The World Beyond Our Senses

BY CARL SNYDER

THE world wherein lives Helen Keller would seem to us, translated there, singular enough. In her world floats no sound; the rustle of the forest, the roar of the cataract, the harmonies of Wagner, the magic of the spoken word, enlist no thrill. Dawn and dusk, days and seasons, are alike. The glory of the summer, the burgeoning of the spring, the colors of October, are known to her only through dim changes in the warmth of her skin. The places of the earth are all the same, the desert or the crowded Strand. Bagdad and the Yosemite differ for her only in their smell. Save for the reports of those around her, of the living world she knows little, and could learn little more.

And we, dowered with the seeing eye and the listening ear, have pity for this stricken girl. Slightly we realize that in some sense we are all Helen Kellers, and that ours too is a Helen Keller world. Suppose, by some magic, our eyes might be opened so that we could see the filmy waves of light which reflect for us the landscape and the morning sky, or the waves of sound which bear to us the carolling of the lark? Suppose that in the dancing air we could see the myriad particles wildly chasing one another at a speed of nearly half a mile a second; that in the lump of sugar or grain of salt we could watch the twirly-whirly Sir Roger de Coverley of the atoms, partners skipping gayly one to the other like as on a ballroom floor; suppose we could watch the twinge of pain, the thrill of joy, as it travels along the nerves; that we could *see* the "lines of force" which circle round a magnet and generate electricity in a dynamo; suppose that beyond the deepest red, or the faintest violet, all the colors of the spectrum might be opened to our view,—would not such a world seem as strange to us as would our visible world could Helen Keller's sightless eyes be touched to the light of day?

It is from our eyes that we learn most concerning the things about us. Were it not for them, the images we make of objects and events would be confused and crude enough. Beside our other senses, marvellous they seem. They measure and compare every little dot and stroke and turn on this printed page, so hopelessly bewildering to the untaught, and alike the gleam of a star distant, it may be, hundreds of thousands of millions of miles.

Yet beyond all that the eye may see, that ear may hear, that hands may feel, outside of taste or smell,—outside of any native sense,—there lies an unseen, unheard, unfelt universe whose fringe we are just beginning to explore.

A flash, so to speak, from this suprasensual world came with the discovery of the Roentgen rays. It is now eight years since we first learned that we may look straight into our bodies and see our bones, that in this light even great books of philosophy become quite clear—transparent even; and the wonder has a little died. But they are still called X-rays, for we still do not know what they are nor where they belong.

What is tolerably sure is that there is a wide gap between the Roentgen light and common light, and the gap seems to lie far above the shortest little light waves hitherto known. It is in the form of minute waves, more than microscopic undulations in the all-pervading ether of space, that physicists nowadays conceive light. And it is a difference in wave length merely that makes what we call color. The red and the orange are long waves, not more than 33,000 to 40,000 to a linear inch; the indigo and violet waves are only about half as long, from 50,000 to 60,000 per inch. In between are the yellow, green, blue, and all their insensible gradations.

It was Sir Isaac Newton's first notable discovery that white light is a compound of all the others, and that a sunbeam may be broken up into its component colors by means of an ordinary three-cornered prism. A three-cornered glass of water or other liquid does much the same, and that is exactly what the rain-drops do when the sun strikes them right. The colored image produced by the prism is an artificial rainbow. Old Sir Isaac called it a spectrum, and the name has held. It is the same as our word spectre, an apparition.

Curious-minded men were not long in finding out that beyond either end of the visible spectrum curious things go on. For example, if a thermometer be held below the red end of this artificial rainbow, in the "infra-red," as it is called, it gets hot, although there is very little heat in the visible part of the spectrum. The quite unbearable heat you get with a burning-glass is due to these invisible heat rays, and not to the light at all. So, for example, it is possible to split up a sunbeam with a prism, and then focus only the invisible infra-red part of the spectrum, and get almost as much heat as though you had focussed the entire body of the light.

Of course if our eyes were sensitive to these invisible "heat rays" as they are to the "light rays," we could "see" with heat just as well as with light. Indeed, we can conceive a race of men fitted with eyes sensitive to the heat rays, and only to them. To such a race our day would be bright as to us, for in the sunlight are both light and heat rays; but they might also sit and read in a room with a warm stove, that to us would be pitch-dark. Their windows might be made of thin plates of hard rubber, to us entirely opaque, and they might look at the sun and the stars through telescopes with lenses made of the same materials. Theirs would be a world beyond our senses.

