

(8) Variations in the properties of the atmosphere with reference to its capacity for allowing the radiation of heat.

Something may be said in favor of all these alleged causes; but as efficient in any important degree in producing the cold and warm climates of the Tertiary period, the greater number of them may be dismissed as incapable of effecting such results, or as altogether uncertain with reference to their having occurred. The earth has been gradually cooling in the course of geological time; but this is a continuous process, and its effects within the later periods can be shown to have been inappreciable. The obliquity of the ecliptic is not believed to have changed to any great degree, and its effect would be merely a somewhat different distribution of heat in different periods of the year. The relations of the lines of upheaval of our continents to great circles of the earth tangent to the polar circle, and the distribution of sediments by the arctic currents along these lines, show that throughout geological time the axis of the earth's rotation has occupied its present position. That the absolute amount of heat given off by the sun varies from time to time there seems to be evidence in the periodicity of sun-spots, and the effects on climate attributed to this cause; but we know of no long and regular cycles of this kind. We can imagine that the sun's heat may have been increased at uncertain intervals by the fall of cometary matter or similar causes; but we have no knowledge of the actual occurrence of such accidents, and we know no similar cause of refrigeration. Of difference in temperature in portions of space traversed by the earth we have no evidence whatever. It is extremely probable that in early geological periods the presence of a larger quantity of carbonic dioxide in the earth's atmosphere may have diminished the radiation from its surface, and so have caused its heat to be retained; but this cannot have produced any material effect so late as the glacial period.

There remain two theories, the fourth and seventh of the above list, which may be said to divide between them the suffrages of geologists at present, tho some have endeavored to unite them in one comprehensive explanation. This last was the position of Sir Charles Lyell as it is that of Wallace; and Croll, who is the most able advocate of the fourth, also admits