expression of *Hox* genes originally regulating rear-limb development. Alternatively, both forelimbs and hind limbs might have evolved from a single, continuous lateral fin fold, which was once hypothesized as being the primitive condition for the ancestors of vertebrates with paired fins. Coates (1993, 1994) responded with extensive evidence from the fossil record demonstrating that the pectoral girdle evolved in several groups of primitive fish prior to the appearance of the pelvic fin, and that no vertebrates were known to have had a continuous lateral fin fold.

The oldest adequately known fossils of craniates, from the Middle Ordovician (Gagnier 1993), have a continuous covering of dermal bone over the head and trunk, back to the base of the tail, clearly precluding the presence of any paired fins. A large number of craniate lineages are known by the beginning of the Devonian, representing all the major groups of aquatic vertebrates. These show many different stages in the origin of paired fins. Unfortunately, the interrelationships of these groups are not well established, and it is still very difficult to distinguish whether different stages in the elaboration of paired fins can be attributed to a succession of changes within a particular lineage, or if they have evolved separately in different groups. The general picture is that the earliest craniates lacked any trace of paired fins, and that the pectoral and pelvic fins evolved separately but in that order: Pelvic fins are never found in the absence of pectoral fins; nor is there any fossil evidence that once-continuous lateral fin folds may have divided to form successive anterior and posterior fins (Carroll 1987).

Although most of the well-known genes that control limb development are the same as those expressed in the posterior trunk region, a few are not. *Hoxb-8* is expressed in both the anterior and posterior limbs early in development in the mouse, but it is involved with further development only in the pectoral limb (Charité et al 1994). *Hoxc-6* is expressed in the formation of the pectoral limb field in mice, the frog *Xenopus,* and zebra fish; it is also involved in regeneration of both the front and hind limbs in the salamander *Notophthalmus* (Savard and Tremblay 1995), and is expressed in the front and hind limbs of the frog *Xenopus,* although in low concentrations. In addition, *Hoxb-5* is involved in determining the position of the shoulder girdle in mice (Rancourt, Teruhisa, and Capecchi 1995).

The pattern of expression of these genes in modern bony fish and tetrapods suggests that development of paired appendages may originally have been regulated by *Hox* genes common to the appropriate portion of the trunk, but that once both anterior and posterior fins had evolved, they both came under the influence of a group of *Hox* genes that was initially involved in establishing the sequence of structures at the end of the trunk and tail. Research on the distribution of *Hox* genes in the pelvic fin of bony fish, both pectoral and pelvic fins of Chondrichthyes, lungfish, and coelacanths, as well as gene groups 9–13 in jawless fish, would contribute substantially to determining what changes may have occurred during the origin of paired fins and their transition to the paired limbs of tetrapods.

The origin of tetrapod limbs

Neither the fossil record nor study of development in modern genera yet provides a complete picture of how the paired limbs in tetrapods evolved, but this problem