

SUMMARY OF KEY CONCEPTS: WEEK #1

This is the first of weekly summaries of what I consider to be the key concepts introduced in class. These summaries are not intended to replace your own notes, and are by no means inclusive (i.e. anything we've covered in class or in readings from the textbook is 'fair game' for an exam question), but they should help when it comes to reviewing the class for the tests.

Lecture #1

What do we mean by science and what is involved with studying a subject using the 'scientific method'? Science seeks the *simplest natural* explanation for observed phenomena (note natural rather than supernatural), and advances via a process of first formulating *hypotheses* and then testing them against experiments or new observations. A theory that makes no testable predictions is not normally regarded as scientific. Chapter 3 of the textbook (either edition) discusses this in detail.

We then did a super-quick overview of the Universe:

1. The Sun is a star. Stars have a range of masses, and mass is the most important factor controlling how they evolve. Stars don't live forever (though the lifetime of the Sun, about 10 billion years, is very long), and when they die they normally eject gas back into space and leave behind a stellar remnant. If the star is massive enough, this can be a black hole.
2. A *galaxy* is an 'island of stars' held together by gravity. Our own galaxy, called the Milky Way, has about 100 billion stars. On the largest scale (of the whole observable Universe) the galaxy is the basic building block. Galaxies often collide with each other (very very slowly, over billions of years), and like stars they come in different types.
3. We observe that almost all galaxies are moving away from us (Hubble's Law). We infer from this that they must have been closer together in the past, and that the Universe had a definite beginning. This is part of the evidence for the Big Bang. We believe (based on strong evidence, to be discussed later) that at early times the distribution of matter in the Universe was much smoother than it is today – gravity has subsequently caused the mass to clump together forming galaxies, stars and planets.

Lecture #2 – textbook Chapter 14 (4th edition) or 15 (3rd edition): 'Our star'

The visible surface (where the light comes from) of the Sun is called the *photosphere*, beyond that is a region of very hot, diffuse gas called the *corona*, and beyond that the *solar wind*.

The Sun is mostly made of hydrogen gas.

Sunspots appear on the photosphere and rotate around with the Sun – their number varies on an 11-year cycle called the Solar Cycle. We know that sunspots are regions where the magnetic field of the Sun is escaping into space, but the details of why the Solar Cycle behaves as it does remain unclear (magnetism and differential rotation of the Sun are almost certainly involved). There are suggestions – but no proof – that changes in the Solar Cycle in the past may have influenced climate on Earth.

As well as sunspots, we can observe a 'boiling' pattern on the photosphere. Technically this is called *granulation*, and it's the surface manifestation of a process called *convection* in which hot gas rises to the surface, loses energy and cools, before dropping back down. Convection is how the energy generated in the deep interior of the Sun makes its way to the surface.

In the corona, magnetic fields power various phenomena: solar flares, prominences, and coronal mass ejections. These can be studied most easily by looking at the Sun in X-rays or UV light that trace the very hot coronal gas (1 million K).

The Earth is partially protected against coronal mass ejections (or Solar storms) by our own magnetic field: observable effects include the aurora and occasional damage to power grids and satellites in places exposed to the high energy radiation released during Solar storms. Astronauts away from low Earth orbit (e.g. en route to Mars) would have to be especially careful.