to concentrate its attention upon the thing seen rather than upon the muscular act incidental to the process of seeing it. This represents the germ of attention and of mental concentration in general. But the power of automatically moving the eyes with such accuracy that the images of an object upon the two retinæ could be focussed with precision upon exactly corresponding spots made possible the acquisition of stereoscopic vision, the ability to appreciate the form, size, solidity, and exact position in space of objects. It also prepared the way for the development in each retina of a particularly sensitive spot, the macula lutea, which enabled the animal to appreciate the texture, colour, and other details of objects seen with much more precision than before. Hence probably for the first time in the history of living creatures an animal acquired the power of "seeing" in the sense that we associate with that verb. The attainment of these new powers of exact vision further stimulated the animal's curiosity to examine and handle the objects around it and provided a more efficient control of the hands, so that acts of increasing degrees of skill were learned and much more delicate powers of tactile discrimination were acquired. Out of these experiments also there emerged a fuller appreciation of the nature of the objects seen and handled and of the natural forces that influenced the course of events.

With the acquisition of this new power of learning by experimentation, events in the world around the animal acquired a fuller meaning; and this enriched all its experience, not merely that which appealed to the senses of sight and touch, but hearing also. Thus in the series of Primates there is a sudden expansion of the acoustic cortex as soon as stereoscopic vision is acquired, and the visual, tactile, motor and prefrontal cortex also feel the stimulus and begin rapidly to expand. This increase of the auditory territory is expressed not only in a marked increase of acoustic discrimination but also by an increase in the power of vocal expression. At a much later stage of evolution the fuller cultivation of these powers conferred upon their possessors the ability to devise an acoustic symbolism capable of a much wider range of usefulness than merely conveying from one individual to another cries expressive of different emotions. For when true articulate speech was acquired it became possible to convey ideas and the results of experience from individual to individual, and so to accumulate knowledge and transmit it from one generation to another. This achievement was probably distinctive of the attainment of human rank, for the casts obtained from the most primitive brain-cases, such as those of Pithecanthropus and Eoanthropus, reveal the significant expansion of the acoustic cortex. This new power exerted the most profound influence upon human behaviour, for it made it possible for most men to become subject to tradition and to acquire knowledge from their fellows without the necessity of thinking and devising of their own initiative. It is easier to behave in the manner defined by convention than to originate action appropriate to special circumstances.

Within the limits of the human family itself the progressive series of changes that we have witnessed in man's Primate ancestors still continue; and as we compare such a series of endocranial casts as those of Pithecanthropus, Eoanthropus, *Homo rhodesiensis*, *Homo neanderthalensis*, and *Homo sapiens*, we can detect a progressive expansion of the parietal, prefrontal, and temporal territories, which are associated with the increasing powers of manual dexterity and discriminative power, of mental concentration and of acoustic discrimination.

The study of such factors of cerebral development will eventually enable us to link up the facts of comparative anatomy with psychology, and enable us the better to understand human behaviour. Such wider knowledge will, in time, help us to co-ordinate the principles that underlie customs and beliefs, and from such researches there will eventually emerge a distinctive discipline and a more strictly scientific method.

For the full realisation of this vision, what is necessary above all is that the universities should recognise the importance of this new conception of humane studies and take an active part in building up a science of man that is more scientific than what at present are known as the humanities and more human than biology. The fundamental aim of all education is the fuller understanding of the forces of Nature and of human behaviour. The necessity for attacking the latter problem with more directness and precision is urgent; and it is impossible to exaggerate the importance of a fuller cultivation in our universities of the study of the nature of man and of the springs of human conduct. It lies at the root of all knowledge and the intelligent control of all human affairs. I need not emphasise the tremendous practical importance of such studies to an Empire such as ours at the present time. The Pan-Pacific Conference held in Australia recently is an earnest of the realisation of this fact by statesmen and administrators and of the usefulness of collaborating with men of science to acquire an understanding of subject peoples and their social problems. This policy of peaceful development of the Pacific is a good augury for the fuller recognition of the value of anthropology to the world at large.

Some Bearings of Zoology on Human Welfare.[1]

By Prof. J. H. ASHWORTH, D.Sc., F.R.S.

THE bearings of zoology on human welfare—as illustrated by the relation of insects, protozoa, and helminthes to the spread or causation of disease in man—have become increasingly evident in these later years, and are familiar to every student of zoology or of medicine. At the time of the last meeting of the British Association in Liverpool (1896), insects were suspected of acting as transmitters of certain pathogenic organisms to man, but these cases were few, and in no single instance had the life-cycle of the organism

[1] From the presidential address delivered to Section D (Zoology) of the British Association at Liverpool on September 13.

