The phylotypic stage

One of the most striking features of the *Hox* complex, beyond its expression in all adequately known metazoan groups, is the colinearity of the genes within the complex and their expression along the body axis of the developing embryo. Although the number of *Hox* genes differs from phylum to phylum as well as within phyla, the sequence of genes that are recognized as homologous between one phylum and another is nearly constant. With the exception of some insects, including *Drosophila*, few non-*Hox* genes interrupt the sequence within each cluster.

Duboule (1994) provided a simply functional reason for this phenomenon that simultaneously explains the constraint expressed in the basic body plan within each of the metazoan groups. Although there may be significant differences in the early stages of their cell division – through the formation of the gastrula among vertebrate groups and the larval stages in many other metazoan phyla – all metazoans go through a developmental period termed the **phylotypic stage**, during which embryos within each phylum are strikingly similar to one another (Slack, Holland, and Graham 1993). This is particularly evident among vertebrates, in which the early embryos of fish, amphibians, reptiles, birds, and mammals appear almost identical (Fig. 10.6).

Duboule argued that the constancy of body form at the beginning of morphogenesis is necessary to correlate the timing of gene expression with the anterior to posterior sequence of development in the embryo. *Hox* genes are activated in a linear sequence corresponding to their position along the chromosome and the anterior–posterior axis of the body. More specifically, they are activated in a sequence that corresponds with a short period of time during which cells, arranged along the axis of the body in an anterior to posterior direction, are actively proliferating. That is, there is a *temporal* colinearity of cell proliferation that must correlate with the *spatial* colinearity of the genes on the chromosomes and the appropriate areas of gene expression in the developing embryo.

The initial activation of DNA within the cells that will lead to the formation of the major structural features of the body is limited to a very narrow temporal window, corresponding to the early somite stage in development. It is at this time that the embryos of all vertebrate groups are most similar to one another. This is the period during which anterior to posterior progression of somite formation and closure of the neural tube are clearly evident. In the mouse, this takes about two days. Subsequent development, initiated by the activation that occurred during this short time frame, proceeds differently from this stage onward, modified by more specific developmental processes.

The constancy of the function and linear expression of *Hox* genes provides a stable framework about which other elements can change without jeopardizing the survival of the organism. Their stability among vertebrates and among each of the other metazoan phyla is equivalent to the stability of the genetic code among all organisms. They provide the most general level of explanation for the endurance of features common to each phylum (Hall 1996). Although individual *Hox* genes may continue to vary in details of their DNA composition, their basic function in controlling the degree, place, and nature of expression of other genes responsible for particular developmental processes has apparently remained nearly constant.