became a structure concerned with balance, equilibrium, and muscular coordination.

2. The midbrain became specialized as the **optic lobes**, visual centers associated with the optic nerves.

3. The forebrain became divided into an anterior portion consisting of the **cerebrum**, with its prominent olfactory bulbs, and a posterior portion consisting of the **thalamus** and **hypothalamus**.

During the course of vertebrate evolution, there have been few changes in the midbrain, though the cerebellum has become larger and more complex in many animals. The truly major evolutionary change has been the steady increase in size and importance of the cerebrum, with a corresponding decrease in relative size and importance of the midbrain (see Figure).



The ancestral cerebrum was only a pair of small smooth swellings concerned chiefly with the sense of smell. The gray matter (cell bodies and synapses) of the brain as mostly internal, as it is in the spinal cord. The synapses functioned predominantly as relays between the olfactory bulbs and more posterior parts of the brain; little, if any, processing of sensory information occurred in the cerebrum. The cerebrums of modern fishes are still little more than relay stations, although the areas of gray matter are more massive. In amphibians, which evolved from ancestral fish, there was an expansion of the gray matter and a multiplication of synapses between neurons. No longer was the cerebrum only a relay station; it now functioned as a processing center for impulses coming to it from various sensory areas of the brain. Slowly, much of the gray matter moved outward from its initially internal position, until it came to lie on the surface of the cerebrum. This layer is known as the **cerebral cortex**. Finally, in certain derived reptiles a new component of the cortex, called the **neocortex** (or neopallium), arose at a point on the anterior surface of the cerebrum. Mammals, which evolved from reptiles of this type, show the greatest development of the neocortex.