DOWNLOAD PDF COMPARATIVE ANATOMY OF THE NERVOUS SYSTEM OF VERTEBRATES, INCLUDING MAN

Chapter 1 : Elizabeth C. Crosby - Wikipedia

This exhaustive review of the comparative anatomy of the vertebrate nervous system is more than an accumulation of anatomical facts. It attempts to answer why the phylogenetic development of the.

We cannot study behavior in fossils or the internal structure of the brain of organisms long dead. In our lifetimes, we experience but a very brief interlude in the long evolutionary process. What leads us to believe that it is possible to investigate the evolution of the brain and its relation to behavior? An answer lies in the encouragement investigators obtain from examining the brains of those contemporary organisms which have close links with their fossil ancestors. Patterns in the brain are found which are common to these and different species suggesting parallels with common ancestry. Comparative behavior provides similar encouraging parallels. In practice, it is reasonable to suggest that comparative neurology and comparative behavior have information to offer which is relevant for evolutionary theory and, conversely, that evolutionary perspective provides a framework for making sense out of comparative material. Historical highlights and approaches C. Herrick was moved by such considerations when he founded the Journal of Comparative Neurology in His original vision was that the study of comparative neuroanatomy could be integrated with the study of comparative behavior. Herrick, such as C. Coghill, continued in the tradition of the elder Herrick after his death. Herrick concentrated on the connections found in amphibian nervous systems, relating his information to the findings of workers who used other forms and interpreting the possible significance of the described connections. Coghill spent much of his life in the study of the development of the nervous system of the salamander, in conjunction with a study of the development of behavior. Both Coghill and C. Herrick worked in an era of considerable interest in comparative neuroanatomy. Concurrently, others studied comparative behavior effectively without a simultaneous study of the structure of the nervous system , but they did not overlook the possibility of relating behavior to the nervous system. Characteristically, their studies were concerned with discriminative capacities, learning abilities, tropisms, stereotypical behavior, and sensitivities in various species. Lashley was noted for his studies of the role of the mass of cerebral tissue in learning and intelligence. Sherrington was concerned primarily with the problems of the organization of the nervous system in the regulation of reflex actions. Pavlov had a similar broad concern but an entirely different approach, stressing the general concept that the study of the elicitation or suppression of reflexes by systematically paired, concurrent stimulation was the key to understanding the role of the cerebral cortex. Although the work of many of the men whose names are mentioned here and of numerous contemporary workers has never been specifically addressed to the problems of the evolution of the brain and behavior, much of the data is relevant. The information accumulated and available is overwhelming but riddled with hidden error, gaps, and misconceptions. Since the work on behavior and the nervous system is being done on various species, we are obliged to make explicit our views of the relationships of these organisms, including man, if we hope to extrapolate results from one species to another. Specifically, we must clarify the evolutionary perspective with which comparative work is to be viewed. Attributes of the central nervous system The common origins of the various vertebrate species are reflected in the organization of the brain and spinal cord. Man, as would be expected, possesses the neuroanatomical characteristics of the vertebrates in general, the mammals in particular, and the primates especially. Among the primates, progressively greater proportions of neocortex are found in successively evolved representatives Clark Sensorimotor and central systems of connections The portions of the nervous system most directly significant for behavior are the connections formed by the processes of the billions of nerve cells. Microscopic examination of suitably prepared biological material reveals the connections to be systematically organized. Systems of connections exist within the central nervous system which allow identification of the sensory routes, the motor pathways, and the organization of central connections. It is a common feature of the vertebrates that the