

The following lecture is an excellent example of the way science may be advanced by an impartial editor who can bring together the results of a number of researches and fit them together into a new whole. It is a process which is becoming increasingly difficult at the present time on account of the constantly growing volume of scientific researches and the inadequacy of mechanical means of bringing them together for comparison.

To condense Young's lecture for presentation in a small space is not an easy task. The plan of the lecture is to state the outline in the form of hypothesis and proposition, and then to illustrate, rather than argue, with quotations from the leading thinkers on the subject, especially Newton. Since the context of these quotations is now so well known, it has seemed permissible to the present editor to abridge this section of the lecture, giving however Young's own contribution to the advancement of knowledge practically in full.

*The Bakerian Lecture. ON THE THEORY OF LIGHT AND COLOURS. By Thomas Young, M. D., F. R. S., Professor of Natural Philosophy in the Royal Institution. Philosophical Transactions of the Royal Society of London. For the year MDCCCII (1802). Read November 12, 1801.*

Although the invention of plausible hypotheses, independent of any connection with experimental observations, can be of very little use in the promotion of natural knowledge; yet the discovery of simple and uniform principles, by which a great number of apparently heterogeneous phenomena are reduced to coherent and universal laws, must ever be allowed to be of considerable importance towards the improvement of the human intellect.

The object of the present dissertation is not so much to propose any opinions which are absolutely new, as to refer some theories, which have been already advanced, to their original inventors, to support them by additional evidence, and to apply them to a great number of diversified facts, which have hitherto been buried in obscurity. Nor is it absolutely necessary in this instance to produce a single new experiment; for of experiments there is already an ample store, which are so much the more unexceptionable, as they must have been conducted without the least partiality for the system by which they will be explained; yet some facts, hitherto unobserved, will be brought forwards, in order to show the perfect agreement of that system with the multifarious phenomena of nature.

The optical observations of NEWTON are yet unrivalled; and, excepting some casual inaccuracies, they only rise in our estimation, as we compare them with later attempts to improve on them. A further consideration of



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the colours of thin plates, as they are described in the second book of NEWTON'S optics has converted that prepossession which I before entertained for the undulatory system of light, into a very strong conviction of its truth and sufficiency; a conviction which has been since most strikingly confirmed, by an analysis of the colours of striated substances. The phenomena of thin plates are indeed so singular, that their general complexion is not without great difficulty reconcilable to any theory, however complicated, that has hitherto been applied to them; and some of the principal circumstances have never been explained by the most gratuitous assumptions; but it will appear, that the minutest particulars of these phenomena, are not only perfectly consistent with the theory which will now be detailed, but that they are all the necessary consequences of that theory, without any auxiliary suppositions; and this by inferences so simple, that they become particular corollaries, which scarcely require a distinct enumeration. . . .

*Hypothesis I.* A luminiferous Ether pervades the Universe, rare and elastic in a high degree.

*Hypothesis II.* Undulations are excited in this Ether whenever a Body becomes luminous.

*Hypothesis III.* The Sensation of different Colours depends on the different frequency of Vibrations, excited by Light in the Retina.

*Hypothesis IV.* All material Bodies have an Attraction for the ethereal Medium, by means of which it is ac-

cumulated within their Substance, and for a small Distance around them, in a State of greater Density, but not of greater Elasticity.

*Proposition I.* All Impulses are propagated in a homogeneous elastic Medium with an equable Velocity.

*Scholium 1.* It has been demonstrated, that in different mediums the velocity varies in the subduplicate ratio of the force directly, and of the density inversely.

*Scholium 2.* It is obvious, from the phenomena of elastic bodies and of sounds, that the undulations may cross each other without interruption. But there is no necessity that the various colours of white light should intermix their undulations; for, supposing the vibrations of the retina to continue but a five hundredth of a second after their excitement, a million undulations of each of a million colours may arrive in distinct succession within this interval of time, and produce the same sensible effect, as if all the colours arrived precisely at the same instant.

*Proposition II.* An Undulation conceived to originate from the Vibration of a single Particle, must expand through a homogeneous Medium in a spherical Form, but with different quantities of Motion in different Parts.

*Proposition III.* A Portion of a spherical Undulation, admitted through an Aperture into a quiescent Medium, will proceed to be further propagated rectilinearly in concentric Superficies, terminated laterally by weak and irregular Portions of newly diverging Undulations.

*Proposition IV.* When an Undulation arrives at a Surface which is the Limit of Mediums of different Densities, a partial Reflection takes place, proportionate in Force to the Difference of the Densities.

*Proposition V.* When an Undulation is transmitted through a Surface terminating different Mediums, it proceeds in such a Direction, that the Sines of the Angles of Incidence and Refraction are in the constant Ratio of the Velocity of Propagation in the two Mediums.

*Corollary 1.* The same demonstrations prove the equality of the angles of reflection and incidence.

*Corollary 2.* It appears from experiments on the refraction of condensed air, that (*Turn to next page*)

## Young on the Theory of Light—Continued

the ratio of the difference of the sines varies simply as the density. Hence it follows, by Schol. 1, Prop. 1. that the excess of the density of the ethereal medium is in the duplicate ratio of the density of the air; each particle co-operating with its neighbours in attracting a greater portion of it.

