formation and evolution appeared. According to this framework, cosmic structures emerged from the gravitational evolution of CDM-dominated primordial perturbations. The distributions, inner properties, and evolution of the collapsed CDM structures (halos) were predicted in detail by cosmological N-body simulations. Ab initio (deductive) models, as well as full numerical simulations including hydrodynamics, were developed in order to follow the complexity of baryon physics during the process of galaxy formation and evolution inside the growing CDM halos. Several of the physical ingredients and parameters of the models, as well a some of the subgrid parameters of the simulations, are actually determined/calibrated from mainly local observations. The deductive approach has enormously contributed to our understanding of galaxy formation and evolution in the cosmological context though many questions remain yet unsolved, including the validity of the backbone of this approach itself: the existence of the elusive CDM.

The halo mass growth in the ΛCDM cosmology is on average hierarchical, from bottom to up. How is the $M_{\rm s}$ assembly of galaxies formed inside the CDM halos and how does it compare with observations? *A sharp test for the ΛCDM scenario may arise from this comparison*. For this, however, several theoretical and observational "biases" should be first well understood. Neither the galaxies trace directly the assembly of their halos –here is implied all the complex baryon physics– nor the observed galaxy populations at different redshifts offer a direct way to determine the individual evolution of galaxies – instead they are inferred and the results are strongly dependent on selection effects and biases. It should be said that misunderstandings and oversimplifications of the scenario have led to some incorrect interpretations. For example, it is common to hear that since in the ΛCDM hierarchical scenario dark halos assemble through violent major mergers ("walnut tree"), therefore galaxy formation is merger-dominated, something that could be in conflict with the observed large abundance of spiral galaxies or the non-negligible fraction of bulgeless galaxies. In fact, most of the mass of galaxy-sized ΛCDM halos (and most of halos) was (were) not assembled by major mergers but by smooth accretion and minor mergers ("pine tree"; Maulbetsch et al. 2007; Genel et al. 2010). Besides, only a fraction of halo-halo mergers end producing galaxy-galaxy mergers. By analyzing the results of the SAM implemented in the Millenium simulation (De Lucia et al. 2005), in De Rossi et al. (2009) it was concluded that only ≈12% of Milky Way-type galaxies experienced a major merger during their lifetimes.

2.3. *The empirical approach*

Thanks to the vertiginous advance of instrumental facilities and multi-wavelength large-area survey programs, the empirical or "look-back time" approach has come to stay. The main photometric and spectral properties of whole galaxy populations obtained at different z allow us to infer $M_{\rm s}$, SF rate (SFR), and other physical properties of galaxies[3]. Given the large numbers and high sensitivities of current surveys, relatively complete samples characterized by the mentioned above properties down to nearly dwarf galaxy masses and out to high redshifts become possible (e.g., $M_{\rm s}\gtrsim 10^8$ at $z\approx 0$ or $M_{\rm s}\gtrsim 3\times 10^9$ at $z\approx 2$). Thus, progress has been made in determining locally and at higher z: (1) the total galaxy stellar mass function, $GSMF$, and its dissection into blue/star-forming and red/passive components, (2) the SFRs of galaxies as a function of their mass traced by different indicators, from the UV to the radio, and (3) the galaxy rate of merging at different masses and epochs, although with still very large systematic uncertainties. In some works, these determinations have been obtained as a function of environment.

Based on all these observational data, a purely empirical picture of $M_{\rm s}$ assembly as a function of mass, type and environment is emerging now. A general result is that ∼50% of the local stellar mass density was assembled since $z=1$, and ∼90% since $z=3.5$ (e.g., Pérez-González et al. 2008). Possibly the main new concept distilled from the empirical picture is that of *cosmic downsizing*, a term coined by Cowie et al. (1996) to describe the decline with cosmic time of the maximum rest-frame $K-$band luminosity of galaxies undergoing active SF. This term has been more recently used to describe a number of trends of the galaxy population as a function of mass that imply in general galaxy buildup from top to down. However, these different trends are actually related to different astrophysical phenomena and galaxy evolutionary stages (Fontanot et al. 2009). From the most general point of view, the many downsizing manifestations can be separated into those that refer to the evolution of:

(A) Massive galaxies, which today are on average red and passive (quenched SF). Observations show

[3]For several of these inferences, stellar population synthesis models should be used. These models had a vigorous advance in the last years, however, several uncertainties remain yet unsolved (for a recent review see Bruzual 2010).