sensory pathways have a continuity with motor pathways at various levels. We speak, therefore, of sensorimotor continuities which form the basis of simple and complex reflexes. Together with the action of central systems, the outcome of activity of higher continuities may become considerably more elaborate than the reflexes. First-level sensorimotor continuity The simplest reflex is formed by the continuity of sensory cells and motor cells, the sensory cells sending their processes directly to the motor cells. Such reflexes are represented in the spinal cord and in the brain stem and are common to all vertebrates. The reflex closing of the jaws as they tend to open of their own weight is an example of the simplest reflex, the two-neuron or monosynaptic reflex. Stretch receptors in the jaw muscles conduct the excitation directly into the brain via sensory neurons. The muscle stretched is the same muscle that is thereby stimulated to contract. The simplest reflexes are segmental reflexes, the afferent and efferent neurons belonging to the same segment or segment fraction. Vertebrate segmentation is comparable in terms of embryological origins, and the concept of segmentation is used to include the structures related to each of the fifth, seventh, ninth, and tenth cranial nerves. The jaw muscles, for example, which possess an afferent and efferent supply from the same segment fifth nerve , tend to remain reflexly in a steady state as they respond to the steady pull of gravity. The significance of the reflexes of a segment fraction is more far-reaching than indicated thus far. The first-level reflexes are the reflexes of sustained activity tonic reflexes , and they are generally opposed by the second-level reflexes. The reflexes of the first and second levels form a reciprocal dichotomy. We are dealing here with only the first half of the dichotomy. Tonic reflexes are supported by cutaneous stimulation as well as by stretch stimulation. The skin is systematically supplied by spinal nerves and cranial nerves in a segmental pattern. In all vertebrates, particular portions of the body surface belong to distinct segments or segment fractions. As in the stretch reflex , it is reasonable to suggest that moderate stimulation of a given area of the body surface results in reflex action which is prolonged and keeps the stimulated body surface in continuing contact with the stimulus. The extensor muscles of the limbs, in response to stimulation of the toe pads, reflexively support the standing posture of the quadruped and thus enhance the continuing stimulus. The radial nerve which innervates the dorsal surface of the hand also supplies the extensor muscles in the upper limb. The median nerve supplies the palmar surface and the flexor muscles of the hand. The grasp reflex of the human infant is understandable in a similar way. Second-level sensorimotor continuity The reflexes of the second level form the other half of the reciprocal dichotomy. Each of the first-level reflexes can be inhibited and replaced by an antagonistic action when the stimulus strength changes from moderate to intense. A thorn in the knuckle of the ape prevents extension and produces flexion. A beesting to the palmar surface will break the grasp reflex and produce opening extensor action of the hand. These are examples of the basic withdrawal reflexes which depend upon inhibition of the simpler reflexes in order to appear. They are polysynaptic reflexes which also depend upon sensorimotor continuities in the spinal cord and brain stem. It is reasonable to regard these second-level reflexes as discharging motor neurons in segment fractions adjacent to the stimulus and inhibiting motor neurons in the same segment fraction as the originating stimulus. The second-level continuities are common to all vertebrates. In vertebrates without appendages the form of the first-level and second-level reflex organization need not differ fundamentally from that found in the other vertebrates. It is characteristic of all vertebrates that the cutaneous portion of the fifth nerve, which provides the nerve supply to the face, extends its fibers into the cervical spinal cord, where contact is established with motor neurons controlling the neck musculature. The arrangement allows for reflex turning of the head toward or away from the side of cutaneous stimulation. When the stimulus to one side of the face is strong, the neck musculature reflexly turns the head away from the stimulus. When the stimulus is moderate, the neck musculature turns the head toward the side of the stimulus. It is instructive to note with regard to the above statements that the larval form of the primitive