*Proposition VI.* When an Undulation falls on the Surface of a rarer Medium, so obliquely that it cannot be regularly refracted, it is totally reflected, at an angle equal to that of its Incidence.

*Proposition VII.* If equidistant Undulations be supposed to pass through a Medium, of which the Parts are susceptible of permanent Vibrations somewhat slower than the Undulations, their Velocity will be somewhat lessened by this vibratory Tendency; and, in the same Medium, the more, as the Undulations are more frequent.

*Corollary.* It was long an established opinion, that heat consists in vibrations of the particles of bodies, and is capable of being transmitted by undulations through an apparent vacuum. This opinion has been of late very much abandoned. Count RUMFORD, Professor PICKETT, and Mr. DAVY, are almost the only authors who have appeared to favour it; but it seems to have been rejected without any good grounds, and will probably very soon recover its popularity.

*Proposition VIII.* When two Undulations, from different Origins, coincide either perfectly or very nearly in Direction, their joint effect is a Combination of the Motions belonging to each.

*Proposition IX.* Radiant Light consists in Undulations of the luminiferous Ether.

This proposition is the general conclusion from all the preceding; and it is conceived that they conspire to prove it in as satisfactory a manner as can possibly be expected from the nature of the subject. It is clearly granted by NEWTON, that there are undulations, yet he denies that they constitute light; but it is shown . . . that all cases of the increase or diminution of light are referable to an increase or diminution of such undulations, and that all the affections to which the undulations would be liable, are distinctly visible in the phenomena of light; it may therefore be very logically inferred, that the undulations are light.

A few detached remarks will serve to obviate some objections which may be raised against this theory.

1. NEWTON has advanced the singular refraction of the Iceland crystal, as an argument that the particles of light must be projected corpuscles; since he thinks it probable that the different sides of these particles must be differently attracted by the crystal, and since HUYGENS has confessed his inability to account in a satisfactory manner for all the phenomena. But, contrarily to what might have been expected from NEWTON's usual accuracy and candour, he has laid down a new law for the refraction, without giving a reason for rejecting that of HUYGENS, which Mr. HAUY has found to be more accurate than NEWTON's; and, without attempting to deduce from his own system any explanation of the more universal and striking effects of doubling spars, he has omitted to observe that HUYGENS's most elegant and ingenious theory perfectly accords with these general effects, in all particulars, and of course derives from them additional pretensions to truth: this he omits, in order to point out a difficulty, for which only a verbal solution can be found in his own theory, and which will probably long remain unexplained by any other.

2. Mr. MICHELL has made some experiments, which appear to show that the rays of light have an actual momentum, by means of which a motion is produced when they fall on a thin plate of copper delicately suspended. But, taking for granted the exact perpendicularity of the plate, and the absence of any ascending current of air, yet since, in every such experiment, a greater quantity of heat must be communicated to the air at the surface on which the light falls than at the opposite surface, the excess of expansion must necessarily produce an excess of pressure on the first surface, and a very perceptible recession of the plate in the direction of the light. Mr. BENNET has repeated the experiment, with a much more sensible apparatus, and also in the absence of air; and very justly infers from its total failure, an argument in favour of the undulatory system of light. For, granting the utmost imaginable subtlety of the corpuscles of light, their effects might naturally be expected to bear some proportion to the effects of the much less rapid motions of the electrical

fluid, which are so very easily perceptible, even in their weakest states.

3. There are some phenomena of the light of solar phosphori, which at first sight might seem to favour the corpuscular system; for instance, its remaining many months as if in a latent state, and its subsequent re-emission by the action of heat. But, on further consideration, there is no difficulty in supposing the particles of the phosphori which have been made to vibrate by the action of light, to have this action abruptly suspended by the intervention of cold, whether as contracting the bulk of the substance or otherwise; and again, after the restraint is removed, to proceed in their motion, as a spring would do which had been held fast for a time in an intermediate stage of its vibration; nor is it impossible that heat itself may, in some circumstances, become in a manner latent. But the affections of heat may perhaps hereafter be rendered more intelligible to us; at present, it seems highly probable that light differs from heat only in the frequency of its undulations or vibrations; those undulations which are within certain limits, with respect to frequency, being capable of affecting the optic nerve, and constituting light; and those which are slower, and probably stronger, constituting heat only; that light and heat occur to us, each in two predicaments, the vibratory or permanent, and the undulatory or transient state; vibratory light being the minute motion of ignited bodies, or of solar phosphori, and undulatory or radiant light the motion of the ethereal medium excited by these vibrations; vibratory heat being a motion to which all material substances are liable, and which is more or less permanent; and undulatory heat that motion of the same ethereal medium, which has been shown by Mr. KING, and M. PICTET, to be as capable of reflection as light, and by Dr. HERSCHEL to be capable of separate refraction. How much more readily heat is communicated by the free access of colder substances, than either by radiation or by transmission through a quiescent medium, has been shown by the valuable experiments of Count RUMFORD. It is easy to conceive that some substances, permeable to light, may be unfit for the transmission of heat, in the same manner as particular substances may transmit some kinds of light, while they are opaque with respect to others. (*Turn to next page*)

# Trachoma Leading Cause of Blindness

*Medicine*

The chief cause of the nearly two and one-half million cases of blindness existing in the world today is trachoma, Lewis H. Carris, managing director of the National Society for the Prevention of Blindness, stated on his return from a world conference on blindness held at the Hague.

