Galaxy formation ↔ Galaxy classification

Generally, the systematic categorization of properties of objects (taxonomy) is an early stage in the development of a science. Later work then focuses on physical (biological, ...) processes and origins.

Q. What are some examples, from within astronomy & from outside it?

Q. What differentiates a good classification scheme from a bad one?

An early (and influential) classification scheme for galaxies was based on morphology only: the Hubble classification.

Based on optical properties only.
The Hubble sequence

Ellipticals: smooth, round → flattened
featureless, reddish
centrally concentrated; may be triaxial

SO's: intermediate between E & S
smooth, little dust usually has disk

Spirals: classified by bulge-to-disk ratio
gas content also varies Sa - Sc
roughly half have bars
gas content ↔ ongoing star formation
Figure 2.2. Hubble’s tuning-fork diagram, filled in with galaxies. This collection of galaxies spans the classical Hubble types, illustrating the changes in bulge-to-disk prominence and spiral pattern along the sequences. Beyond this original set of types, and not shown here, are even less organized Sd/SBd spirals plus their corresponding irregular galaxies. These are optical images, close or identical to the photographic bands used to define Hubble’s classifications. (Data by the author, from Kitt Peak and Lowell; from Greg Bothun; and taken from the Digitized Sky Survey, taken by the Oschin Schmidt Telescope on Palomar Mountain, with compression and distribution by STScI.)
Figure 2.3. The changing appearance of galaxies in different parts of the electromagnetic spectrum is illustrated by this series of images, showing the nearby spiral galaxy M81. In X-rays, only the active nucleus and accreting compact objects in binary systems (white dwarfs, neutron stars, and black holes) appear, with no hint of the rich stellar structure. In the ultraviolet, only the hottest (unobscured) stars are bright, so that the spiral pattern can be traced via star-forming regions, but the central bulge of old stars has almost vanished. This appearance resembles some spiral galaxies seen at large distances, where the redder bulge light has shifted out of the optical bands. The familiar visible-light image shows both the spiral pattern and the old bulge population, while in the near-infrared, the spiral pattern and star-forming regions are much more subdued. This change in apparent structure with wavelength has been dubbed the “morphological K-correction”. X-ray data are from ROSAT, extracted from the HEASARC archive at NASA’s Goddard Space Flight center. The UV image is a combination of observations obtained by the GALEX satellite at wavelengths 1,500 and 2,300 Å, used courtesy of NASA. The optical images are reproduced courtesy of Greg Bothun. (The infrared data are from the 2-Micron All Sky Survey (2MASS), a joint project of the University of Massachusetts and the Infrared Processing and Analysis Center/California Institute of Technology, funded by NASA and the NSF.)
What Hubble Missed

Dwarf galaxies

There are dwarf equivalents of ellipticals and S0s. Dwarf ellipticals are completely different: their luminosity is not as centrally concentrated.

Peculiar galaxies

Defy classification; many of these are ongoing mergers.

Later types: Sa, Sb, Sc, Sm, Ir

Magellanic spirals intermediate between spirals & irregulars.

Low surface brightness galaxies (LSBs)

There are galaxies with low luminosity density (number of stars per unit area) which are dwarf ellipticals, and some disk galaxies too. Perhaps half of all galaxies are LSBs.
Night sky brightness

Even when there is no moon, the night sky has a finite brightness.

For very faint objects, this limits observations more than photons collected.

Sources

- City lights
- Airglow — emission lines from upper atmosphere, irregular, variable, worst in infrared
- Faint & unresolved stars in our Galaxy
- Distant, faint, unresolved galaxies
- Zodiacal light