So too with the other end of the spectrum, the beyond-the-violet end. When Daguerre and others found that upon certain delicate salts, like nitrate of silver, light has a chemical action, they opened the way for an exploration of the ultra-violet. For it did not take long to find out that here again it was a question of invisible forces. A large part of the waves which affect a photographic plate do not affect the eye at all. So it is possible, by means of a prism and a little screen, to shut out all the visible parts of the spectrum and still take photographs just as usual. These are the so-called actinic or chemical rays, and in a chemist's hands they are capable of a variety of actions. Had they been known two or three centuries ago, men would surely have thought they had found the philosopher's stone, for these rays will turn one kind of phosphorus into another and quite different kind; they will produce violent explosions, and make substances conduct electricity which otherwise do not. They seem to have healing powers, for under their influence cancers disappear, and many skin diseases may be similarly treated. Their rôle in nature, too, is immense, for it is these rays which in the green leaves of the plant turn the carbonic acid and water into sugars and starches: the first of those conversions of the inert materials of the air and the soil into food; the first step toward the organization of life.

These ultra-violet rays go through many substances impervious to visible light, so that if we had a race of men with eyes attuned to these rays, they too might live in rooms black as ink to us. In some sense theirs, too, would be another world than ours.

Has any one the notion that while these suprasensual domains may exist, after all they do not amount to much? Let him construct for himself a scale, that he may have a clear idea of precisely how much his chief and most highly developed sense, the sense of sight, really takes in.

Waves of light are measured in millionths of a millimetre—that is, in units of about one-twenty-five-millionth of an inch. They are called micro-microns, and written with the two Greek letters $\mu\mu$, for short. One $\mu\mu$ bears the same relationship to an inch as one inch does to fifteen miles.

The longest red rays visible measure about 810 $\mu\mu$, and the shortest visible violet rays are about 380 $\mu\mu$—that is, about one-half as long as the red. It is not possible as yet to go very far into the ultra-violet; when it is we shall get very close to the ultimate structure of matter. But even now it is possible to detect invisible rays that have only a quarter the length of the shortest visible ray—that is, about 100 $\mu\mu$.

Far out in the spaces beyond the beyond-the-violet, in regions yet unexplored, lie probably the Roentgen rays, and yet others possibly which experiment may disclose the effect, even though we may not as yet apprehend them directly. Far beyond the confines of what we call matter there seem to be minute particles, the tiny grains of which the relatively huge atoms of matter are made. These particles are thrown off from all highly heated or highly electrified bodies, such as the sun, the electric arc, etc. They are the so-called cathode "rays," which Sir William Crookes and latterly Professor J. J. Thomson, of Cambridge in England, have studied so deeply. These, bombarding space and all it holds with terrific speed (fifty to a hundred thousand miles *per second*), give rise to all sorts of perturbations of the ether, and of these the X-rays are one. The cathode rays are made to impinge upon certain chemical substances, and through this impact we have that peculiar fluorescence which shows through solid things. No means have yet been found to measure the wave length of this new kind of light.

Beyond the other end of the spectrum the measuring hand has gone much farther. The longest light wave is but 810 micro-microns; the longest heat wave so far measured is 70,000. Here are the materials for a scale. This will give you an idea of the compass of the rays upon which we depend for the most of our knowledge of things outside us:

would be needful that we have a temperature sense as acute as our sense of sight, and eyes as sensitive as a photographer's plate. We have neither. A comparison may help to make this clearer. The naked eye, in clear skies, might count in all the heavens perhaps two to four thousand stars; the number would vary greatly with individuals and climes. Aided by the finest telescopes, this number rises to tens of hundreds of thousands, and more. Calling in the aid of the photographic plate, an international star-map is now being made which will definitely locate the position of twenty to thirty million suns. That is the difference between the eye and the camera. In some part, these twenty-odd million stars are fixed by means of the invisible rays of the ultra-violet, to which the eye is wholly insensible.

Again, it is with difficulty that we realize a change in temperature until that change amounts to several degrees on the thermometer. In order to detect and map the invisible rays of heat, the infra-red rays, it was needful to construct instruments about one million times as sensitive. The most delicate of these devices is the bolometer, which was the invention of Professor S. P. Langley, secretary of the Smithsonian Institution at Washington. It will accurately register a change in temperature of one-millionth of a degree, Centigrade. It will register the heat of a candle a mile and a half distant.

Lest any one surmise that there is some guesswork about this, it may be noted that there are several heat-measurers, of almost equal sensibility,

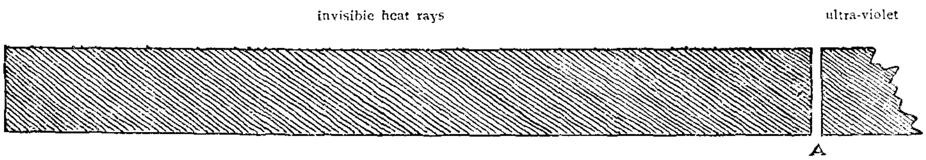

Diagram scale, showing the relations of the visible part of the spectrum to the invisible

The small portion of ether waves concerned in vision is indicated by the little gap marked "A." By far the larger part of the ether vibrations, the "heat rays," and the ultra-violet, affect our senses but slightly.