eel, Petromyzon marinus, shows reactions comparable to those of the human infant. The infant turns its head toward the nipple as it contacts the cheek but turns its head away if the cheek is pinched. The larval form of Petromyzon marinus burrows into the mud of the river bed. The burrowing is accomplished by undulatory movements of the entire body as the organism penetrates the mud head first. It is logical to expect that, as it burrows, it presses the side of its head first to one side and then to the other side of the hole it makes as it burrows. It would be consistent with effective burrowing for the larva to continue to press to one side until the cutaneous stimulus became strong on that side and then to reverse its pressing, the pressing continuing on the other side until the stimulus there became strong, and so on to produce successive undulations starting near the head and proceeding tailward down the body until the animal has gone far into the mud by the forward propulsion of these undulations. Copulatory reflexes, which are, of course, essential for species propagation, may be viewed as special instances of alternating first-level tonic, thrusting and second-level withdrawal reflexes. Third-level sensorimotor continuity A continuity of sensory to motor fibers is established through the medial reticular formation of the brain stem in all vertebrates. Sensory fibers of the dorsal root ganglia connect with interneurons of the spinal cord. Many of these interneurons send their processes directly to the large cells of the medial reticular formation. It should be said parenthetically that the brain-stem reticular formation consists of a meshwork of cell bodies and fibers in the core of the brain stem, and it is in the medial part thereof that the large cell bodies are situated. The large cell bodies send processes back to interneurons of the spinal cord, where contact with motor neurons can be made. The medial reticular formation is also influenced by cranial nerves, which directly contact the dorsolateral portion of the reticular formation. The dorsolateral portion, in turn, connects with the medial reticular formation. The significance of the third level of continuity lies in providing a route through which existing reflex activity may be enhanced and competing, antagonistic reflex activity may be weakened. It is a route through which stimulation arising in one segmental fraction may influence sensorimotor action in more widely distributed segments or many segments at once. In concert with intersegmental spinal connections, the third level stabilizes the stereotyped whole-body postures of terrestrial forms and the stereotyped whole-body movements of aquatic forms. In stabilizing the upright posture of the vertebrate, the reticular role is heavily dependent on the action of the vestibular nerves. Vestibular reflexes, stimulated by the pull of gravity, define the symmetrical, upright posture of the head and body. Magnification of the action is achieved through level 3. Except for primates in which even higher levels of sensorimotor continuity are required for effective standing, level 3 is adequate for maintaining an exaggerated, crude, upright position. When the organism is ill or weary, however, the upright posture collapses. The mechanism of the action is unknown, but it is evident that the vestibular reflexes and the actions of level 3 are considerably diminished under such circumstances. It is possible that a source of inhibition on the medial reticular formation rather than simply an exhaustion of reticular activity enforces the resourcerestoring condition of rest. Fourth-level sensorimotor continuity Interneurons of the spinal cord, serving spinal afferents, and neurons of the brain stem, serving cranial nerve afferents, distribute axons to the cerebellar cortex. The cerebellar cortex, in turn, connects with deep cerebellar nuclei, which send axons to the medial reticular formation. These connections form the fourth level of sensorimotor continuity. The arrangement is one which allows sensory feedback to have a regulative impact on the actions of the medial reticular formation. Broadly speaking, sensory elements responding to muscle tension and elements responding to moderate cutaneous stimulation are sources of negative feedback. Elements responding to intense stimulation such as pain are sources of positive feedback , which serves to sensitize all reflexes except the first-level reflex to the local stimulus. The vestibular nerve connects directly with the fourth level. Typically, the result of vestibular activity is dependent on asymmetry of stimulation of the vestibular receptors on the two sides.

