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Nonautonomous dynamical systems provide a mathematical framework for temporally changing phenomena, where the law of evolution varies in time due to seasonal, modulation, controlling or even random effects. Our goal is to provide an approach to the corresponding geometric theory of nonautonomous discrete dynamical systems in infinite-dimensional spaces by virtue of 2-parameter semigroups (processes). These dynamical systems are generated by implicit difference equations, which explicitly depend on time. Compactness and dissipativity conditions are provided for such problems in order to have attractors using the natural concept of pullback convergence. Concerning a necessary linear theory, our hyperbolicity concept is based on exponential dichotomies and splittings. This concept is in turn used to construct nonautonomous invariant manifolds, so-called fiber bundles, and deduce linearization theorems. The results are illustrated using temporal and full discretizations of evolutionary differential equations.