been one of the most intricate and difficult of engineering problems. The destructive effects of the sea and storms upon the foundations of these buildings early proved disastrous, and in the history of the science many unfortunate failures have been recorded. The need of a lighthouse at critical points has generally been almost in direct proportion to the difficulties of constructing such a building. Shifting sands have always formed insecure foundations for high buildings, and when these were aggravated by heavy seas and universal storms and winds the problem was intensified. Even the construction of a tall lighthouse on the sandy beach some distance back from the sea was not always a matter of easy engineering work. The encroachment of the sea upon the land in many places slowly undermined the foundations until they had to be strengthened or abandoned. One of the most effectual ways to protect the lighthouses on our sandy coasts adopted in recent years has been to build dykes of piles and brush far out into the sea foi the purpose of making the ocean build up rather than tear down the beach. The tides and currents of the ocean, eddying in at particular points on the coast, would slowly wash away the beach and destroy it; but by constructing the dykes in the water these same destructive currents contributed to build up the land. When the tide laden with fine, loose sand strikes the brush anchored between the rows of piles, it either deposits the sand in passing through the obstruction, or collects it in a heap just where the angle is formed by being forced to one side by the brush. Slowly but surely land is thus formed. Half a dozen lighthouses along the Southern coast have been saved from total destruction in this way. Several of them, which a dozen years ago stood perilously near the edge of the water, now stand five hundred yards back from the tumbling ocean.

Even the best modern engineering has not yet been able to make the shifting sands a secure and permanent foundation for heavy structures. The difficulty of digging down into the sand for a secure foundation is sometimes attended by unexpected developments and obstructions that render the work almost of no avail. Forty and fifty feet below the sands nothing but soft, shifting quicksands have frequently been discovered, and the site of the new structure has had to be abandoned as a result. The difficulty of finding the right sort of foundation on the low sandy coast of our Southern States has consequently made lighthouse building more intricate in detail than along the rocky New England shore. Some of the most perplexing engineering problems have been solved in that part of the country.

One of the most noted advances in modern times has been the abandonment of the old towers of stone or brick and the adoption of the steel tubular structures in their places. The latter are built more easily on a solid, rocky foundation than the old huge piles of masonry. The steel skeleton is bolted into the solid rock or anchored there by means of long spindle-like legs, which sink many feet down into the firm foundation. These huge cylindrical towers of steel withstand the pressure of wind far better than the stone and brick structures, and their strength is so great that there is practically no danger of their ever being seriously injured by the elements. Even where the lighthouses are built in the water to mark shoals or dangerous reefs, the steel tubular style of structure is adopted. The foundation work of the structure is built up above the water with stone or concrete, and to this the steel tower is bolted. The latter looks more like a giant smokestack than anything else, and it stands as a permanent beacon of the sea to warn mariners of their danger.

Not only is additional strength and security obtained through the adoption of the steel tubular lighthouses, but the cost of construction is greatly reduced. Modern lighthouses cost far more than they did in former days, but that is due to the fact that they are built on a larger and more enduring scale, and the lights are of far greater power and intensity. A modern American lighthouse frequently costs $125,000, and often one-third of this is spent in the electric light and apparatus alone. In the old system the lights represented a comparatively small proportion of the expense. The finest French mirrors and lenses used were considered costly, but not in comparison to the electric lights and equipments. The gain obtained in the power of the light more than counterbalances the extra cost. There are a score or two of lighthouses in existence whose lights throw a beam of 100,000 candle power. The tendency is to increase the power of the lights, for by so doing the great link of lighthouses is made more secure and more trustworthy.

To maintain the lighthouse service a corps of over 4,000 men is constantly employed, and a fleet of more than fifty vessels. These latter are required to make periodical visits to the different lighthouses, light ships, and buoys, carrying supplies to the men and inspecting the lights in the interests of the department. The lighthouse keepers receive on an average $600 a year for their services. With the salaries of the crew, coal and provisions, it costs the government about $6,000 a year to maintain a first-class lightship, and about $500 a year for each of the 5,000 buoys scattered along the coast. At present the sum of nearly $750,000 is required to pay the lighthouse service men who watch the lights, tend the buoys, and live their solitary existence on the lightships. The service is altogether well handled, and as efficient as it is possible to make it, while the keepers and crews are as enthusiastic in their work as any body of men in the world.