Chapter 2 : Read Download Comparative Anatomy Of The Vertebrates PDF â€“ PDF Download

The Comparative Anatomy of the Nervous System of Vertebrates Including Man.. Toward a True Understanding of the Nervous System.

Dendrite There are literally hundreds of different types of synapses. In fact, there are over a hundred known neurotransmitters, and many of them have multiple types of receptors. Molecular neuroscientists generally divide receptors into two broad groups: When a chemically gated ion channel is activated, it forms a passage that allows specific types of ions to flow across the membrane. Depending on the type of ion, the effect on the target cell may be excitatory or inhibitory. When a second messenger system is activated, it starts a cascade of molecular interactions inside the target cell, which may ultimately produce a wide variety of complex effects, such as increasing or decreasing the sensitivity of the cell to stimuli, or even altering gene transcription. Nevertheless, it happens that the two most widely used neurotransmitters, glutamate and GABA , each have largely consistent effects. Glutamate has several widely occurring types of receptors, but all of them are excitatory or modulatory. Similarly, GABA has several widely occurring receptor types, but all of them are inhibitory. Strictly speaking, this is an abuse of terminologyâ€”it is the receptors that are excitatory and inhibitory, not the neuronsâ€”but it is commonly seen even in scholarly publications. One very important subset of synapses are capable of forming memory traces by means of long-lasting activity-dependent changes in synaptic strength. This change in strength can last for weeks or longer. Since the discovery of LTP in , many other types of synaptic memory traces have been found, involving increases or decreases in synaptic strength that are induced by varying conditions, and last for variable periods of time. Neural circuits and systems The basic neuronal function of sending signals to other cells includes a capability for neurons to exchange signals with each other. Networks formed by interconnected groups of neurons are capable of a wide variety of functions, including feature detection, pattern generation and timing, [47] and there are seen to be countless types of information processing possible. Warren McCulloch and Walter Pitts showed in that even artificial neural networks formed from a greatly simplified mathematical abstraction of a neuron are capable of universal computation. Descartes believed that all of the behaviors of animals, and most of the behaviors of humans, could be explained in terms of stimulus-response circuits, although he also believed that higher cognitive functions such as language were not capable of being explained mechanistically. The circuit begins with sensory receptors in the skin that are activated by harmful levels of heat: If the change in electrical potential is large enough to pass the given threshold, it evokes an action potential, which is transmitted along the axon of the receptor cell, into the spinal cord. There the axon makes excitatory synaptic contacts with other cells, some of which project send axonal output to the same region of the spinal cord, others projecting into the brain. One target is a set of spinal interneurons that project to motor neurons controlling the arm muscles. The interneurons excite the motor neurons, and if the excitation is strong enough, some of the motor neurons generate action potentials, which travel down their axons to the point where they make excitatory synaptic contacts with muscle cells. The excitatory signals induce contraction of the muscle cells, which causes the joint angles in the arm to change, pulling the arm away. In reality, this straightforward schema is subject to numerous complications. Furthermore, there are projections from the brain to the spinal cord that are capable of enhancing or inhibiting the reflex. Although the simplest reflexes may be mediated by circuits lying entirely within the spinal cord, more complex responses rely on signal processing in the brain. The initial sensory response, in the retina of the eye, and the final motor response, in the oculomotor nuclei of the brain stem, are not all that different from those in a simple reflex, but the intermediate stages are completely different. Instead of a one or two step chain of processing, the visual signals pass through perhaps a dozen stages of integration, involving the thalamus, cerebral cortex, basal ganglia, superior colliculus, cerebellum, and several brainstem nuclei. These areas perform signal-processing functions that include feature detection , perceptual analysis, memory recall , decision-making , and motor planning. At each stage, important information is extracted from the signal ensemble and unimportant information is discarded. By the end of the process, input signals representing "points of light" have been transformed into a neural representation of objects in the surrounding world and their properties. The most sophisticated sensory processing occurs inside the brain, but complex feature extraction also takes place in the spinal cord and in peripheral sensory organs such as the retina. Intrinsic pattern generation Although stimulus-response mechanisms are the easiest to understand, the nervous system is also capable of controlling the body in ways that do not require an external stimulus, by means of internally generated rhythms of activity. Because of the variety of voltage-sensitive ion channels that can be embedded in the membrane of a neuron, many types of neurons are capable, even in isolation, of generating rhythmic sequences of action potentials, or rhythmic alternations between high-rate bursting and quiescence. When neurons that are intrinsically rhythmic are connected to each other by excitatory or inhibitory synapses, the resulting networks are capable of a wide variety of dynamical behaviors, including attractor dynamics, periodicity, and even chaos. A network of neurons that uses its internal structure to generate temporally structured output, without requiring a corresponding temporally structured stimulus, is called a central pattern generator. Internal pattern generation operates on a wide range of time scales, from milliseconds to hours or longer. One of the most important types of temporal pattern is circadian rhythmicity â€”that is, rhythmicity with a period of approximately 24 hours. All animals that have been studied show circadian fluctuations in neural activity, which control circadian alternations in behavior such as the sleep-wake cycle. Experimental studies dating from the s have shown that