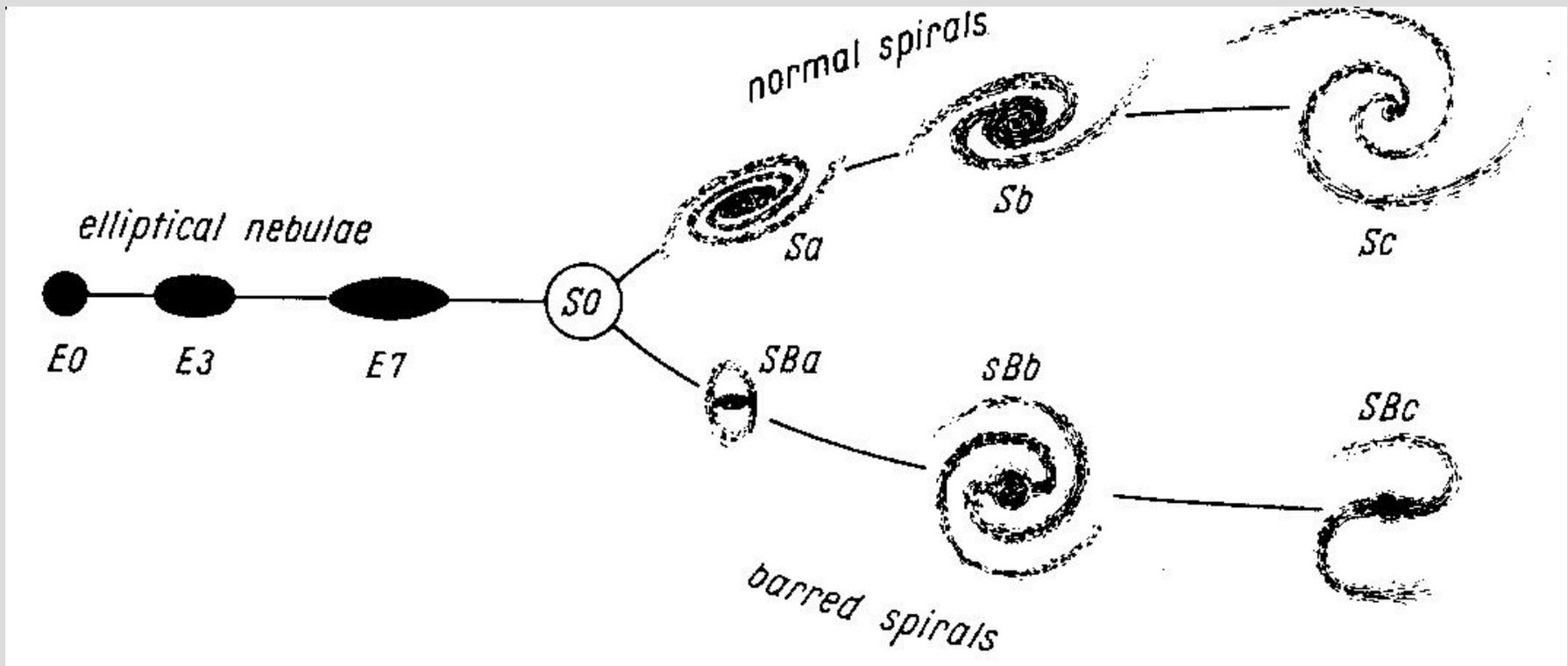# Morphological classification of galaxies
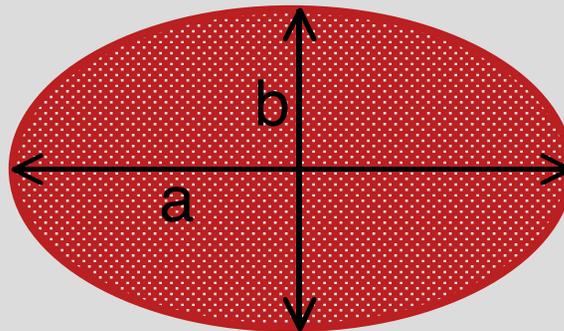
Edwin Hubble devised a scheme for classifying galaxies, based on their appearance, in his 1936 book *The Realm of the Nebulae*.

Elliptical galaxies

Spiral galaxies

Elliptical galaxies are smooth, usually round, and almost featureless. No spiral arms or dust lanes. Generally lacking in cool gas, and hence few young blue stars.

Ellipticity is defined as: $\varepsilon = 1 - \dfrac{b}{a}$

Elliptical galaxies are denoted E*n*, where: $\dfrac{b}{a} = 1 - \dfrac{n}{10}$

A round elliptical is E0, the most elongated ellipticals are of type E7.

