discovered how to master the forces of nature all history has been tending toward this goal. Gibbon's final remark is, "We may therefore acquiesce in the pleasing conclusion that every age of the world has increased and still increases the real wealth, the happiness, the knowledge and perhaps the virtue of the human race."

The conclusion is pleasing; the premise is false. Professor Nef's researches show that the rate of increase of real wealth is rapidly declining. Though knowledge has grown from more to more, happiness and virtue have not. And we see that a barbarian conqueror equipped with knowledge is more barbarous, as well as more dangerous, than any of his unlettered predecessors.

The centrifugal forces released through the dissolution of ultimate beliefs have split the universities into a thousand fragments. When men begin to doubt whether there is such a thing as truth or whether it can ever be discovered, the search for truth must lose that precision which it had in the minds of the founders of the University of Chicago. If we doubt whether man is rational, we can not lightly put our trust in the exercise of reason. And if the traditional notion of freedom, when dragged up out of our subconscious, looks less impressive than we had always supposed it would; if we think on the one hand that freedom is doing as one likes, and on the other that man is a mere automaton, free inquiry ceases to be that infallible guide to terrestrial salvation which Mr. Harper thought it was. After fifty years we must confess that the beacons established to illuminate the pathway of our people give a light that is flickering and dim. The universities, instead of leading us through the chaos of the modern world, mirror its confusion.

If we are to do for our own day what the founders of the University of Chicago did for theirs, we shall have to continue what they did, and we shall have to do something more. We shall have to recapture, revitalize and reformulate for our time the truths which gave purpose and significance to their work. We are in the midst of a great moral, intellectual and spiritual crisis. To pass it successfully or to rebuild the world after it is over we shall have to get clear about those ends and ideals which are the first principles of human life and of organized society. Our people should be able to look to the universities for the moral courage, the intellectual clarity and the spiritual elevation needed to guide them and uphold them in this critical hour. The universities must continue to pioneer on the new frontiers of research. But to-day research is not enough either to hold the university together or to give direction to bewildered humanity. We must now seek not knowledge alone, but wisdom.

This is what the University Grants Committee of England meant when it said: "Here arises the responsibility of the universities. They are the inheritors of the Greek tradition of candid and intrepid thinking about the fundamental issues involved in the life of the individual and of the community, and of the Greek principle that the unexamined life is no life for man."

Candid and intrepid thinking about fundamental issues—in the crisis of our time this is the central obligation of the universities. This is the standard by which they must be judged. This is the aim which will give unity, intelligibility and meaning to their work. This is the road to wisdom. Upon that road the American university will regain its own soul and bring hope and comfort to a distracted world.

HYPOTHESIS AS TO THE ORIGIN OF COSMIC RAYS AND THE EXPERIMENTAL TESTING OF IT IN INDIA AND ELSEWHERE[1]

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THE hypothesis here adopted as to the mode of origin of the cosmic rays makes possible the prediction of five definite vertically incoming cosmic-ray bands. As the observer moves north from the magnetic equator each of these five bands should begin to reach the earth at a particular latitude and continue reaching it at all more northerly latitudes. Between each latitude of first entrance of a band of particular energy and the latitude of first entrance of the band of next lower energy there should be found a plateau of constant vertically incoming cosmic-ray energy. Four such plateaus should be experimentally observable.

The hypothesis rendering possible these predictions rests upon five major discoveries made by the workers in the Norman Bridge Laboratory of Physics at the California Institute at Pasadena. These discoveries are (1) that more than 60 per cent. of all incoming cosmic-ray energy is of the nature of incoming

[1] From a symposium celebrating the Fiftieth Anniversary of the University of Chicago, the American Association for the Advancement of Science collaborating.

