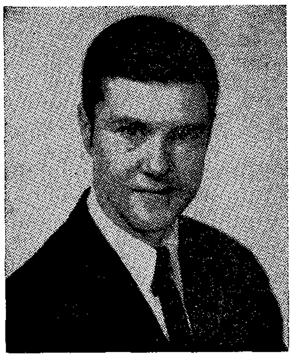
THE RESEARCH FRONTIER



—Canada Agriculture.

WHERE IS SCIENCE TAKING US? *Among the most dependable of early indicators of direction are confidential reports exchanged at the Gordon Research Conferences, symposia in chemistry held annually on the campuses of a half dozen Atlantic and Pacific coastal schools during academic recess. In each of these meetings, a single subject of study is discussed exclusively and exhaustively for an entire week. Subjects assigned for the summer of 1965 include organic photochemistry—the study of the effects of light on biological systems. Below is a brief description of the growing edge of knowledge of this continuing mystery of creation. Dr. Douglas J. C. Friend is a plant physiologist in the Canada Department of Agriculture, Ottawa, momentarily assigned to the Commonwealth Scientific and Industrial Organization in Australia. His report here originated with an item in the "Canadian National Research Council News."*

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WHEN light falls on an object, one of two things happens: The light is either reflected or absorbed. To have any effect on a living system, absorption of light must take place. The absorbing substance is often a brightly colored pigment such as the green chlorophyll in the leaves of plants or the visual purple in the retina of animal eyes.

One way to identify the particular pigment responsible for light-stimulated reactions is to irradiate a plant or animal with light of different colors. In this way it has been found that red and dark-red light can have very profound effects on many aspects of plant growth. The pigment responsible has now actually been isolated by plant physiologists of the U.S. Department of Agriculture at Beltsville, Maryland, and given the name of "phytochrome."

Although normally present in plants in extremely low concentration, extracts from about three pounds of oat seedlings have been sufficiently concentrated to establish that the pigment is a protein, blue-green in color. This pigment has some remarkable properties; it is energized by red light in some way not yet understood to set in action a whole train of chemical reactions that can profoundly alter the pattern of plant growth. Seed of lettuce and many other plants is stimulated to germinate by this activation of phytochrome; in other plants, the greening of seedlings when they come into the light, the reddening of the skin of apples, and the formation of a yellow pigment in the skin of tomatoes all depend on the activation of phytochrome.

Only a low intensity of light is needed to activate phytochrome. Bright moonlight just about reaches the level of effectiveness for some plants, and the duration of illumination is usually more important than the intensity of the light.

The flowering of fall-blooming plants such as chrysanthemum can be prevented if the naturally short daylengths of autumn are extended by artificial light. In summer-blooming plants such as snapdragon, use of artificial light to lengthen the effect of winter sunlight has exactly the opposite effect: Flowering is hastened by the activation of phytochrome.

Once phytochrome has been activated by red light it is either used up in further chemical reactions, or else converted back into "inactive" phytochrome. This conversion can take place in the dark, or, more rapidly, under the influence of dark-red light. The exact proportion of red light and dark-red light in the illumination determines the amount of phytochrome activated and the response of the plant.

In addition to phytochrome there is increasing evidence of the existence of another pigment that is activated most by dark-red light and can promote flowering in wheat and barley. This pigment has not yet been isolated.

The most important action of light on living organisms is photosynthesis, the building up of sugars from the carbon-dioxide of the air in the green leaves of plants. Without photosynthesis there would be no green plants, no food for animals, no coal or oil—in fact, no life as we know it!

The energy that is used to make the sugars comes from the light absorbed by the green pigment, chlorophyll. It now appears that the color of light can determine the type of organic compounds that are formed. For example, more glycine is created in red light than in blue.

