

silica, iron, alumina, lime, magnesia, potash, soda; also phosphoric and sulphuric acids and chlorine: they are necessary in a soil because they are necessary to animals who have to derive their food from the soil.

The most abundant supply of all the four organic elements first mentioned, which exist in the air, could not produce the smallest plant or the veriest insect that crawls, unless it was in union with the other bodies last named, which are derived from the soil. The soil thus furnishes a material class of bodies which cannot exist in the air, necessary to the animal and necessary to the plant, and with which we must supply the soil, if they be absent, before vegetable life can be produced. In my first report I gave a table showing that all of the mineral constituents named above were necessary; that the absence or deficiency of one could not be compensated for by an excess of the others. Thus—no amount of lime would compensate for the absence of magnesia; no abundance of chlorine be a substitute for sulphuric acid; no quantity of sulphuric acid could counterbalance a deficiency of phosphoric acid or phosphates. Let those who deny this doctrine and say that all these constituents are not necessary, show a single grain of wheat, a single blade of grass, or any soil capable of producing either, which does not contain them. But not only this, a part of the substances existing in the air are first taken in by the soil and then furnished to the plant—the soil being a medium, a kind of stomach for the proper digestion of the food obtained from the air, so that it may be used by the plant. This digestive power, or ability to produce nutritive matter, such as ammonia, from crude substances, (hydrogen and nitrogen,) depends partly on texture, partly on chemical constitution. Ammonia, as I have before said, is a compound of hydrogen and nitrogen, which is supplied abundantly to crops by the air, provided the soil has the capacity of absorbing it, or of forming it from its elements; but many soils have not this power, and it then must be supplied from other sources, such as Peruvian guano, stable manure, &c. So, then, the capacity of production in soils depends upon the presence in them of the last ten substances named, and upon their ability to form ammonia from its elements, to absorb and retain it when already formed, and to absorb and retain watery vapor—products of the four first named. This power of absorption is due partly to their chemical, partly to their mechanical nature. We must look to their chemical constitution to determine the presence, absence, or deficiency of those first named, to the chemical constituents and to their mechanical texture, to the fineness of the several particles which make up the mass of soils, to determine their absorbent quality.

The organic elements form, by different modes of combination,