THE PHYSIOLOGY OF CERTAIN COLORS.

BY JAMES WEIR, JR., M.D.

Havelock Ellis, several months ago, had an article on "The Psychology of Red" in Popular Science Monthly, in which he showed that red has an unmistakable effect on the psychical organism. Incidentally, he also demonstrated the fact that color has likewise a physical effect both upon plants and upon animals. He does not, however, discuss the physiological causes for each effect. It is the purpose, therefore, of this brief paper to bring out the probable action of color on the basic principles of life as far as we know them.

Thousands of years ago, it was noticed that plants reared in darkness were colorless and of weak and fragile habit. It was also observed that men who passed their lives in darkness or semi-darkness were not as robust as those who lived in the light of day. So the general conclusion was reached very early in the history of the world, that the light of the sun directly influenced both animal and plant life.

Recently, it has been determined that the rays of the sun exert dynamic, chemic, and physiologic effects on the *vis vitæ* of plants and animals. The three forces through which the rays of the sun act, viz., the dynamic, the chemic, and the physiologic, are, to a certain extent, intercorrelated; therefore, they must be studied together.

It will hardly be necessary to point out the fact that white light or daylight is a combination of all of the primary colors, violet, indigo, blue, green, yellow, orange, and red. It is highly important to my thesis, however, to demonstrate that certain of these colors exert a selective or elective influence on the physiology of animate organisms, and, individually, affect such organisms in some degree.

Flammarion's beautiful experiments at the climatological station at Juvisy, have shown beyond question of doubt, the widely different effects of the red and violet rays on plants. The plants chosen were of the genus *Mimosa* or "Sensitive Plant," and were subjected to the same environments with the exception that some were reared beneath dark blue glass, and others beneath red glass.

In four months, the plants grown under the red glass had attained extraordinary development, while those subjected to the violet rays had made no progress whatever. Similar effects were noted in the case of strawberries, and numerous other vines, plants, and shrubs.

The plants grown beneath blue glass did not die, but seemed to remain in a dormant condition without growth or further development.

Zacharawietz, of Vaucluse, has also shown that plants are strongly affected along the lines of rapid growth and development by red and orange rays. As early as 1883 I demonstrated and published the fact that typhoid fever germs would not live when subjected to the blue or violet rays.

Ward, Finsen, Berghold and others have shown that the blue, violet and ultra-violet rays are fatal to bacteria and that the other colors are not, while Finsen has made successful use of this knowledge in the treatment of zymotic skin diseases, such as smallpox, measles, and scarlatina. It would appear from these observations that the red and orange rays have a distinctly favorable physiological action on plants, while the blue, violet, and ultra-violet rays are as distinctly deleterious.

When we come to observe the action of the violet rays on animal life, we see that such action is, apparently, markedly different from that to be observed in vegetable life. But, as Davenport has pointed out, this difference is more apparent than real; for these effects on animal and plant physiology are due to the same chemical metabolic changes, but, "while plants succumb to the influence of the violet rays, animals, being more highly organized, are able to take advantage of them and flourish."

In 1883, while studying tinctumutation or the color-changing function in certain animals, I reared a large number of newts, or salamanders, from the eggs. The eggs were placed in shallow vessels which were covered by colored glasses, blue, orange, green, and red.

The eggs under the blue glass hatched out first; under the orange, second; under the red, third; and under the green, last of all. The young larvæ under the red glass were much more active, at first, than those under the other glasses, and attained full maturity several days earlier. The larvæ under the blue glass, however, grew to be much larger and in the end were much stronger and more agile. Under the green glass, the larvæ were sluggish, and of slow growth. I noticed, moreover, that whereas there were no monstrosities or deformed animals under any of the other glasses, there were many under the green and the orange glasses.