It is only through the little gap marked "A" that we get a glimpse of the real world. In order that we might make use of this wide range of ether waves it whose results accord perfectly with Professor Langley's extraordinary machine.

From the longest heat rays, measuring 70,000 $\mu\mu$, to the shortest known rays of the ultra-violet, but 100 $\mu\mu$ in length, we have an unbroken series of ether waves. This series covers the first faint tremblings sent out, let us say, by a bar of iron that we have begun to raise in temperature, up through the red glow which first makes the bar visible in the dark, to the dazzling light it sends forth when it has become white hot. What we call heat and light, then, are but purely personal or subjective sensations, aroused by the same medium, and differing only in the rapidity of motion in this medium.

Have we reached nature's limits, or may we farther go? At the moment exploration of the ultra-violet seems blocked, but at the opposite end subtle experiment is reaching out to link yet another great field of science to this long chain. That is the field—one might almost say empire—of electricity. I have elsewhere given account of recent endeavors to ascribe electrical phenomena to the movement of extremely minute particles of matter, a thousandfold smaller than the smallest atom known, called corpuscles or electrons. However this may turn out, it is certain that some forms of electricity, and heat and light, are very close of kin, apparently merely varieties of ether motion.

This was predicted by Clerk-Maxwell in a purely mathematical calculation more than forty years ago, long before sufficient experimental evidence existed. Its verification, in the hands of Heinrich Hertz, a quarter of a century after, was the strongest support the ether-wave theory has yet received.

If Maxwell's ideas were sound, a discharge of electricity across a gap would set up vibrations in the ether round about, just as a stone dropped in a pond will set up waves that go travelling outward in every direction. And Hertz found that this is exactly what happens. It was this discovery which made wireless telegraphy possible. These ether vibrations are called, in honor of their discoverer, Hertz waves.

Hertz found that his electric waves measured about 150 feet from node to node—that is, from the top of one wave to the top of the next. The waves used by Marconi, in telegraphing across the Atlantic, are considerably longer than this — 600 feet or more. These waves travel at the same speed as light—that is, at the incredible rate of 184,000 miles *per second*. Apparently they go straight through walls and mountains, and are only arrested by metal. Hence the employment of a network of wires at the receiving-stations in wireless telegraphy.

From an electric wave 150 feet long to a light wave measuring a few millionths of an inch is a far cry. The gap is wide. Nevertheless, the scientific imagination bridged that gap and accepted Hertz's discovery as proof of the identity of the two. Since then the Calcutta physicist, Jagadis Chunder Bose, who was the first to send a signal by wireless telegraphy, has succeeded in producing electric waves but two or three millimetres (about a tenth of an inch) long. The waves sent out by this delicate little machine are much nearer to the longest heat rays than to the longest electric waves. The actual gap is only from three millimetres to seventy micromillimetres. Filling this gap is really a mere mechanical detail.

Thus is one great chapter in the physical account of this world practically complete.

It need hardly be added that, as for the longer waves of heat our senses grow dim and uncertain, for the electric waves we have no sense at all. They lie outside our sensual world, and until science had devised new senses, as it were, we had not so much as a suspicion of their existence. Suppose that we could be dowered with such an electric sense: the spark gap of the oscillator, or sender, answers to a source of light, the receiver to a mechanical eye. If our eyes were sensitive like this mechanical eye, then we might watch the progress of a play in Buenos Ayres, or have witnessed the struggles at Peking through the long days which brought no word. Only years of patient and toilsome research, — the steady labors of men stirred not by love of money, but by love of knowledge,—will disclose to us what more we may learn concerning the unseen world about us.

The Bluebird

BY JOHN BURROUGHS

A WISTFUL note from out the sky,
  "Pure, pure, pure," in plaintive tone,
  As if the wand'rer was alone,
And hardly knew to sing or cry.

But now a flash of azure wing,
  Flitting, twinkling by the wall,
  And pleadings sweet and am'rous call,—
Ah, now I know his heart doth sing.

O bluebird, welcome back again;
  Thy burnished coat and ruddy vest
  Are hues that April loveth best,—
Warm skies above the furrowed plain.

The farm-boy hears thy tender voice,
  And visions come of crystal days,
  And sugar-camps in maple ways,
And scenes that make his heart rejoice.

The lucid smoke drifts on the breeze,
  The steaming pans are mantling white,
  And thy blue wing's a joyous sight
Among the brown and leafless trees.

The loosened currents glance and run,
  The buckets shine on sturdy boles,
  The forest folk peep from their holes,
And work is play from sun to sun.

The downy beats his sounding limb,
  The nuthatch pipes his nasal call,
  The sparrow sings atop the wall,
And robin lifts his evening hymn.

Now go and bring thy homesick bride,
  Persuade her here is just the place
  To build a home and found a race,
In downy cell, my lodge beside.