Galaxy morphology and environment

What are some examples of processes important in forming galaxies that are largely independent of the galaxy’s environment that depend on a galaxy’s environment?

Density-morphology relation

No of ellipticals & S0 galaxies increases as local density of galaxies ↑

No. of spirals ↓

regular clusters, the the same changes of n the regular clusters.
has developed which neighbors to each of and after computing r field galaxy density, y in galaxies Mpc$^{-2}$.
different magnitude shifts. as described in I computed density $< -20.4 \left( \frac{H_0}{50} \right)$
ren sorted by type so solutions as a function
shows that the populations change smoothly with density over five orders of magnitude, from $10^{-2}$
to $10^3$ galaxies Mpc$^{-3}$.
The advantage afforded by the use of density instead of radius as the independent parameter in the study of population gradients is illustrated in Figure 5.
FIG. 1.—Population fraction as a function of space density for the CfA sample. The group contribution to the morphology-density relation is indicated by the solid histograms; the cluster contribution, by the dashed histograms. Dressler's morphology-density relation is indicated by the solid curves which are color corrected and shifted to correspond to $H_0 = 100$ km s$^{-1}$ Mpc$^{-1}$. 
THE GALAXY LUMINOSITY FUNCTION


let $\phi(L)$ be the number of galaxies per unit volume in the luminosity interval between $L$ & $L+\Delta L$

$$\phi(L) \propto L^\alpha e^{-L/L_*} \quad \text{ (Schechter)}$$

* Note that some authors use luminosity function $\phi$ to describe the probability distribution for of galaxies, not the number density *

absolute magnitude $M_*$, corres. to $L_*$
of order $M_* B_\odot = -21$
$$\alpha \approx -1.2$$
Fig. 2.—Best fit of analytic expression to observed composite cluster galaxy luminosity distribution. Filled circles show the effect of including cD galaxies in composite.
Problem

How would you go about measuring a galaxy LF, in a cluster & in the field?

What would be possible biases in the field? In clusters?

What effect might large-scale structure have on your results?
The Local Group

\~1997

<table>
<thead>
<tr>
<th>Milky Way</th>
<th>SBBc</th>
<th>M31 (NGC 224)</th>
<th>Sb</th>
<th>M83 (NGC 598)</th>
<th>Sc</th>
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<tr>
<td>SMC</td>
<td>Ir</td>
<td>M 32 (NGC 221)</td>
<td>E</td>
<td>NGC 147</td>
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<td>LMC</td>
<td>Ir</td>
<td>NGC 185</td>
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<td>NGC 205</td>
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<td>M 83 (NGC 598)</td>
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<td>NGC 6822</td>
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<td>IC 1613</td>
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<td>Fornax</td>
<td>dE</td>
<td>Sagittarius</td>
<td>dE</td>
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<td>Sculptor</td>
<td>dE</td>
<td>Leo I</td>
<td>dE</td>
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<td></td>
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<td>Leo II</td>
<td>dE</td>
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<td></td>
<td></td>
<td>Canes Venatici</td>
<td>dE</td>
<td>Ursa Minor</td>
<td>dE</td>
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<td>Draco</td>
<td>dE</td>
<td>Dorado</td>
<td>dE</td>
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<td>DDG 210</td>
<td>lmr</td>
<td>Tucana</td>
<td>dE</td>
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<td></td>
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<td>Sextans (Leo A lmr)</td>
<td>dE</td>
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</tbody>
</table>
Major I, Willman I, Canes Venatici I, Bootes, and Ursa Major II—can be usefully taken together as a group. They were all discovered in the same data set with similar methods, although this does not necessarily imply any underlying physical commonality. The locations of the 10 SDSS objects in the Galactic sky are shown in Figure 7, together with the nine previously known dSphs. Prior to SDSS, it had long been suspected that there may be some missing dSphs at low Galactic latitude in the zone of avoidance (see, e.g., Mateo 1998). However, the SDSS objects all lie at high Galactic latitude, as the survey is concentrated around the north Galactic pole. It is difficult to escape the conclusion that there are many more Milky Way companions waiting to be discovered. Assuming that (1) all dwarf satellites in the area of sky covered by SDSS have been found and (2) the distribution of dwarf satellites is isotropic, then there may be ~50 dwarfs in all. In fact, both assumptions are surely incorrect. Systematic surveys for all satellites in SDSS DR5 are underway (S. Koposov et al. 2007, in preparation) and will undoubtedly uncover further candidates. The spatial distribution of dwarf galaxies is a controversial issue, although the most recent analysis of the simulation data suggests that dwarf satellites may lie preferentially along the major axis of the mass distribution of the host galaxy (see, e.g., Zentner et al. 2005; Yang et al. 2006 and references therein). If so, then our extrapolation to a total of ~50 dwarfs may still be an underestimate.

Figure 8 shows objects plotted in the plane of absolute magnitude and half-light radius. This includes the 10 SDSS discoveries in the Milky Way (filled circles) and the eight Milky Way dSphs omitting Sgr (open circles). We have added to the sample of SDSS discoveries two dSphs found around M31, namely, And IX and X (Zucker et al. 2004, 2006c). We have also added to the sample of SDSS discoveries two dSphs found around M31, namely, And IX and X (Zucker et al. 2004, 2006c).
Figure 1  The LF of field galaxies (top) and Virgo cluster members (bottom). The zero point of log $\varphi(M)$ is arbitrary. The LFs for individual galaxy types are shown. Extrapolations are marked by dashed lines. In addition to the LF of all spirals, the LFs of the subtypes Sa + Sb, Sc, and Sd + Sm are also shown as dotted curves. The LF of Irr galaxies comprises the Im and BCD galaxies; in the case of the Virgo cluster, the BCDs are also shown separately. The classes dS0 and "dE or Im" are not illustrated. They are, however, included in the total LF over all types (heavy line).
- It now seems that there is not a single LF for both cluster & field, but a type-specific LF for various Hubble Types

"Discussing these samples in terms of a Schechter function over all types is like covering a wealth of details with a thick blanket."

- Note that dE galaxies show a strong density-morphology relation..... much more common in clusters than fields

  Why??

- Bright end of LF for various types look similar, but there are large differences at faint end
Flavors of elliptical galaxy

Elliptical galaxies include both the most luminous galaxies known, and the least luminous.

Categories:

- cD galaxies: "central dominant" galaxy in a rich cluster of galaxies.
  - Very luminous: $M_B = -22$ to $-25$ mag.
  - Extended outer envelope which may merge with "intracluster starlight"

- Normal ellipticals (e.g. m32)
  - Include giant Es, low-luminosity Es, compact Es
  - $M_B$ range: $-15 \rightarrow -23$

(when I say 'elliptical' this is what I mean)
• dwarf ellipticals (dE) e.g. NGC 205
  Quite different in structure from normal Es
  \( M_B : -13 \text{ to } -19 \)
  exponential radial dropoff, not \( R^{1/4} \)
  lower in surface brightness

• dwarf spheroidals (dSph) e.g. I
  Extreme low-luminosity end of dE class.
  can be very low surface brightness
  \( M_B : -8 \text{ to } -15 \)
  Overlap globular clusters in mass!
  Dark matter dominated

Milky Way and M31 are both accreting
dSph galaxies at present (e.g Sgr, and VIII)