This disease is found in nearly every part of the globe, but it is at its worst in Oriental countries. It is most prevalent in Egypt and along the borders of the Mediterranean Sea, in Palestine, China, the Balkan States, India, the hot sections of Brazil, and, in our country, among the inhabitants of the Appalachian and Ozark Mountain districts and among American Indians.

Trachoma is a highly contagious disease. The roller towel has been the cause of many epidemics of the disease in industrial plants. A common family towel is also a potent spreader of the disease among members of the same household. Poverty, crowding and unsanitary living conditions are important factors in the contraction and spread of trachoma.

The disease causes redness, painful inflammation and granular growths, looking something like sago, within the lids. These irritate the cornea, producing ulcers and later scars. The scar formation may produce an opaque layer covering the pupil which results in loss of sight.

In individual cases the disease may be checked by proper treatment, but trachoma is so widespread that it cannot be entirely controlled until more is known of its cause. Dr. Hideyo Noguchi, working at the Rockefeller Institute for Medical Research, thought that he had found the organism or germ causing trachoma. Since his death the work has been continued, but further results have not yet been announced. Other investigators have considered diet a causative or predisposing factor.

The United States has for many years refused admission to immigrants showing symptoms of trachoma. The U. S. Public Health Service has been conducting extensive studies of the disease in the sections of this country where it is prevalent.

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## Rocket to Moon

*Astronomy*

Prof. H. Oberth, a German scientist living in Roumania, has secured the support of UFA, a German film company, for his research on a rocket to fly to the moon.

Professor Oberth was last spring awarded the Esnault-Pelterie-Hirsch prize given by the Astronomical Society of France for the most practical invention designed to promote interplanetary navigation.

*Science News-Letter, November 2, 1929*

## Young on the Theory of Light—Continued

On the whole it appears, that the few optical phenomena which admit of explanation by the corpuscular system, are equally consistent with this theory; that many others, which have long been known, but never understood, become by these means perfectly intelligible; and that several new facts are found to be thus only reducible to a perfect analogy with other facts, and to the simple principles of the undulatory system. It is presumed, that henceforth the second and third books of NEWTON'S Optics will be considered as more fully understood than the first has hitherto been but, if it should appear to impartial judges, that additional evidence is wanting for the establishment of the theory, it will be easy to enter more minutely into the details of various experiments, and to show the insuperable difficulties at-

tending the Newtonian doctrines, which without necessity, it would be tedious and invidious to enumerate. The merits of their author in natural philosophy, are great beyond all contest or comparison; his optical discovery of the composition of white light, would alone have immortalized his name; and the very arguments which tend to overthrow his system, give the strongest proofs of the admirable accuracy of his experiments.

**Thomas Young** (1773-1829) was a physician by profession, although he took part in most of the scientific life of his time. At the age of 28 he was appointed Professor of Physics at the Royal Institution. During the following two years he gave 91 lectures, in which the famous ones on light were included. At the end of two years he gave up the professorship because it interfered with his practice of medicine.

*Science News-Letter, November 2, 1929*

## To Unite Medicine

*Medicine*

Closer unity between the various branches of medicine will be brought about by the new Department of the History of Medicine and the William H. Welch Medical Library of Johns Hopkins University, prophesied Dr. Harvey Cushing, professor of surgery of Harvard University.

From being very compact in its early stages, medicine has become scattered among the various specialties of medical practice and of medical investigation and experiment. The medical students are now the only tie that holds all these branches together, Dr. Cushing said. But under the direction of Dr. Welch, in whose honor the new library was planned and named and for whom the new chair of the history of medicine has been created, the unification of medicine will surely begin.

The new library will be cultural, not merely vocational, and an active force rather than a passive collection of books and journals, Dr. Cushing declared. Dr. Welch long ago taught that the study of the history of the various medical doctrines broadens a physician's view and increases his perspective. This will be the guiding principle of the new institutions.

The new department is the first of its kind in America. The inauguration of it and the dedication of the library were made the occasion for the many friends and admirers of Dr. Welch, both in America and Europe, to pay the highest honors and tributes to this remarkable man who for over forty years has been an outstanding figure in the medical profession.

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## Drifts 7,000 Miles

*Oceanography*

Two unusually long bottle drifts have just been reported to the Hydrographic Office in Washington. One bottle, thrown overboard by Officer O. Haugstad of the Norwegian steamer Childar, was picked up among the Marshall Islands after having drifted about 6,000 miles. The second was found among the Caroline Islands after a drift of about 7,000 miles. This bottle was one thrown overboard by Second Officer R. M. Stall of the American steamer K. R. Kingsbury.

The longest drift in the records of the Hydrographic Office is one made between May 31, 1909, and May 19, 1912, of about 11,820 statute miles.

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