cause of oceanic circulation. Two rival theories have been given. According to one of these, the circulation entirely arises from that of the air. The trade-winds, blowing from either side of the equator, drive the water before them until the northeast and southeast currents unite in equatorial latitudes into one broad westerly-flowing current. Owing to the form of the land, portions of this main current are deflected into temperate latitudes, and, as a consequence, an equivalent bulk of polar water requires to move toward the equator to restore the equilibrium. According to the other view, the currents arise from differences of temperature (and according to some, of salinity also); the warm and light equatorial water stands at a higher level than the colder and heavier polar water; the former, therefore, flows down as it were poleward, while the latter moves as a bottom-inflow toward the equator; the cold bottom-water under the tropics slowly ascends to the warmer upper layers, and rises in temperature toward the surface, whence it drifts away as warm water toward the pole, and, on being cooled down there, descends and begins another journey to the equator. There can be no doubt, that the winds are directly the cause of such currents as the Gulf Stream, and therefore, indirectly, of return cold currents from the polar regions. It seems hardly less certain that, to some extent at least, differences of temperature, and therefore of density, must occasion movements in the mass of the oceanic waters.²⁵⁸

Apart from disputed questions in physics, the main facts for the geological reader to grasp are—that a system of cir-

²⁵⁸ The student may consult Maury's "Physical Geography of the Sea," but more particularly Dr. Carpenter's papers in the Proceedings of the Royal Society for 1869-73, and Journal of the Royal Geographical Society for 1871-77, on the side of temperature; and Herschel's "Physical Geography," and Croll's "Climate and Time," on the side of the winds.