charged-particle bullets (either electronic or protonic), each of energy between 2 billion electron volts and 15 billion electron volts; (2) Neddermeyer and Anderson's discovery of the production by nuclear impacts within the atmosphere of mesotrons which serve as the chief carriers of the cosmic-ray energy down to the lower levels of the atmosphere; (3) Bowen's remarkable discovery that atoms, when out in interstellar space, are able to undergo atomic transformations forbidden to them within the stars, and (4) Bowen and Wise's discovery that in ring nebulae, trillions of miles away from the exciting star, and therefore presumably reflecting conditions in interstellar space, there are five of the atoms, namely, helium, carbon, nitrogen, oxygen and silicon, each of which is more than ten times more abundant than any other atom save hydrogen (which must be excluded from measurable cosmic-ray effects because of the smallness of its rest-mass energy); and (5) Lauritsen and Fowler's discovery in the Kellogg Radiation Laboratory that a part, at least, of the rest-mass energy of an atom has the power under suitable conditions of transforming itself directly into the creation of a positive-negative charged-particle pair.

The hypothesis made in view of these five discoveries is that while the evolution of energy by the stars is maintained, as Bethe has recently shown, by the *partial* transformation within the stars of the rest-mass energy of hydrogen into radiant energy through the building of helium, carbon and other atoms out of hydrogen, and the release through this process of the so-called "packing-fraction" energy, the energy of cosmic rays on the other hand is maintained by the occasional *complete* transformation in interstellar space of the rest-mass energy of the atoms of helium, carbon, nitrogen, oxygen and silicon (and even heavier aggregates) into cosmic rays, each such event presumably creating either an electron pair or a proton pair (these two events are indistinguishable by our geographic experiments), though an occasional photon pair, or neutron pair, need not *necessarily* be excluded.

The foregoing hypothesis requires that the cosmic rays of measurable energy reveal a spectral distribution of five distinct, definitely measurable bands as follows: (1) a band of rays each having an energy of 1.9 billion electron volts produced by the annihilation, or complete transformation, in interstellar space, of the rest-mass energy of the helium atom; (2) a carbon-atom-annihilation band of energy 5.6 billion electron volts (b.e.v.); (3) a nitrogen-atom band of energy 6.6 b.e.v.; (4) an oxygen-atom band of energy 7.5 b.e.v., and (5) a silicon-atom band of energy 13.2 b.e.v.

The hypothesis requires further that there should be in India, for vertically incoming rays between the magnetic equator and magnetic latitude about 20 degrees N. a plateau of unchanging cosmic-ray intensity with latitude; it requires another such plateau between the latitudes of entrance of the bands due to the silicon and oxygen atoms; it requires a third such plateau between the great band produced by the annihilation of the carbon, nitrogen and oxygen atoms, and that due to the annihilation of helium; and, finally, it requires a fourth such plateau north of Bismarck, North Dakota, where as the observer goes northward the helium band should first be able to get vertically through the blocking effect of the earth's magnetic field and should then be able to enter the earth in full strength at all more northerly latitudes.

The experimental evidence that has been so far obtained in India and elsewhere for the existence of these five bands and four plateaus may be thus summarized. The India evidence seems to be good for the existence of the plateau of constant cosmic-ray intensity from the Equator up to Agra (17 N) and for the appearance just north of Agra of a band that can be identified with that due to silicon. There is some evidence for the existence of the flat plateau just north of the latitude of first entrance of the hypothetical silicon band. There is unambiguous evidence for the entrance at about the computed latitude of a very strong band at between 5.5 and 7.5 b.e.v., and this we tentatively identify with the joint carbon, nitrogen, oxygen bands which, however, we have not yet been able to resolve. There is a little evidence for the existence of a plateau of constant cosmic-ray intensity between the latitudes at which the carbon and the helium bands should appear, and there is fair evidence, too, for the existence of a flat plateau north of the latitude of entrance of the hypothetical helium band, the real existence of which may be stated to have been rendered probable. Not only are all the predicted latitudes in reasonable agreement with the observations, but also the observed intensities are of the right order of magnitude.

Further experiments are being made to see whether better designed apparatus will render the nature of the evidence better or worse for the hypothesis, and new experiments in Mexico and the United States are planned for the coming months.

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