Spiral galaxies are named for their bright spiral arms, which are prominent due either to bright O and B stars (evidence for recent star formation), or to dust lanes.

Define two sequences of spiral galaxies:

Sa   **Sb**   **Sc**   **Sd**

→

Central bulge becomes less important
Disk becomes more important
Spiral arms become more open and ragged

Sba   **SBb**   **SBc**   **SBd**

As above, except that these galaxies also have a central, linear **bar**, while the Sa, Sb… are unbarred

Transition class between ellipticals and spirals are the S0 galaxies, also called **lenticulars**.

S0 galaxies have a rotating disk in addition to a central elliptical bulge, but the disk lacks spiral arms or prominent dust lanes.

Lenticulars can also have a central bar, in which case they are labeled SB0.

Classification of real galaxies on Hubble's **tuning fork** diagram
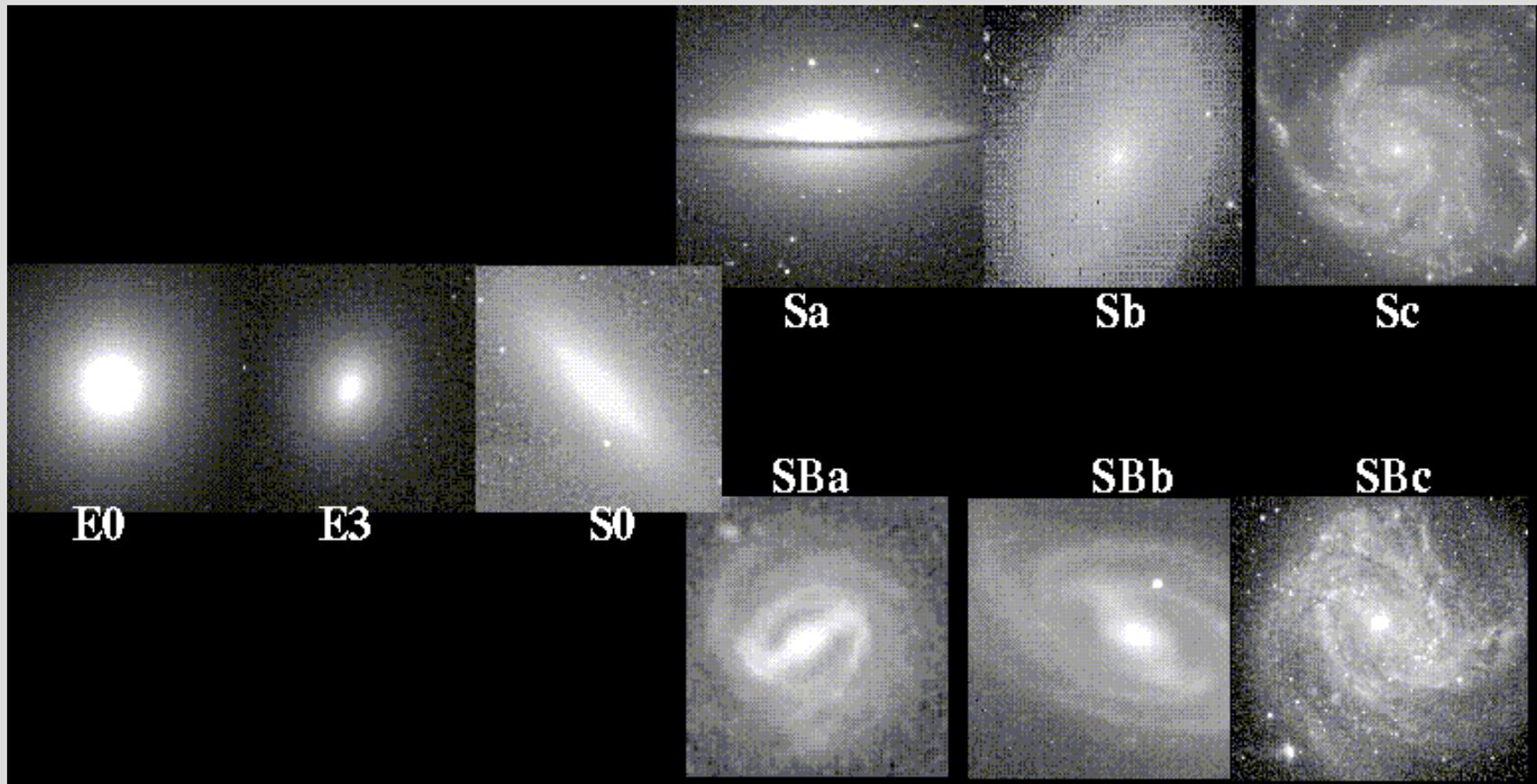
Obviously easiest to classify face-on spirals.