The animals under the blue glass were distinctly darker than those under the other glasses, and, under the microscope, the chromatophores, or color-bearing cells, were seen to be much more numerous.

The violet, and ultra-violet rays have a pronounced chemical as well as physical effect on the human body. They have, also, in all probability, a dynamic effect, which is shown by the feeling of well-being or otherwise. The "summer girl" who, in the early days of her vacation, cannot stand the sun, will, in the middle of summer, welcome the embraces of Phœbus Apollo and will revel in his kisses! She says that she has become accustomed to the rays of the sun and that she no longer feels them because it has become her "habit to walk abroad without hat, parasol, or umbrella." Thus she gives credit to the wrong agent; for her feeling of well-being is not due to habit, but to the thin brown veil of tan which the violet rays with ever-busy brush have spread out on the surface of her body wherever it has been exposed to them. The violet rays thus erect a barrier against themselves, for they cannot pass the tan. Nature always takes care of her children, that is, if they will give her time, and do not, in their ignorance, attempt to hasten her!

It is true that, primarily, the violet rays are superficial in their effect; yet they are, nevertheless, sometimes destructive in a high degree. Ask the boy who awakes in the night after an afternoon in the river, and "moans, and moans, and moans" on account of the intolerable fire between his shoulder blades, what *he* thinks of the ultra-violet rays; or, ask the blind and helpless traveler who stumbles across the weary waste of Arctic snows what *he* thinks of them? Both sunburn and snow-blindness are due to the violet and ultra-violet rays.

Yet, the violet rays are absolutely necessary in the up-building of the normal, healthy man. Their action must be, I take it, primarily through stimulation of the vaso-motor nerves, i. e., the nerves which control blood-vessel action. The first effect is dynamic in character; there is dilatation of the blood vessels with a consequent increased flow of blood. The second effect is chemical in nature; the increased flow of blood incites the blood-producing organs to manufacture new blood-cells, consequently the plasma of these cells differs chemically from the plasma of the old cells. There is, also, increased oxidation and oxygenation due to increased flow of blood through the lungs. The third effect is purely physiological. Owing to the increased flow of new blood cells to the tissues, cell growth is excited and new tissue is formed. Of course, waste is going on all the time; the violet rays merely act as a tonic in stimulating the organs of the animal economy toward repairment of waste by renewing and building up tissue. These beneficial rays are present in diffused daylight, hence the direct rays of the sun are not absolutely necessary in order to produce their good effects on the animal organism. Direct sunlight is, however, an exceedingly efficacious tonic when used moderately and understandingly; there can be intemperance, however, in the use of every good that Nature has given us.

TWO NEW WARSHIPS FOR CHILE.

Remarkable progress has been displayed by Messrs. Armstrong, Whitworth & Co., of Newcastle-on-Tyne, and Messrs. Vickers Sons & Maxim, of Barrow-in-Furness, the famous British armament manufacturers, who are each building a first-class battleship for the Chilean navy. On February 26 last, as both the new ships were to be as nearly alike as possible and brought up to date, Sir Edward Reed, the English M. P., who is naval architect and engineer of the Chilean government, brought the two firms into close communication in respect of everything of first-class importance in these two battleships, including the design of the two ships and of their machinery, armor, guns, etc. The result of the co-operative action of the builders in this instance is that already the Armstrong Company have worked 3,000 tons of materials, and the Vickers Company approximately the same quantity into the hulls of their respective ships, and have made corresponding progress with the armor, guns, etc. The work of construction was hurried forward by the recent threatenings of a rupture between Chile and Argentina, and the two firms contracted to build and arm the ships ready for sea within eighteen months from the date of signing the order; but the new treaty between the two countries has retarded building to a certain extent, though the two firms, in view of the progress that has been made, are yet hopeful of completing the work within the specified time. If the work is fulfilled within the eighteen months, it will constitute a record for speed in the building of a first-class modern battleship.