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been worked out and the mode of its transmission from insect to man ascertained. The late Sir Patrick Manson, working in Amoy, had shown (1878) that the larvæ of *Filaria bancrofti* undergo growth and metamorphosis in mosquitoes, but the mode of transference of the metamorphosed larvæ was not determined until 1900. Nearly two years after the last meeting in Liverpool the part played by the mosquito as host and transmitter of the parasite of malaria was made known by Ross. In addition to these two cases, at least eight important examples can now be cited of arthropods proved to act as carriers of pathogenic organisms to man—*e.g.* Stegomyia—yellow fever; Phlebotomus—sandfly fever; tsetse-flies—sleeping sickness; Conorhinus—South American trypanosomiasis (Chagas' disease); Chrysops—*Filaria* (*Loa*) *loa*; the flea *Xenopsylla cheopis*—plague; the body-louse—trench fever, relapsing fever, and typhus; and the tick Ornithodorus—African relapsing fever.

In selecting examples for brief consideration I propose to deal very shortly with malaria, although it is the most important of the insect-carried diseases, because the essential relations between the Anopheles mosquito and the parasite are well known. There still remain lacunæ in our knowledge of the malarial organisms. Ross and Thomson (1910) showed that asexual forms of the parasite tend to persist in small numbers between relapses, and suggested that infection is maintained by these asexual stages. Such explanation elucidates those cases in which relapses occur after short intervals, but the recurrence of the attacks of fever after long intervals can only be explained by assuming that the parasites lie dormant in the body—and we know neither in what part of the body nor in what stage or condition they persist. Nevertheless, the cardinal points about the organism are established, and preventive measures and methods of attack based on a knowledge of the habits and bionomics of Anopheles have been fruitful in beneficial results in many parts of the world.

If we desire an illustration of the vast difference to human well-being between knowing and not knowing how a disease-germ is transmitted to man, we may turn to the case of yellow fever. When this pestilence came from the unknown, and no one knew how to check it, its appearance in a community gave rise to extreme despair, and in many cases was the signal for wholesale migration of those inhabitants who could leave the place. But with the discovery that Stegomyia was the transmitting agent all this was changed. The municipality or district took steps to organise its preventive defences against a now tangible enemy, and the successful issue of these efforts, with the consequent great saving of life and reduction of human suffering in the Southern United States, in Panama, in Havana, and in other places, is common knowledge. It is a striking fact that during 1922 Central America, the West Indies, and all but one country of South America were free from yellow fever, which had ravaged these regions for nearly two centuries. The campaign against Stegomyia is resulting, as a recent Rockefeller report points out, in yellow fever being restricted to rapidly diminishing, isolated areas, and this disease seems to be one which by persistent effort can be brought completely under control.

In 1895 Bruce went to Zululand to investigate the tsetse-fly disease which had made large tracts of Africa uninhabitable for stock, and near the end of the same year he issued his preliminary report in which he showed that the disease was not caused by some poison elaborated by the fly—as had been formerly believed—but was due to a minute flagellate organism, a trypanosome, conveyed from affected to healthy animals by a tsetse-fly (*Glossina morsitans*). In 1901 Forde noticed an active organism in the blood of an Englishman in Gambia suffering from irregularly intermittent fever, and Dutton (1902) recognised it as a trypanosome, which he named *Trypanosoma gambiense*. In 1902 Castellani found trypanosomes in the blood and cerebrospinal fluid of natives with sleeping sickness in Uganda, and suggested that the trypanosome was the causal organism of the disease. The Sleeping Sickness Commission (Bruce and his colleagues) confirmed this view, and showed that a tsetse-fly, *Glossina palpalis*, was the transmitter. Since then much has been learnt regarding the multiplication of the trypanosome in the fly and its transference to man. For some years this was believed to take place by the direct method, but in 1908 Kleine demonstrated "cyclical" transmission, and this was shown later to be the principal means of transference of *T. gambiense*. In 1910 Stephens and Fantham described from an Englishman, who had become infected in Rhodesia, a trypanosome which, from its morphological characters and greater virulence, they regarded as a new species, *T. rhodesiense*, and its "cyclical" transmission by *Glossina morsitans* was proved by Kinghorn and Yorke. Recent reports by Duke and Swynnerton (1923) of investigations in Tanganyika Territory suggest that direct rather than cyclical transmission by a new species of Glossina is there mainly responsible for the spread of a trypanosome of the *T. rhodesiense* type.

