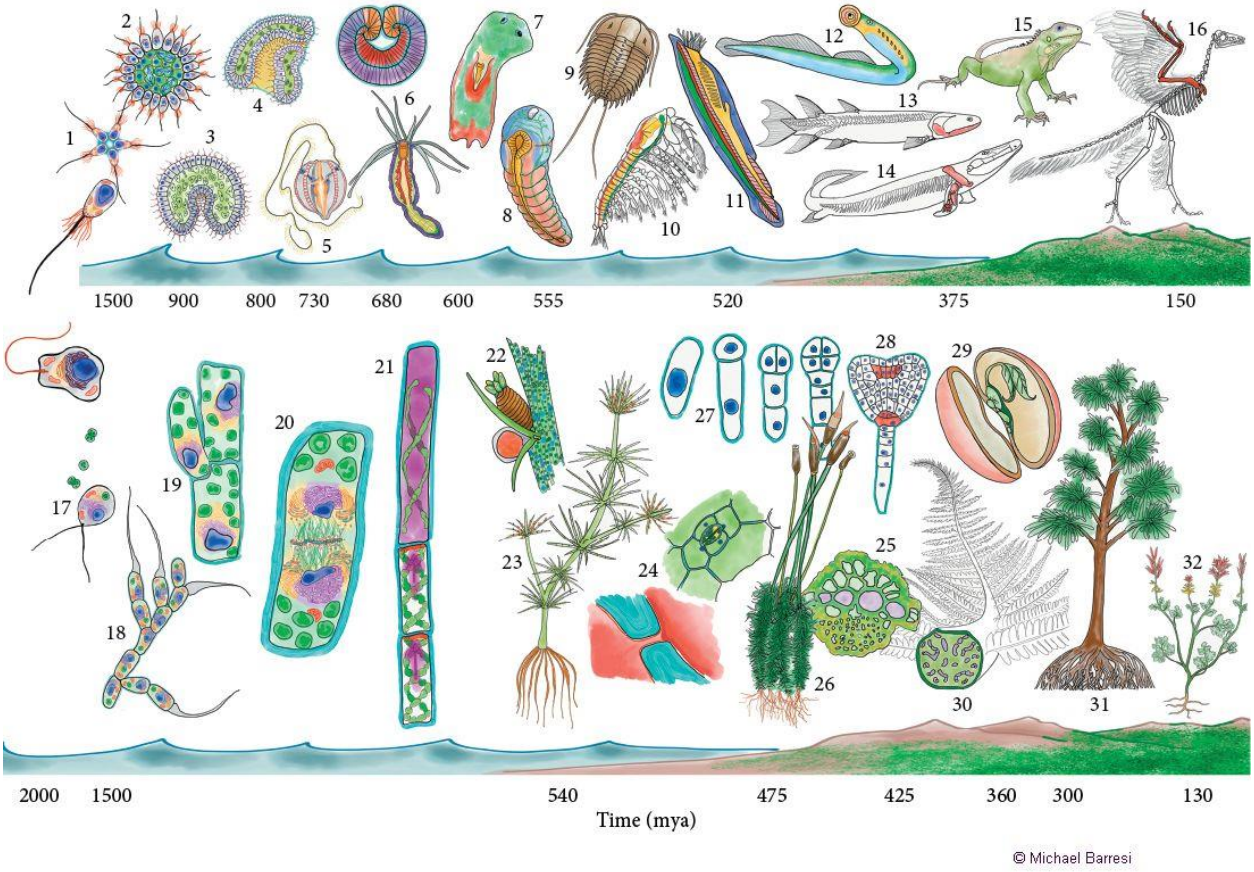
<Further Development 1_6>

The Developmental Evolution of Life



This illustration depicts key developmental adaptations that occurred over the course of evolutionary history in animals (top) and plants (bottom). The last eukaryotic common ancestor (LECA) gave rise to both plants and animals 2000 million years ago (mya). (Top) (1) Colonization of choanoflagellate cells. (2) Development of a two-layered organism with a proliferative inner layer and an epithelial filter-feeding outer layer. (3) Digestive architectures emerge with the evolution of tighter junctions and extracellular matrix (neon blue). (4) A primitive gut with aboral and oral openings appears, as in the sponge. (5) Ctenophores, such as this comb jelly, exhibit the first interconnected system of nerve-like cells. (6) Cnidarians such as the sea anemone show the first signs of gastrulation. (7) Bilateral symmetry evolves (aceols) and (8) segmentation emerges, generating (9,10) a diversity of arthropod lineages. (11) Adaptation of mesoderm produces the first axial derivative—the notochord

(red)—giving rise to chordates. (12–14) From jawless fish (12, lamprey) to jawed fish (13, teleost) and from paired fins to articulating forelimbs (14, *Tiktaalik*), metazoans walk out of the water. (15,16) Among the terrestrial tetrapods, reptiles (15) further adapt their forelimbs into wings, giving rise to avian species (16). (Bottom) (17) Endosymbiosis of a cyanobacterium sets the stage for a path of photosynthesis-driven evolution. (18,19) Fixed modifications of collagen-based extracellular matrix genes foster the formation of filamentous colonies of algae (18) and a more protective cell wall (19, neon blue). (19) Integration of plastid DNA guides the biogenesis of multiplastid cells. (20) The phragmoplast builds the cell wall during cytokinesis. (21) Expansion of the phytohormone machinery opens communication across the entire plant for cell growth and morphogenesis. (22, 23) Alternation of generations is evident in the sporophytic and gametophytic phases displayed by the rhizoid-bearing charophytic algae, the common ancestor of all embryophytes. (24) Stomata and plasmodesmata provide the basis for a vascular future. (25) Hydroid cells (light purple) for nutrient transport are present in the first land plants: bryophytes (26, moss). (27) Embryonic development defines the embryophytes. (28) Pluripotent shoot and root apical meristems fuel indeterminate growth (red). (29) Seed adaptations protect and disperse embryos. (30, 31) Lignin further strengthens the cell wall for increased efficiencies of water and nutrient transport from the first vascular plants (30, ferns) to the tallest trees (31, conifers). (32) Coevolution with metazoan life helps promote an enormous diversity of angiosperms (flowering plants).