# Answer Key

## Answers to Study Questions

1. *Continental drift* is the theory that continents move freely over the Earth's surface, changing their positions relative to one another.

2. *Seafloor spreading* is a hypothesis that the sea floor forms at the crest of the mid-oceanic ridge, then moves horizontally away from the ridge crest toward an oceanic trench.

3. *Pangaea* is a hypothetical supercontinent formed by fitting together the present continents.

4. Four lines of evidence derived from Wegener's study of the continents that support continental drift:

   - the similarity of plant fossils of late Paleozoic age on several different continents;
   - the similarity of rock sequences on five continents even though the locations are now widely separated and younger rocks at the five locations are dissimilar;
   - evidence for late Paleozoic glaciations on continents of the southern hemisphere but not in the northern hemisphere; and
   - paleoclimate evidence suggesting either polar wandering or continental drift.

5. Paleomagnetic data from rocks of the same age on two different continents point to two different locations for the magnetic north pole. Unless there are different magnetic poles for each continent, it is most likely that the poles stood still and the continents moved.

6. The mid-oceanic ridge is more than 80,000 km long and 1500-2500 km wide. It rises two to three kilometers above the ocean floor.

7. The top layer of the oceanic crust consists of marine sediment with an average thickness of 0.5 km. The second layer is about 1.5 km thick and consists mostly of pillowed and fractured basalt. The third layer is 5 km thick and consists of parallel sheeted dikes in the upper section and sill-like gabbro bodies in the lower part.

8. *Ophiolites* are slivers of the oceanic crust and the upper mantle that were caught between converging plates and wedged upward onto continents.

9. Basaltic magma results from the presence of hot mantle rock rising under the ridge (see Figure 3.26 in the textbook).

10. Hess proposed deep mantle convection as the driving mechanism for seafloor spreading.

11. Vine and Matthews hypothesized that tensional cracks that form in the rift valley of the mid-oceanic trench are filled in by basaltic magma, which forms intrusion dikes. In times of "normal" magnetic polarity, the dikes are normally polarized; in times of "reversed" polarity the normal polarity is reversed.

12. Measured rates for seafloor motion range from one to six centimetres per year. Rates are determined by dating a reversal and then measuring the distance of that piece of sea floor from the rift valley of the ridge crest.

13. The congruence of the two hypotheses can be tested by dating a sample of igneous rock at some distance from the ridge crest. If the dated sample is the same age as that predicted for the sea floor at that location based on study of magnetic anomalies, then the hypotheses have been tested successfully.

14. Compare your diagram to Figure 19.18 of the textbook.
    The two hypotheses tested by the study of seismicity of fracture zones associated with the mid-oceanic ridge were 1) that earthquakes are evenly distributed along the entire length of the fracture zone; and 2) that the rocks on either side of the fracture zone move in opposite directions.

15. Stages of development of a divergent plate boundary:
    - formation of a rift valley
        - elevation of the crust
        - occurrence of shallow-focus earthquakes along normal faults
        - formation of a rift valley as a central graben
        - occurrence of high heat flow and basaltic volcanism
    - formation of a sea floor
        - separation of continental crust on the upper part of the plate
        - flooding of sea water into the linear basin
        - development of a series of fault blocks on the edges of the continents

    - erosion of uplifted edges of the continents, which fills the fault basin with continental sediment
    - continuation of volcanism, which builds true oceanic crust
    - evaporation of sea water, leaving a thick layer of rock salt overlying continental sediments
- widening of the sea floor and formation of mid-oceanic ridge
    - widening of the sea, which tears the layer of rock salt
    - development of full-fledged mid-oceanic ridge
    - development of continental shelves and slopes
    - formation of deep continental rise

16. The subduction angle determines the arc-trench spacing.

17. No island arc is associated with a subduction trench when the subduction angle is very shallow and the top of the subduction plate never contacts the asthenosphere.

18. An *accretionary wedge* is the highly contorted, thrust-faulted, marine sediment close to a trench. It is formed by underthrusting of marine sediment that is scraped off the subducting oceanic plate. As underthrusting pushes the wedge upward, a forearc basin forms between the complex and the volcanic arc.

19. *Backarc spreading* is caused by the creation of new sea floor in the backarc region. It is usually attributed to the rising and lateral spreading of a large blob of hot mantle rock, called a mantle diaper.

20. Compare your diagram to Figure 19.23 in the textbook.

21. Four features explained by plate tectonic theory:
    - the distribution and composition of volcanoes
    - the distribution of earthquakes
    - the distribution of young mountains
    - the mid-oceanic ridge and oceanic trenches

22. Possible driving mechanisms for plate motion:
    - plates are pushed apart by intruding magma; con: tension cracks in the rift valley
    - plates are carried by deep mantle convection currents; pro: would produce tension cracks in the rift valley region
    - plates are pulled by the subducting leading edge of the plate; pro: explains tension cracks, explains large negative gravity anomalies, explains why some subducting plates are in tension;

con: some subducting plates are in compression, while other plates subduct at very gentle angles

23. Four processes that are thought to cause lithospheric plates to diverge and sink at plate margins include ridge push, slab pull, trench suction and mantle convection. Ridge push occurs when plates move at spreading margins and cool, subsiding in the process to form a slope in the mantle on which the lithosphere slides away from the ridge.

    The slab pull process occurs at subduction zones. Here, cold lithospheric material that sinks into the mantle at a steep angle pulls the segment of the plate that is at the surface downwards. Slab pull is thought to play a greater role in plate movement than slab pull.

    Trench suction is thought to occur when subducting slabs fall into the mantle at such steep angles that the plate at the surface is dragged horizontally towards the trench.

    Mantle convection has also been proposed as a driver for plate movement. However, it is not clear whether convection drives plate movement or whether it is caused by the movement of plates. A variant of the mantle convection hypothesis is that narrow mantle plumes rising from the lower mantle spread radially near the surface under lithospheric plates, causing them to split and move apart.

24. The theory of mantle plumes proposes that upward convection of hot mantle rock is confined to narrow plumes that extend like vertical pipes deep into the mantle. The downward sinking of cooled mantle rock takes place slowly throughout the rest of the mantle. The radial flow of mantle material outward from the top of plumes tends to break up the lithosphere and move the plates.

25. The mantle plume theory also conjectures that plumes rise, but rather than breaking up the plate, they act as eruptive centres beneath a moving plate. The result is a line of extinct volcanoes that increase in age away from an active volcano directly above the plume.