The impossibility of distinguishing by their morphology what are considered to be different species of trypanosomes, and the difficulty of attacking the fly, are handicaps to progress in the campaign against sleeping sickness, which presents some of the most subtle problems in present-day entomology and protozoology. Here also we come upon perplexing conditions due apparently to the different virulence of separate strains of the same species of trypanosome and the varying tolerance of individual hosts—on which subjects much further work is required.

The relation of fleas to plague provides one of the best and most recent illustrations of the necessity for careful work on the systematics and on the structure and bionomics of insects concerned in carrying pathogenic organisms. Plague was introduced into Bombay in the autumn of 1896, and during the next two years extended over the greater part of Bombay Presidency and was carried to distant provinces. The Indian Government requested that a commission should be sent out to investigate the conditions. The commission, which visited India in 1898–99, came to the conclusion (1901) that rats spread plague and that infection of man took place through the skin, but—and this is amazing to us at the present day—"that suctorial insects do not come under consideration in connection with the spread of plague." Further observations, however, soon showed this conclusion to be erroneous. Liston found in Bombay in 1903 that

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the common rat-flea was *Pulex* (*Xenopsylla*) *cheopis*, that it was present in houses in which rats had died of plague and in which some of the residents had become infected, that the plague-bacillus could multiply in the stomach of this flea, and that the flea would—in the absence of its usual host—attack man. These observations pointed to the importance of this flea in the dissemination of plague, and the Second Plague Commission, which was appointed and began work in 1905, definitely proved that *Xenopsylla cheopis* is the transmitter of the plague-organism from rat to rat and from rat to man.

The mechanism of transmission of the plague-bacillus was worked out by Bacot and Martin in 1913. They showed that in a proportion of the fleas fed on the blood of septicæmic mice the plague-bacilli multiply in the proventriculus—which is provided with chitinous processes that act as a valve to prevent regurgitation of the blood from the stomach—and a mass of bacilli is formed which blocks the proventriculus and may extend forward into the œsophagus. Fleas in this condition are not prevented from sucking blood, because the pharynx is the suctorial organ, but their attempts to obtain blood result only in distending the œsophagus. The blood drawn into the œsophagus is repeatedly forced backwards into contact with the mass of plague-bacilli, and on the sucking action ceasing some of this infected blood is expelled into the wound. The transmission of plague depends on the peculiar structure of the proventriculus of the flea and on the extent to which, in certain examples, the plague-bacilli multiply in the proventriculus. Such "blocked" fleas being unable to take blood into the stomach are in a starved condition, and make repeated attempts to feed, and hence are particularly dangerous.

Until 1913 it was believed that all the fleas of the genus Xenopsylla found on rats in India belonged to one species (*cheopis*), but in that year L. F. Hirst reported that the rat-flea of Colombo was *X. astia*, which had been taken off rats in Rangoon, and described by N. C. Rothschild in 1911. Hirst ascertained that this flea did not readily bite man if the temperature were above 80° F. A collection of 788 fleas from Madras City proved to consist entirely of *X. astia*, and Hirst suggested that the explanation of the immunity of Madras and Colombo from plague was the relative inefficiency of *X. astia* as a transmitter. Cragg's examination (1921, 1923) of 23,657 fleas obtained from rats in all parts of India shows that they include three species: *Xenopsylla cheopis*, *X. astia*, and *X. brasiliensis*. This last species is common in the central and northern uplands of peninsular India, but its bionomics have not yet been investigated. *X. cheopis* is the predominant species in the plague areas, while *X. astia* is the common flea in those areas which have remained free from plague or have suffered only lightly. In Madras City, for example, during the twenty-one years, 1897–1917, plague has occurred in twenty of these years, but the average mortality was only 0·013 per thousand—that is, though the infection has been repeatedly introduced there, it failed each time to set up an epidemic. The significance of an imported case of plague depends in large measure on the local species of Xenopsylla. Hirst has made numerous attempts during the plague season in Colombo to transmit plague by means of *X. astia* from rat to rat, but with negative results, and *X. astia* was never found to behave like a "blocked" *X. cheopis*.