Hubble interpreted this diagram as an evolutionary sequence - this is not supported by more modern work.

Other galaxy types

Hubble dubbed galaxies that didn't fit into his scheme **irregular**

Today: irregular galaxies are defined as small blue galaxies lacking any organized spiral structure

Other types of galaxy Hubble called irregular are now identified as **starburst** or **interacting** galaxies. These have a disturbed appearance due to recent episodes of violent star formation, or close encounters with other galaxies.

The Mice
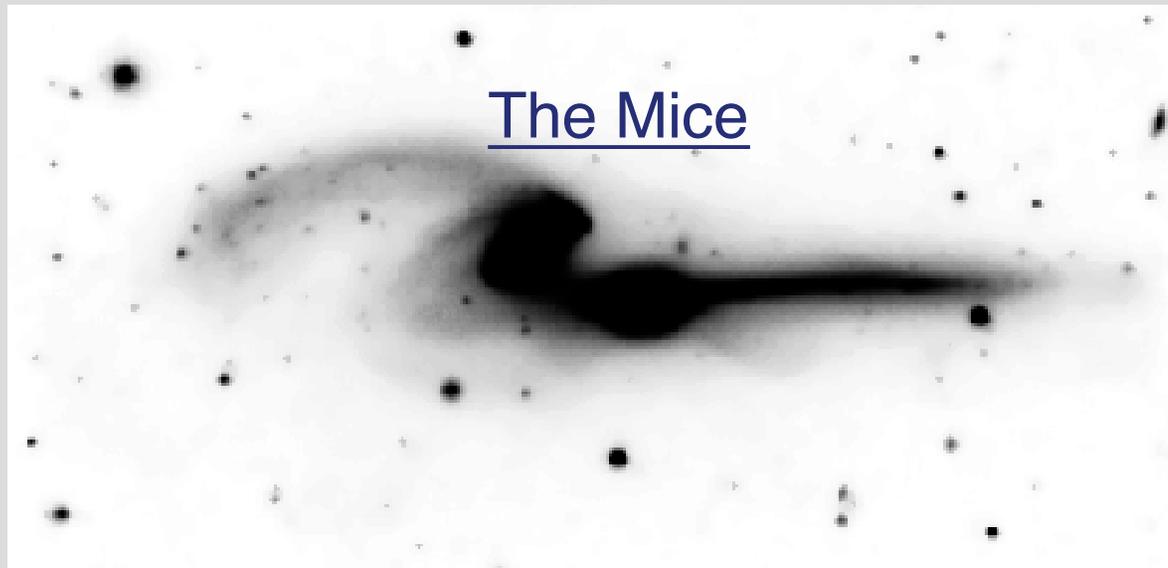
Problems with traditional galaxy classification

<u>Subjective</u> - especially for spiral galaxies

In practice, experienced observers can almost always provide a consistent classification, at least for well resolved galaxies, so this is not a major problem.

Very large surveys, such as the Sloan Digital Sky Survey currently in progress, will image ~ 10^8 galaxies:
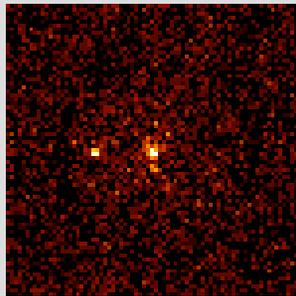
> Development of several automated schemes to classify galaxies. Some based on the Hubble system, others use different criteria.
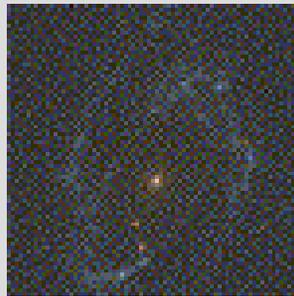
Problems with traditional galaxy classification

Appearance of galaxies is strongly dependent on **which wavelength** the observations are made in.
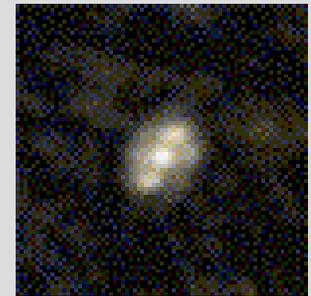
e.g. the nearby galaxy M81

| X-ray | UV | Visible | Near-IR | Far-IR |

Note: large change in appearance between the UV and the near infrared images.

Galaxies look `clumpier' in the UV, and increasingly smooth as we go to the visible and longer wavelengths.