Field measurements of both the quantity and quality of light help us to understand the way in which light is trapped by different crops, and may perhaps eventually lead to further improvements in yield through better utilization of sunlight. New instruments have been constructed for measuring the quantity of light falling on a crop and for measuring the energy in different regions of the spectrum. Some of these instruments are portable, for use within the crop itself; one is even able to "put out a feeler" which measures the light while moving along between the leaves of a crop. A photocell mounted on the end of a boom travels horizontally through the leaf canopy. This sampling is automatically repeated at different heights from the ground to give a complete three-dimensional picture of the pattern of light absorption within the crop.

The forests forming such a dense cover over much of our land are one of the most efficient "crops" for using the light energy from the sun; methods have been worked out for measuring the light energy that filters through the forest canopy and is therefore available for plants underneath. One such instrument is similar to a photographic light meter, but contains a special photocell that mimics the effect of light on photosynthesis. Unlike the photographic light meter, which is most sensitive to yellow-green light—the same as the human eye—the response of the forest instrument has been adjusted to have highest sensitivity in the blue and red, the regions of the spectrum most active in photosynthesis.

HUMAN beings and animals are sensitive to light in a surprising number of ways. For instance, the effect of light on pigments in our skin must be evident to anyone who has ever been sunburned! When we "see" light or color, we are actually responding to nerve impulses triggered by the absorption of light in the pigment of the eye. The pigment that absorbs light is situated in special cells of the retina called rods and cones; the rods are more sensitive to low light intensity than are the cones.

Many animals, such as rats and mice, are active at night, quiet by day. It has recently been found that the Arctic lemming remains far more active in light than the deer mouse. A correlation has been found between this difference in activity and retina composition. The retina of the deer mouse is composed mainly of rods, while there is strong evidence that the retina of the lemming contains only cones.

The attraction that light has for insects is well known, but the reason for it is not yet completely clear. Sometimes it seems to be advantageous for insects to avoid light; for instance, the maggot of the common housefly moves away from light shining in a certain direction, although it can't "see" the light because it has no eyes.

The length of day controls the reproductive cycle in some animals as well as plants, but the pigment responsible is not yet known. In the aphids (greenflies) the *length* of the daily period of illumination determines whether the female gives birth to living young or lays eggs. In the short days of fall, eggs are laid, but lengthening the days by means of artificial light causes the birth of living young, as occurs under the long daylengths of mid-summer under natural conditions.

In some plants and animals there are strong rhythmic processes that may be only partly determined by the daily change from light to darkness. Some plants will continue to lower their leaves in "sleep" movements every twelve hours even if kept in continuous illumination or continuous darkness. Such "biological clocks" are also found in animals; the nocturnal activity of mice will continue to show a more or less daily rhythm even in continuous darkness. The main action of light in these cases is to keep the "biological clock" on time, and here again phytochrome may be involved.

There is some argument as to whether the timing mechanism for the "biological clock" exists within the organism itself or is maintained by outside influences such as daily changes in the earth's magnetic field. Dr. B. G. Cumming here in Ottawa has been accumulating experimental evidence of a relationship between storms on the sun and germination of seeds here on earth. He has reported a significant correlation between changes in the solar radio flux (measured at 10.7 centimeter wave lengths) and germination of seed of a common weed, goosefoot. Periods of high sunspot activity coincided with periods of increased germination, over a two-year period. As these seeds were germinated at weekly intervals under constant conditions of temperature, light intensity, and humidity, we can only surmise that seed germination is stimulated by some physical factor associated with sunspot activity. Whether increased radio emissions from the sun at this time or parallel changes in the earth's magnetic field are responsible remains to be determined.

THE frontier that stretches ahead of us in photobiology is exciting enough to give the illusion of a new science. In truth, photobiology is an old science that is attracting new attention, as witnessed by the recent formation of photobiology societies in countries all over the world. An International Photobiology Congress was held in Oxford last year. The search for trace pigments capable of absorbing light, participating in photochemical reaction, and triggering biological responses (the latter often expressed at a much later date) is being intensified as the result of new insights, new methods, new instruments, and new training.