The distinction of *X. cheopis* from *X. astia* is not an entomological refinement with purely systematic significance, but corresponds with a different relation of the species to the epidemiology of plague, and hence becomes a factor of great practical importance. If through these researches it has become possible by examination of the rat-fleas of a locality to estimate accurately its liability to plague, anti-plague measures may henceforward be restricted to those areas in which plague is likely to occur, *i.e.* where *X. cheopis* is the predominant flea. Thus a great economy of effort and of expenditure and a higher degree of efficiency may be achieved; in fact, the problem of the prevention or reduction of plague may be brought from unwieldy to practicable proportions. When it is remembered that since 1896 some ten and a quarter millions of people have died in India from plague, we have a more than sufficient index of the importance of a precise knowledge of the systematics, structure, and bionomics of the insect-carrier of *Bacillus pestis*.

Another of the outstanding features of the period under review has been the extensive and intensive study of the Protozoa. The structure and the bionomics and life-history of these organisms have been investigated with the help of the finest developments of modern technique. It is fitting here to record our acknowledgment to two staining methods—Heidenhain's iron-hæmatoxylin and the Romanowsky stain (including Giemsa's and Leishman's modifications), which have added greatly to our technical resources.

There is time to refer only to certain of the Protozoa which directly affect man. Twenty years ago our knowledge of the few species of Protozoa recorded from the human alimentary canal was defective in two important respects—the systematic characters and the biology of the species—so there was much confusion. Subsequent investigations, and especially those of the last ten years (by Wenyon, Dobell, and others), have cleared up most of the doubtful points, but owing to the difficulties of size and the paucity of characters available, it is by no means easy in practice to distinguish certain of the species. Of the seventeen species now known to occur in the intestine of man, *Entamœba histolytica* has received particular attention. This organism lives as a tissue parasite in the wall of the large intestine, where, as a rule, the damage caused is counterbalanced by the host's regenerative processes. But when the destruction outstrips the regeneration intestinal disturbance results, leading to the condition known as amœbic dysentery. The specific characters and the processes of reproduction and encystment of *E. histolytica* are now well ascertained, and it is realised that in the majority of cases the host is healthy, acting as a "carrier" dangerous to himself, for he may develop into a case of acute dysentery, and to the community—for he is passing in his fæces the encysted stage which is capable of infecting other persons. Whether an infected person will suffer from dysentery or act as a healthy "carrier" apparently depends upon his own susceptibility rather than on any difference in the virulence of different strains of the Entamœba.

In all work with Entamœbæ infecting human beings

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there is need for critical determination of the species, for, in addition to *E. histolytica*, a closely similar species, *E. coli*, is a common inhabitant of the intestine. This, however, is a harmless commensal, feeding on bacteria and fragments derived from the host's food. The distinction between the two species rests chiefly upon the characters of the nuclei and of the mature cyst—quadrinucleate in *E. histolytica* and octonucleate in *E. coli*—and considerable care and technical skill are requisite in many cases before a diagnosis can be given. Yet this distinction is definitely necessary in practice, for indiscriminate treatment of persons with Entamœba is indefensible; treatment is only for those with *E. histolytica*; it is useless for those with *coli*, and subjects them needlessly to an unpleasant experience.

A notable result of recent work is the proof that the more common intestinal Protozoa, formerly believed to be restricted to warmer countries, occur indigenously in Britain. This was first established by a group of observers in Liverpool, and has been confirmed and extended by subsequent workers. There is good reason for believing that in Great Britain the incidence of infection with *E. histolytica* is about 7 to 10 per cent., and with *E. coli* about five times as great (Dobell).

The discovery (1903) of Leishmania, the organism of kala azar and of oriental sore, added another to the list of important human pathogenic Protozoa, but the mode of transmission of this flagellate has not yet been proved.

Of the problems presented by the parasitic worms, the most momentous are those associated with Ancylostoma and its near relative Necator, which are prevalent in countries lying between 36° N. and 30° S.—a zone which contains more than half the population of the earth. Heavy infection with Ancylostoma or with Necator produces severe anæmia, and reduces the host's physical and mental efficiency to a serious degree. Until 1898 there was no suggestion that infection was acquired in any other way than by the mouth, but in that year Looss published his first communication on the entry of the larvæ of Ancylostoma through the skin, and in 1903 gave an account of further experiments which proved that dermal infection resulted in the presence of worms in the intestine. At the meeting of the British Association in Cambridge in 1904 Looss demonstrated to a small company his microscopical preparations showing the path of migration of the larvæ. His investigations served to establish the importance of the skin as the chief portal of entry of Ancylostoma, and pointed the way to effective methods of prevention against infection.

