16. In the change which takes place in the natural clothing of animals at the approach of winter, we observe a beautiful provision against the severity of the season. Hair is changed into wool, feathers interspersed with a thick lining of down, and furs thickened by a dense mass of short hairs.

17. Brittle bodies are liable to be cracked or broken upon the sudden application of heat. Hot water poured into glass decanters, tumblers, &c., frequently breaks them. The glass, being a bad conductor of heat, has one surface suddenly expanded, whilst the other remains nearly in the same state as before. The unequal expansion causes a disruption of the substance of the glass. This effect is most observed when the glass is thick, and presents an obstacle to the passage of heat, and a uniform expansion of its parts. Plates of heated cast iron are also often broken when cold water is poured upon them. One side is suddenly contracted by cold, while the other suffers little diminution in its temperature. The unequal contraction disarranges the particles of the brittle iron, and forcibly separates them.

18. Many extensive and highly important natural phenomena depend upon the expansion of air and water by heat, and the current induced by that effect. The heat which proceeds from the sun imparts very little of its effect to the transparent air through which it passes. It is received by the earth, which in many parts of the world would become intolerably hot, but for the air which envelopes it. The layer of air next to the earth becomes warm by its contact with the heated surface of that body, it is immediately expanded, and rendered lighter than the colder air above it. It rises in consequence, and gives place to a supply of cold air from the colder regions, which is warmed in turn, and ascends to make room for fresh additions from the vast reservoir from above and around. It is thus that the earth is cooled and the air warmed. In the islands of tropical seas, this phenomenon is of vast importance to the inhabitants. The cool and refreshing breezes sweeping over the surface of the waters, convey away the heat of the hot soil, re-animate all orders of animal life, and revive the drooping forms of the vegetable world. The trade winds spring from the same cause. The currents established in an unequally heated vessel of water will afford an apt illustration of the mode in which these great operations of nature are silently and imperceptibly going on. Dissolve some sugar in a glass of cold water, which, when at rest, place over a spirit lamp, and observe the course of the currents immediately formed. Fig. 5 represents the glass vessel and lamp—the arrows show the direction of the currents, the warmed water ascends by the sides of the vessel, the cold fluid from above descends and occupies its place, until it receives that accession of heat which renders it lighter than particles above it; it then ascends by the sides.

Fig. 5

19. Radiation.—A hot body gives off a portion of its heat in straight lines, and in all directions. Heat thus given off, is said to be radiated, like rays of light. It moves with inconceivable rapidity, and does not always affect the body through which it passes. Heat from the sun is altogether radiated. It proceeds to the earth and into the planetary spaces in straight lines at the rate of eleven millions of miles in one minute. It produces very little effect upon the atmosphere before it reaches the earth. Whenever heat is transmitted from one body to another without affecting intervening matter, it consists of radiant heat. If, when standing before a hot fire, we suddenly interpose a screen, the effect is felt instantaneously; showing that the warmth came directly from the fire in straight lines, without increasing the temperature of the intervening air to any great degree.

20. The power of radiating heat, or giving it off in straight lines seems to depend upon the nature of the surfaces of the radiating bodies. This, however, is not the case; it has been ascertained that the radiating power of the same body is in the ratio of its density. The discussion of this question is of too scientific a character to be introduced into a popular view of the subject.

21. Radiant heat is absorbed by bodies possessing rough or dark surfaces, such as stones, dark woods, bricks, soils, animal and vegetable substances, &c., their temperature being increased by the heat absorbed. Polished and white surfaces reflect heat, that is, they throw it back again in straight lines.

22. Hold a piece of polished tin before a fire, or in the rays of the sun, it will reflect the greater portion of the radiant heat falling upon it, and its temperature will increase very slowly. If its polished surface be roughened, scratched, or painted, it will absorb heat rapidly, and reflect but little, consequently its temperature will soon be heightened. The best absorbing surfaces are the best radiators. If a painted and a polished tin plate be heated to the same temperature, and then exposed to air on a cloudless night, the painted surface will give off its heat much more rapidly than that which has its surface polished. If hot water be poured into two glass or tin vessels, one being smeared on the outside with lamp black, the other wiped dry and clean, the water will cool much more rapidly in the painted than in the polished vessel. It follows from these singular properties, that whenever heat is required to be retained for a length of time in any vessel, the sides of the vessel should be highly polished. We observe this principle introduced into practice, in the construction of various utensils, as tea-pots, tea-urns, &c., their bright metallic surfaces retarding the radiation of heat. We blacken the outside of stoves and stove pipes for a contrary purpose, namely, to induce them to radiate the heat they contain as much as possible, so that their warmth may be imparted to the objects in the room. In cooking vessels, such as boilers, kettles, pans, &c., that part exposed to the fire should be black and rough, in order that it may absorb heat with rapidity, whereas those parts not immediately exposed to the fire, should be highly polished, that they may radiate the heat received through the bottom from the fire as little as possible.

23. Colors affect the absorption and radiation of heat to a great degree. Dark colors when exposed to radiant heat soon become warm, and they give off their absorbed heat with equal rapidity. A dark soil will be hotter during the day time than a light coloured one, it will also cool more rapidly when the sun sets.

24. The deposition of dew upon the stalks and leaves of vegetables is due to the power they possess of radiating heat, which passes off into the planetary spaces. The quantity of moisture which air can contain in the state of invisible vapour is dependent upon its temperature. Air at 80° will dissolve more vapour of water than air at 50°. If a substance cooler than air is brought in contact with it, a portion of the heat of a thin stratum of air passes into the body it envelopes, its temperature is consequently lessened, and it cannot continue to hold in solution the vapour of water it may have previously dissolved. A portion of such vapour will immediately assume the fluid form, and be deposited upon the surface of the cool body. Leaves radiate heat with great facility: on clear nights they become cooler than the surrounding air. A thin stratum of air above them gives off its heat to the leaves, and loses the power of retaining all the moisture it had previously dissolved. A portion is therefore deposited upon the surfaces of the leaves in the form of dew.

25. Pour cold water from a well into a glass vessel in a warm room, the outside will soon become moist with dew. On a clear evening place a board about a foot above the grass, radiation will be prevented, and if the night is calm, no dew will be deposited upon the leaves of the covered grass. A thin fleecy covering of clouds obstructs the radiation of heat from leaves of trees into the planetary spaces. Clouds, atmosphere, and leaves preserve a nearly uniform temperature under such circumstances; hence dew is not seen on cloudy nights.

26. A beautiful instance of the effects of radiation is observed on a large scale during a Canadian winter. It is invariably found that snow which lies near the fences, trunks of trees, logs, and tufts of grass, melts much more rapidly than at a distance from them. The snow, in fact, receives radiated heat not only from the sun but also from the bodies it surrounds. A tree or log becomes warm by the absorption of heat from the sun; it radiates the heat it has received in all directions, and it is found that heat thus radiated by terrestrial bodies is more rapidly absorbed by snow than the direct heat from the sun, the greater portion of the latter being reflected. Cattle find the bush much warmer than the open fields, during the cold days and nights of the winter season. Radiation of heat from the earth is much retarded by the covering of forest trees; the trunks and branches of the trees themselves also radiate the heat they have absorbed from the sun's rays during the day time, these causes unite with the protection afforded from cold winds, in elevating the temperature of the bush far above that of the open unprotected plains.