Review and Discussion of Ch. 2: *The Heliocentric Revolution*

1. What contributions to modern astronomy were made by Chinese and Islamic astronomers during the Dark Ages of medieval Europe?

   The Chinese kept thorough records of celestial events, such as passing comets, novae and eclipses. They may have been the first to see sunspots.

2. Briefly describe the geocentric model of the universe.

   The geocentric model had the Earth at rest at the center while the Sun, Moon and other planets orbited around the Earth. The model required many devices like epicycles and deferents in order to come close to matching the observations.

3. The benefit of our current knowledge lets us see flaws in the Ptolemaic model of the universe. What is its basic flaw?

   The basic premise of geocentricism was a flaw of the Ptolemaic model. It was also not true that the planets must move in circular paths. A flaw of all of the models at the time was they had no theory to explain why the planets would orbit at all.

4. What was the great contribution of Copernicus to our knowledge of the solar system? What was still a flaw in the Copernican model?

   Copernicus demonstrated that Aristarchus' Sun-centered idea could be applied to all of the known planets. An unnecessary limitation for Copernicus was to continue insisting on circular paths for the planets. A basic flaw was that there was no physical theory for explaining why the planets would orbit at all.

5. What is a theory? Can a theory ever be proved to be true?

   A framework of ideas and assumptions that represents our best possible explanation for things that happen in the real world. Theories are always subject to challenge, and thus can never be proven to be true. They can, however, be proven to be false, meaning they no longer explain the phenomenon adequately. A good theory survives attempts at disproving it and makes predictions about future events.

   - Dictionary definition: "a scheme of relations subsisting between the parts of a systematic whole"
   - A theory is usually bigger and more all-encompassing than an hypothesis.
   - Example: electromagnetic theory.
   - A theory cannot be proven, only disproven.

6. When were Copernicus' ideas finally accepted?

   - No definite answer because it was a gradual process and there still may be skeptics today.
   - Kepler and Galileo accepted Copernicus' hypothesis, but their contemporaries did not.
   - The majority probably accepted the heliocentric theory by the end of Newton's life.

7. What is the Copernican principle?

   - That we are not at the center of things. First, this applied to our solar system, then to our galaxy, then our universe. It could even be that ours is not the only universe - but it is the only observable universe.

8. What discoveries of Galileo helped confirm the views of Copernicus, and how?

   - The gibbous phase of Venus was the one that disproved the Ptolemaic system, because that model kept Venus between the Earth and Sun so only crescent phases could be seen.
   - The moons orbitting Jupiter. This shows that not everything is orbitting around the Earth, therefore, why should the other planets?
   - Mountains and valleys on the Moon. This should how Earth-like the Moon was, whereas Aristotelian theory said it was mid-way between the base, corrupt Earth and the perfect heavens.
   - The Sun has spots and rotates. The Sun was supposed to be perfect and heavenly.

9. Briefly describe Keplers three laws of planetary motion.

   - First law: the orbits of planets, including the Earth, are in the shape of an ellipse with the Sun at one focus.
   - Second law: a line connecting the Sun and a planet sweeps out equal areas in equal time intervals - planets move fastest near perihelion.
   - Third law: the square of a planet's orbital period (in years) is proportional to the cube of the semimajor axis of its orbit (in astronomical units).

10. How did Tycho Brahe contribute to Keplers laws?

    Through years of meticulous observations of the motions of the planets among the stars, Tycho provided huge amounts of data that was later analyzed by Kepler to produce the laws of planetary motion.

11. If radio waves cannot be reflected from the Sun, how can radar be used to find the distance from Earth to the Sun?

    First, we can find the distance between Earth and Venus (d_{E-V}) at its *closest approach* by timing the round-trip journey of radio waves that are bounced off of Venus. Then, the ratio of Venus' orbit to that of the Earth's can be to be about 0.7 found using geometry and the greatest elongation angles (47 degrees). (This was known in Kepler's time.) Then, the Earth-Sun distance (AU) can be found from this formula: $AU = d_{E-V}/(1 - 0.7)$.

12. How did astronomers determine the scale of the solar system prior to the invention of radar?

    Astronomers used transits of the Sun by Mercury and Venus to calculate distances. When these planets passed in front of the Sun, astronomers at different locations on Earth would observe and time the transits. Using these techniques of triangulation, they were able to calculate distances.

13. What does it mean to say that Kepler's laws are empirical?

    They are developed to match observations, but are irrespective of any general theory. A theory would explain why the planets move the way they do, not just how they move.

14. What are Newtons laws of motion and gravity?

    - 1st law: an object continues at constant velocity until acted on by a net force.
    - 2nd law: an object accelerates proportional to the force acted on it ($a = F/m$).
    - 3rd law: for every force there is an equal but opposite counter - force.
    - Law of Gravitation: the force of gravity obeys an inverse-square law: $F = \frac{GMm}{r^2}$.

15. List the two modifications made by Newton to Keplers laws.

    - Kepler's 1st law was modified to say that the planets move in elliptical orbits with the solar system's *center of mass* at one focus (not the Sun).
    - Kepler's 3rd law was modified to apply to any two-body system. $P^2 = a^3/M_{total}$

16. Why do we say that a baseball falls toward Earth, and not Earth toward the baseball?

    - Both the Earth and the baseball experience an attractive force, and both feel a force of the same magnitude. However, the Earth is so much more massive that its acceleration is imperceptible, while the baseball clearly accelerates.

17. Why would a baseball go higher if it were thrown up from the surface of the Moon than if it were thrown with the same velocity from the surface of Earth?

    - The force of gravity is weaker on the Moon, so the baseball accelerates far less, thereby moving in a gentler trajectory. If there were no gravity, the ball would continue in a straight line.

18. In what sense is the Moon falling toward Earth?

    - In the sense that it is not moving in a straight line, but is continuously curving towards the Earth. Although its distance is not always decreasing, there is a force attracting it towards the Earth.

19. What is the meaning of the term escape speed?

    - The speed required of an object to escape from the gravitational pull of a (usually larger) object. By "escape", we mean that the object will never return to its starting point (unless some other force acts upon it), but continually move farther away.

20. What would happen to Earth if the Sun's gravity were suddenly "turned off"?

    - The Earth would continue moving at about 29 km/s, but instead of moving in a nearly-circular orbit, it would move in nearly a straight line which is tangent to the original orbit.