Another notable advance in helminthology is the working out of the life-cycle of Schistosoma (Bilharzia)—a genus of trematode worms causing much suffering in Egypt and elsewhere in Africa, as well as in Japan and other parts of the world. These worms when mature live in pairs, a male and female, in the veins of the lower part of the abdomen, especially in the wall of the bladder and of the rectum. The eggs, laid in large numbers by the female worm, provoke inflammatory changes, and cause rupture of the veins of the organs invaded. Until about ten years ago the life-history of Schistosoma had been traced only as far as the hatching of the ciliated larva or miracidium, which takes place shortly after the egg reaches water, but it was then shown that this larva is not, as had been held by Looss, the stage which infects man. Miyairi and Suzuki (1913) found that the miracidium of *Schistosoma japonicum* entered a fresh-water snail which acted as the intermediate host, and Leiper and Atkinson (1915) confirmed and extended this observation, and showed that the miracidia develop into sporocysts in which cercariæ are formed. We owe chiefly to Leiper's work (1915–16) our knowledge of the life-history and method of entry into man of the Egyptian species of Schistosoma. He demonstrated that two species of this parasite occur in Egypt, and established that the miracidia develop in different intermediate hosts: those of *S. mansoni* enter Planorbis, while those of *S. hæmatobium* penetrate into Bullinus—the molluscs being abundant in the irrigation canals. The sporocysts produce cercariæ, which escape from the snails and gather near the surface of the water, and experiments with young mice and rats showed that the cercariæ attach themselves to the skin, enter, and reach the portal system, from which they travel to the veins of the lower part of the abdomen. Infection of man takes place chiefly through the skin when bathing or washing in water containing the cercariæ, though infection may also occur through drinking such water. So, at last, these worms which have troubled Egypt for at least thirty centuries have become known in all their stages, and measures for preventing infection—which were of great use during the War—have been devised, and curative treatment introduced.

Other recent helminthological researches deserve consideration did space permit, for there has been much excellent work on the life-history of the liver-flukes and lung-flukes of man, and the life-cycle of the tape-worm, *Dibothriocephalus latus*, was worked out in 1916–17. Mention should also be made of Stewart's investigations (1916–19) on the life-history of the large round-worm *Ascaris lumbricoides*, during which he made the important discovery that the larvæ on hatching in the intestine penetrate into the wall and are carried in the blood to the liver, and thence through the heart to the lungs, where they escape from the blood-vessels, causing injury to the lungs. The larvæ, now about ten times their original size, migrate by way of the trachea and pharynx to the intestine, where they grow to maturity. During last year Dr. and Mrs. Connal have worked out the life-history of *Filaria* (*Loa*) *loa* in two species of the Tabanid fly, Chrysops, and investigations on other Filarias have thrown light on their structure, but there is still need for further researches on the conditions governing the remarkable periodicity exhibited by the larvæ of some species (*e.g. F. bancrofti*; in some parts of the world the larvæ of this species are, however, non-periodic). The period under review has obviously been one of great activity in research on helminthes, and fertile in measures tending to reduce the risks of infection.

Insects, protozoa, and helminthes not only inflict direct injury on man; they also diminish his material welfare by impairing the health or causing the death of his horses, cattle, and sheep, by destroying food crops during growth, and, in the case of insects, by devouring the harvested grain. The measure of control which man can gain over insects, ticks, and

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endoparasitic organisms, will determine largely the extent to which he can use and develop the natural resources of the rich tropical and sub-tropical zone of the earth.

Other applications of zoology to human well-being cannot be dealt with here, but mention should be made of two—the researches on sea-fisheries problems which have formed an important branch of the zoological work of Great Britain for forty years, and the studies on genetics which made possible an explanation of the mode of inheritance of a particular blood-group, and of some of the defects (*e.g.* colour-blindness and hæmophilia) and malformations which appear in the human race.

The Theory of the Affine Field.[1]

By Prof. ALBERT EINSTEIN, For. Mem. R.S.

THE theory of the connexion between gravitation and electromagnetism outlined below is founded on Eddington's idea, published during recent years, of basing "field physics" mathematically on the theory of the affine relation. We shall first briefly consider the entire development of ideas associated with the names Levi-Civita, Weyl, and Eddington.

The general theory of relativity rests formally on the geometry of Riemann, which bases all its conceptions on that of the interval ds between points indefinitely near together, in accordance with the formula[2]

$$ds^2 = g_{\mu\nu} dx_\mu dx_\nu \quad . \quad . \quad . \quad . \quad (1)$$

These magnitudes $g_{\mu\nu}$ determine the behaviour of measuring-rods and clocks with reference to the coordinate system, as well as the gravitational field. Thus far we are able to say that, from its foundations, the general theory of relativity explains the gravitational field. In contrast to this, the conceptual foundations of the theory have no relations with the electromagnetic field.

