temperature of the earth raised above 212°, we should then have moved under an atmosphere of steam of the same pressure as at present, transparent and colourless, and might only have heard of water as a curious substance obtained from the compression of the air. The phenomena of steam are much simplified and more perfectly explained when we take this enlarged view of its analogy with other kinds of matter.

9. We are most familiar with steam when in the act of rising violently from heated water in the process of *ebullition.* The history of steam at this crisis is highly instructive, and its phenomena may be studied with advantage by examining it in a glass vessel placed over a strong lamp. When heat is first applied, a rapid circulation of the fluid ensues. The water on the bottom, being first heated and expanded, becoming lighter than the rest, rises to the top, and is replaced by the current of colder water descending to receive in its turn a further accession of heat. By and by, small globules of steam, formed on the bottom and surrounded by a film of water, are observed adhering to the glass ; as the heat increases they enlarge, in a short time several of them unite, form a bubble larger than the others, and, detaching themselves from the glass, rise upwards in the fluid. But they never reach the sur face ; they encounter currents of water still comparatively cold, and descending to receive from the bottom their sup ply of heat ; and encountering them, the bubbles are robbed of their heat, shrivel up into their original bulk, and are lost among the other particles of water. In a short time the mass of the water becomes more uniformly heated, the bubbles, becoming larger and more frequent, are condensed with a loud crackling noise, and at last, when the heat of the whole mass reaches 212°, the bubbles from the bottom rise without condensation through the water, swell and unite with others as they rise, and burst out upon the air in a copious volume of steam, of the same heat as the water from which they are formed, and pushing aside the air, make room for themselves. In this process, by continuing the application of heat, the whole of the water may be “ boiled away” or converted into steam.

10. The singular sounds produced from a vessel of water exposed to heat, previously to boiling, have attracted attention ; the water is then vulgarly said to be simmering or singing ; and, when this takes place, it is because the vessel is boiling at one place and comparatively cold at another. This noise is most distinctly heard when the fire or flame applied is small, and its heat in teuse, when the vessel is large and the water deep ; for in that case the entrance of the caloric will take place more rapidly than the circulation can convey it to the remote particles of fluid, and so bubbles of steam will form rapidly at one place and be rapidly condensed at another ; the degree of velocity with which such bubbles succeed will determine the pitch of the singing tone. We have observed this phenomenon in greatest perfection when we have attached a slender pipe to a close boiler producing steam, and carried its open mouth, of the diameter of 1/8 or 3/16 of an inch, down below the surface of cold water in a glass jar. When the mouth of the steam-pipe is held just below the surface of the water, the steam issues with great rapidity in small bubbles, producing an acute tone ; and, on the other hand, when the pipe is held at a considerable depth, the concussions become more violent and louder, their intervals of succession greater, the tone is lowered, and finally, the shocks become detached, and so violent as to shake the glass and surrounding objects with much force. On this subject Professor Robison observes, \*that a violent and remarkable phenomenon ap pears, if we suddenly plunge a lump of red-hot iron into a vessel of cold water, taking care that no red part be near the surface. If the hand be now applied to the

side of the vessel, a most violent tremor is felt, and sometimes strong thumps ; these arise from the collapsing of very large bubbles. If the upper part of the iron be too hot, it warms the surrounding water so much, that the bubbles from below come up through it uncondensed, and produce ebullition without concussion. The great resemblance of this tremor to the sensation which we experience during the shock of an earthquake, has led many to suppose that the latter is produced in the same way ; and their hypothesis, notwithstanding the objections which we have elsewhere stated to it, is by no means unfeasible. Any obstruction on the bottom of a boiler, on the inside, as a piece of metal or stone introduced among the water, may produce a succession of smart concussions by the sudden condensation of gas collected under it.

11. The permanence of the boiling point is one of the most remarkable of the phenomena of ebullition. When water has once been brought to boil in an open vessel, it is not possible to make the water sensibly hotter, however strongly the fire may be urged or its intensity increased. This circumstance is very striking, because we know that heat continues to be thrown in exactly as fast as before the boiling point, and that in that case the heat rose rapidly, whereas now it has altogether ceased to increase. If a thermometer of mercury, air, oil, or metal be placed among the water, the temperature will constantly increase, and expand the matter of the thermometer, until the water boils, and then, whether it boil slowly or rapidly, with a strong fire or a gentle one, the thermometer will continue to stand at the same point. This point is so well defined, as to furnish our standard for the comparison of temperatures, and is the same on all thermometers, being called *the boiling point,* although it is differently numbered on each, being called 212° on our common thermometer or Fahrenheit’s, 80° on Reaumur’s, and 100° on the centigrade thermometer.

It is also to be remarked, that the temperature of the steam issuing from boiling water is the same with the temperature of the water itself, and remains equally invariable ; so that all the steam produced from water boiling at 212° is itself at 212°. This remark will assist us in accounting for the disposal of the heat which the fire gives out during the time of ebullition ; for it is manifest that the heat is all the while carried off by the large volumes of steam, nt a temperature of 212°, that are diffused through the air ; and so it happens that an increase of heat in the fire, instead of increasing the heat of the water, only increases the volumes of the steam thrown off, and the quantity of heat carried away. This view of the subject is confirmed by a simple experiment. Take a strong glass flask, place water in it and a thermometer among the water, and let it be held over a lamp until the water boil, and the thermometer will be observed rising till it reach 212°, when the steam will begin to escape rapidly from the neck of the flask. Let it now be corked tightly, and the heat continually applied ; and it will be observed that the thermo meter does not now stand at 212°, but rises rapidly from that point up to 220° and 230°, showing that the free escape of the steam into the open air is necessary to the permanence of the boiling point. If the heat be still applied, the experiment may be rendered still more instructive, by suddenly pulling out the cork of the flask, when the vapour will instantly rush out in a large volume, and the thermometer sink down to 212°, showing that all the excess of heat has been carried off by the steam into the air.

12. Wo have thus seen that a large quantity of heat may be given out to the particles of a certain quantity of water, converting them into steam, and yet that the thermometer shall afford no indication of this quantity. As soon as water boils, the whole mass is heated up to 212°;