

Phylogenetical evolution of the kidney in vertebrates

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Phylogenetical evolution of the kidney in vertebrates The kidneys are the result of an evolutionary process revealed by their own structure in the vertebrates. The excretory system develops from the mesoderm in all vertebrates. The nephrogenic material has metameric segmentation only in amniotes and forms nephrotomes only in its upper part. The caudal part is non-metameric and forms a renal blastema from which the nephrons will differentiate later. In its most primitive form, the nephron is a simple tube opening through a nephrostome in the general cavity and through the other extreme in the Wolffian duct. Three stages characterise the evolution of the nephron. The first stage is the open nephron with external glomerulus. The glomerulus, a cluster of capillaries, is enclosed in the small evagination of peritoneum near the nephrostome. In the second stage, the open glomerulus develops on the nephron and the nephrostome is still present. A double-walled capsule surrounds the glomerulus of a nephron. In the third stage, the nephrostome disappears and the nephron is closed with internal glomerulus. In vertebrates, the urinary system develops in three stages, forming three succeeding organs in the cranio-caudal direction: the pronephros, the mesonephros and the metanephros. The pronephros appears in any vertebrate embryo. It arises from cervical nephrotomes starting with segment 2-3. Every nephrotome forms a nephron opening in a common collection duct, the pronephric duct that ends in the cloaca. The pronephros is the morphological and functional kidney of the cyclostomes and cartilaginous fish, under the form of a lymphoid organ called cephalic kidney. The mesonephros arises from the nephrogenic material of the thoracolumbar region that lies on the embryonic sides from the pronephros to the pelvic region. The mesonephric nephrons have an internal glomerulus enclosed in a capsule. The nephrostomial orifices disappear. The nephrons use the pronephros duct, now called the Wolffian duct or the primary ureter. The mesonephros is a large organ with pectinate aspect because of its numerous transverse canaliculi. Its appendix is a port system. The mesonephros becomes the functional kidney in adult cyclostomes, fish and amphibians. The metanephros is the most complex kidney structure, as the functional kidney of amniotes. It develops from the nephrogenic blastema in the caudal regional, near the cloaca. It is always drained by a secondary ureter arising from a diverticulum of the Wolffian duct, from which the whole excretory system grows. Its nephrons have the most developed structure and function, do not have nephrostomes and contain internal glomerulus. The fact that the three kidney types succeed one another in the ontogenetic development proves that the evolution of the kidney started from the pronephros to the metanephros and structurally from the open nephron with external glomerulus to the complex nephron with internal glomerulus.