LETTERS TO THE SCIENCE EDITOR

Fluoride's Side Effects

IN "Fluoridation vs. the Constitution" [*SR*, Apr. 3], Professor Arthur Selwyn Miller stated that the case for holding fluoridation unconstitutional would be strengthened if there existed soundly documented medical evidence that fluoridation threatened the health of the population. My own research, as well as the research of others, strongly suggests that fluoridation constitutes a hazard to the health of a significant portion of the population.

I have been engaged in the diagnosis and treatment of allergy since the inception of this specialty in the early 1920s and have contributed to development of the discipline through clinical research. I established and directed allergy clinics in five Detroit hospitals. Currently, I am consultant in allergy at Harper Hospital, Detroit, and attending physician at Woman's Hospital, Detroit. I am a Fellow of the American Academy of Allergy, the American College of Allergists, and the American College of Physicians.

In 1953 I was first to report, in the *Journal of the American Medical Association* (vol. 151, page 1398), a new disease caused by smoking. This disease, which I termed "smoker's respiratory syndrome," simulates asthma and eventually leads to emphysema. I would not have recognized the illness in my patients had I not by chance suffered from it myself. Because I recovered upon ceasing to smoke, I began to take a closer look at some of my patients who, presumably suffering from allergic asthma, had failed to respond to the conventional treatment for that ailment. A large percentage of these patients recovered without treatment when they stopped smoking. Since publication of my article in *JAMA*, numerous physicians have corroborated my observation and have thus prevented chronic emphysema in their patients.

In that same year 1953, Mrs. S. S., aged forty, a resident of Bay City, Michigan, was referred to me by her physician for allergic studies in order to determine the cause of a gastrointestinal disorder accompanied by migraine-like headaches. My tests revealed that her illness was not due to allergy. She wondered why her condition always tended to clear up when she was away from Bay City but became aggravated upon her return. She questioned whether the Bay City water might be involved. At that time neither she nor I was aware that Bay City's water had been fluoridated since 1951, when her illness began.

I had dismissed this case from my mind when, in September 1954, a patient from Highland Park, Michigan, consulted me because of a serious, progressive illness. The description of its initial stage resembled that of Mrs. S. S. of Bay City. Careful studies in a Detroit hospital, laboratory tests, and consultations with nine specialists ruled out illnesses with which these specialists were acquainted. I would not have linked the Highland Park patient's disease with fluoridated water had I not noted that the patient's teeth were mottled, an indication that she was intolerant to fluoride. In questioning her subsequently, I learned that as a child she had lived in an area in China where water naturally contains fluoride in appreciable concentrations. Upon eliminating fluoridated water for drinking and cooking at her home in Highland Park, she recovered without medication. She agreed to participate in controlled studies with minute doses of fluoride in water; these tests proved that she was unusually susceptible to ill effect from fluoride.

A few weeks after fluoridation had been discontinued in Saginaw, Mich., in November 1954, I had an opportunity to examine thirty patients, nine of whom appeared to be afflicted with the same condition. Their own attention was drawn to fluoride in drinking water because during the weeks since fluoridation had been abandoned they had, for reasons unknown to them, markedly improved or completely recovered from an otherwise progressive chronic illness.

In November, 1955, I encountered additional cases during a visit to Charlottesville, Va., just after fluoridation had been discontinued there. Most impressive was the case of Mr. R. R. H., whose illness had baffled leading clinicians at two medical centers. He had not obtained a diagnosis of his illness nor had he received benefit from treatment. Like the others, he had no knowledge that fluoride was being added to his drinking water until he recovered his health following discontinuance of fluoridation.

As a medical practitioner in a city where the water is unfluoridated, I am likely to encounter only a limited number of cases of this sort compared with those that might occur in medical practice in a fluoridated area. Nevertheless, I have had experience with more than 100 patients in the last decade. At least fifteen were hospitalized for detailed studies, two within recent weeks. Others have been examined in my clinic. The salient symptoms have been sharp pains in the stomach area associated with nausea, spasticity of the bowels (ileitis, colitis), arthritic pains especially in the lower spine, migraine-like headaches, numbness and pains (paresthesia) in arms and legs with loss of muscular power. Some patients have had ulcers in the mouth, some