These facts suggest the following question. Is it not possible to generalise the mathematical foundations of the theory in such a way that we can derive from them not only the properties of the gravitational field, but also those of the electromagnetic field?

The possibility of a generalisation of the mathematical foundations resulted from the fact that Levi-Civita pointed out an element in the geometry of Riemann that could be made independent of this geometry, to wit, the "affine relation"; for according to Riemann's geometry every indefinitely small part of the manifold can be represented approximately by a Euclidean one. Thus in this elemental region there exists the idea of parallelism. If we subject a contravariant vector A^σ at the point x_ν to a parallel displacement to the indefinitely adjacent point $x_\nu + \delta x_\nu$, then the resulting vector $A^\sigma + \delta A^\sigma$ is determined by an expression of the form

$$\delta A^\sigma = -\Gamma^\sigma_{\mu\nu} A^\mu \delta x_\nu \quad . \quad . \quad . \quad . \quad (2)$$

The magnitudes Γ are symmetrical in the lower indices, and are expressed in accordance with Riemann geometry by the $g_{\mu\nu}$ and their first derivatives (Christoffel symbols of the second kind). We obtain these expressions by formulating the condition that the length of a contravariant vector formed in accordance with (1) does not change as a result of the parallel displacement.

Levi-Civita has shown that the Riemann tensor of curvature, which is fundamental for the theory of the gravitational field, can be obtained from a geometrical consideration based solely on the law of the affine relation given by (2) above. The manner in which the $\Gamma^\sigma_{\mu\nu}$ are expressible in terms of the $g_{\mu\nu}$ plays no part in this consideration. The behaviour in the case of differential operations of the absolute differential calculus is analogous.

These results naturally lead to a generalisation of Riemann's geometry. Instead of starting off from the metrical relation (1) and deriving from this the coefficients Γ of the affine relation characterised by (2), we proceed from a general affine relation of the type (2) without postulating (1). The search for the mathematical laws which shall correspond to the laws of Nature then resolves itself into the solution of the question: What are the formally most natural conditions that can be imposed upon an affine relation?

The first step in this direction was taken by H. Weyl. His theory is connected with the fact that light rays are simpler structures from the physical view-point than measuring-rods and clocks, and that only the ratios of the $g_{\mu\nu}$ are determined by the law of propagation of light. Accordingly he ascribes objective significance not to the magnitude ds in (1), *i.e.* to the length of a vector, but only to the ratio of the lengths of two vectors (thus also to the angles). Those affine relations are permissible in which the parallel displacement is angularly accurate. In this way a theory was arrived at, in which, along with the determinate (except for a factor) $g_{\mu\nu}$ other four magnitudes ϕ_ν occurred, which Weyl identified with electromagnetic potentials.

Eddington attacked the problem in a more radical manner. He proceeded from an affine relation of the type (2) and sought to characterise this without introducing into the basis of the theory anything derived from (1), *i.e.* from the metric. The metric was to appear as a deduction from the theory. The tensor

$$R_{\mu\nu} = -\frac{\partial \Gamma^\alpha_{\mu\nu}}{\partial x_\alpha} + \Gamma^\alpha_{\mu\beta}\Gamma^\beta_{\nu\alpha} + \frac{\partial \Gamma^\alpha_{\mu\alpha}}{\partial x_\nu} - \Gamma^\alpha_{\mu\nu}\Gamma^\beta_{\alpha\beta} \quad . \quad (3)$$

is symmetrical in the special case of Riemann's geometry. In the general case $R_{\mu\nu}$ is split up into a symmetrical and an "anti-symmetrical" part:

$$R_{\mu\nu} = \gamma_{\mu\nu} + \phi_{\mu\nu} \quad . \quad . \quad . \quad . \quad (4)$$

One is confronted with the possibility of identifying $\gamma_{\mu\nu}$ with the symmetrical tensor of the metrical or gravitational field, and $\phi_{\mu\nu}$ with the antisymmetrical tensor of the electromagnetic field. This was the course taken by Eddington. But his theory remained incomplete, because at first no course possessed of the advantages of simplicity and naturalness presented

[1] Translated by Dr. R. W. Lawson.

[2] In accordance with custom, the signs of summation are omitted.

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