circadian rhythms are generated by a "genetic clock" consisting of a special set of genes whose expression level rises and falls over the course of the day. Animals as diverse as insects and vertebrates share a similar genetic clock system. The circadian clock is influenced by light but continues to operate even when light levels are held constant and no other external time-of-day cues are available. The clock genes are expressed in many parts of the nervous system as well as many peripheral organs, but in mammals, all of these "tissue clocks" are kept in synchrony by signals that emanate from a master timekeeper in a tiny part of the brain called the suprachiasmatic nucleus. Mirror neurons A mirror neuron is a neuron that fires both when an animal acts and when the animal observes the same action performed by another. Such neurons have been directly observed in primate species. Some researchers also speculate that mirror systems may simulate observed actions, and thus contribute to theory of mind skills, [66] [67] while others relate mirror neurons to language abilities. Development of the nervous system In vertebrates, landmarks of embryonic neural development include the birth and differentiation of neurons from stem cell precursors, the migration of immature neurons from their birthplaces in the embryo to their final positions, outgrowth of axons from neurons and guidance of the motile growth cone through the embryo towards postsynaptic partners, the generation of synapses between these axons and their postsynaptic partners, and finally the lifelong changes in synapses which are thought to underlie learning and memory. The gastrula has the shape of a disk with three layers of cells, an inner layer called the endoderm , which gives rise to the lining of most internal organs, a middle layer called the mesoderm , which gives rise to the bones and muscles, and an outer layer called the ectoderm , which gives rise to the skin and nervous system. The inner portion of the neural plate along the midline is destined to become the central nervous system CNS , the outer portion the peripheral nervous system PNS. As development proceeds, a fold called the neural groove appears along the midline. This fold deepens, and then closes up at the top. At this point the future CNS appears as a cylindrical structure called the neural tube , whereas the future PNS appears as two strips of tissue called the neural crest , running lengthwise above the neural tube. The sequence of stages from neural plate to neural tube and neural crest is known as neurulation. In the early 20th century, a set of famous experiments by Hans Spemann and Hilde Mangold showed that the formation of nervous tissue is "induced" by signals from a group of mesodermal cells called the organizer region. Induction of neural tissue requires inhibition of the gene for a so-called bone morphogenetic protein , or BMP. Specifically the protein BMP4 appears to be involved. Two proteins called Noggin and Chordin , both secreted by the mesoderm, are capable of inhibiting BMP4 and thereby inducing ectoderm to turn into neural tissue. It appears that a similar molecular mechanism is involved for widely disparate types of animals, including arthropods as well as vertebrates. In some animals, however, another type of molecule called Fibroblast Growth Factor or FGF may also play an important role in induction. Induction of neural tissues causes formation of neural precursor cells, called neuroblasts. A GMC divides once, to give rise to either a pair of neurons or a pair of glial cells. In all, a neuroblast is capable of generating an indefinite number of neurons or glia. As shown in a study, one factor common to all bilateral organisms including humans is a family of secreted signaling molecules called neurotrophins which regulate the growth and survival of neurons. DNT1 shares structural similarity with all known neurotrophins and is a key factor in the fate of neurons in Drosophila. Because neurotrophins have now been identified in both vertebrate and invertebrates, this evidence suggests that neurotrophins were present in an ancestor common to bilateral organisms and may represent a common mechanism for nervous system formation. Psychiatry Layers protecting the brain and spinal cord. The central nervous system is protected by major physical and chemical barriers. Physically, the brain and spinal cord are surrounded by tough meningeal membranes, and enclosed in the bones of the skull and vertebral column , which combine to form a strong physical shield. Chemically, the brain and spinal cord are isolated by the bloodâ€”brain barrier , which prevents most types of chemicals from moving from the bloodstream into the interior of the CNS. Although nerves tend to lie deep under the skin except in a few places such as the ulnar nerve near the elbow joint, they are still relatively exposed to physical damage, which can cause pain, loss of sensation, or loss of muscle control. Damage to nerves can also be caused by swelling or bruises at places where a nerve passes through a tight bony channel, as happens in carpal tunnel syndrome. If a nerve is completely transected, it will often regenerate , but for long nerves this process may take months to complete. Many cases have no cause that can be identified, and are referred to as idiopathic. It is also possible for nerves to lose function temporarily, resulting in numbness as stiffnessâ€”common causes include mechanical pressure, a drop in temperature, or chemical interactions with local anesthetic drugs such as lidocaine. Physical damage to the spinal cord may result in loss of sensation or movement. If an injury to the spine produces nothing worse than swelling, the symptoms may be transient, but if nerve fibers in the spine are actually destroyed, the loss of function is usually permanent. Experimental studies have shown that spinal nerve fibers attempt to regrow in the same way as nerve fibers, but in the spinal cord, tissue destruction usually produces scar tissue that cannot be penetrated by the regrowing nerves. Principles of Anatomy and Physiology 15th edition.

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The comparative anatomy of the nervous system of vertebrates, including man (2 volumes) C. U. Ariens Kappers, G. Carl Huber, Elizabeth Caroline Crosby.

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Chapter 9 : Vertebrates: Comparative Anatomy, Function, Evolution

The nervous system of vertebrates (including humans) is divided into the central nervous system (CNS) and the peripheral nervous system (PNS).. The (CNS) is the major division, and consists of the brain and the spinal cord.