Introduction to Astrophysics

What’s the difference between astronomy and astrophysics?

No very great formal difference.

The core of astronomy is traditionally seen as observing the positions and brightnesses of astronomical objects. Now brightnesses can be measured a large range of the EM spectrum for a huge zoo of ‘astronomical objects.’

Astrophysics is more about the underlying physical processes and their causes, applying physics to understand the astronomical objects.

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Traditional applications of astronomy include: calender construction, time determination, navigation. (Even now: pulsar clocks, quasar reference frames, & astronomical knowledge as the basis of space exploration.)

Astrophysical applications often cut both ways - we use laboratory and theoretical physics to understand astronomical systems, but increasingly we use the natural astronomical laboratories to test, understand, and extend our knowledge of fundamental physics.
Other “Applications” or Consequences:

Biological Cycles and the Sky:
- Sleep cycle - day and night
- Menstrual cycle - month of lunar phases
- Cycle of seasons, e.g. depression in the dark (S.A.D.) - solstices - equinoxes

The Subconscious and the Sky:
- Why is the number 7 lucky in many societies? Sun, moon, and visible planets?
- Why is clockwise clockwise? Path of the sun?
- Circle and sun sign mysticism. Same roots as astrology?
- It goes on and on…..
Physical Processes:

… are generally the same as physical processes on Earth. However, the forces of gravity and cosmological expansion only dominate on cosmic scales. Extreme EM and even neutrino physics effects are also found “out there.”

Unless otherwise noted, images in the course lectures are taken from the Astronomy Picture of the Day (APOD) or the Earth Picture of the Day (EPOD) websites.
Characteristic Structures:

We could define these with a pretty simple morphological definition: things that stand out (I.e., have a good deal of contrast relative to their surroundings). However, this might be a little too broad and inclusive for our purposes.

A better definition would be more along the lines of: a relatively high density, quasi-steady structure in which self-gravity is balanced by some form of pressure.

The short list:

- Planets, planetary systems (We will decline to notice any smaller structures.)
- Stars/Star Clusters
- Large interstellar ‘clouds’
- Galaxies
- Groups and clusters of galaxies
- Superclusters of galaxies
Some Scales (Geography of the Universe)

<table>
<thead>
<tr>
<th>Object</th>
<th>Mass</th>
<th>Size</th>
<th>Timescale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Planet</td>
<td>$M_{\text{earth}} = 6.0 \times 10^{24}$ kg</td>
<td>$1.3 \times 10^{4}$ km</td>
<td>$5 \times 10^{9}$ yr</td>
</tr>
<tr>
<td>Star</td>
<td>$M_{\text{sun}} = 2.0 \times 10^{30}$ kg</td>
<td>$1.4 \times 10^{9}$ m</td>
<td>$10^{7} - 10^{10}$ yr</td>
</tr>
<tr>
<td>Star Cluster</td>
<td>$10^{2} - 10^{6} M_{\text{sun}}$</td>
<td>$10 \text{ pc} \approx 3.1 \times 10^{17}$ m</td>
<td>$10^{8} - 10^{10}$ yr</td>
</tr>
<tr>
<td>Galaxy</td>
<td>$10^{8} - 10^{12} M_{\text{sun}}$</td>
<td>$10 - 100 \text{ kpc}$</td>
<td>$&gt; 10^{10}$ yr</td>
</tr>
<tr>
<td>Galaxy Cluster</td>
<td>$10^{13} - 10^{16} M_{\text{sun}}$</td>
<td>$10 \text{ Mpc}$</td>
<td>def.?</td>
</tr>
<tr>
<td>Observable Universe</td>
<td></td>
<td>$1.3 \times 10^{10}$ light yr.</td>
<td>?</td>
</tr>
</tbody>
</table>
Next 3 images from a web site called “New View of the Planets”(??)
How do we learn about these structures? How do we do astronomy?

- Observation
- Lab Experiment
- Modeling
  - Theory, hypothesis-deduction
  - Analytic calculation
  - Computer simulation
- Prediction
http://anzwers.org/free/universe/

www.atlasoftheuniverse.com