15-5. What does it mean to say that the universe is homogeneous? That it is isotropic?

“Homogeneous” means everywhere the same, not in fine detail, but on a large scale no location is discernible from any other location in any measurable way. To say the universe is isotropic means it looks the same in all directions. As with homogeneity, when the term is applied to the universe is means on a large scale, not to the finest detail.

15-7. Where is the center of the universe?

There is no point that is distinguishable from any other point. One could say the center is everywhere. It is analogous to asking where is the central point on the earth’s surface. One could also say the universe has no center.

15-9. What is the cosmic microwave background?

When the universe was about 300,000 years old, it had cooled to a temperature of about 3000 K. At that time and temperature a great transition occurred. The ordinary matter in the universe had been totally ionized, but cooling made it possible for atoms to form. One consequence of this change was that the universe, which was filled with black body radiation characterized by a temperature of 3000 K, changed from a state of being opaque to radiation to being transparent. The 3000 K radiation was no longer absorbed and it remains in the universe today. However, because of the expansion of the universe, the wavelengths of that radiation have been redshifted to the point that it now looks like black body radiation of temperature 2.7 K, principally in the microwave region of the electromagnetic spectrum. Hence it is dubbed the cosmic microwave background.

15-11. What is dark energy? Describe two ways that we can infer its presence.

No one fully understands what dark energy is. However we can see some of its effects. It is the energy source which is supplying the constantly increasing energy of a universe expanding at a constantly accelerating rate. To observe and interpret that acceleration is one way we can infer its presence. The existence of dark energy is also implied by the apparent flatness of space. The size of “hot spots” in the cosmic microwave background imply that the geometry of space is flat. However the observed density of all ordinary matter plus dark matter would result in a negatively curved, open universe. Only about 30% of the necessary mass density to produce flat space is present in these forms. Hence the other 70% must come from dark energy. This agrees with the amount inferred from the acceleration of the expansion rate.