the world were ruled by reason", ran a leader of 1934, "there is no doubt that every developed country would abjure war, would concentrate on producing those commodities for which it is best suited by its natural wealth, geographical position and the capabilities of its inhabitants, and would exchange them freely for commodities produced abroad"[48]. Societies would never reach the millennium of free trade, however, until it was realized that "the immense complexity of modern pure and applied science requires a corresponding complex social organization"[49]. Once science had been placed at the centre of social consciousness, statecraft would become "mainly a question of making humanity fit for science, or at least of modifying the political and economic systems of the world to enable its inhabitants to enjoy the fruits of scientific endeavour"[33]. The principal agent of such change would accordingly be the scientific expert, who would come to occupy "a position of increasing responsibility, and the security of our civilization largely depends upon his effective participation in public as in industrial affairs"[50].

How then would the technical élites alter the political, economic and social relationships within and between nations? At the national level *Nature* was reticent to suggest any wholesale socialization of the means of production. It is true that the journal sporadically advocated that the administration of industrial research[51] and agriculture[52] should become the exclusive responsibility of the state. Yet such utterances were not in keeping with the journal's general opposition to both nationalization, which it equated with Fascism, and the proletarian socialism of the Soviet Union[53]. To men who believed in the rationalist creed as fervently as did Gregory and Brightman, the violence which accompanied the social transformations of Germany and Russia was anathema.

*Nature* would therefore not propose a social revolution, because "nothing revolutionary can be proposed on any rational basis"[54]. It called instead for a spirit of "class unity"[55] which would allow for the growth of cooperative economic planning. More leaders were devoted to this subject than to any other in the 1930s (see Table 1). In 1931 Brightman defined the journal's concept of planning as "the balancing of opposing group interests on the basis of ascertained facts and not on the self-evaluation of the groups concerned"[56]. Harmony and objectivity also formed the basis of *Nature*'s hopes for a more peaceful world community. Seven weeks before the Munich agreement was signed, the journal emphatically endorsed Salvador de Madaraiga's plea for a World Foundation with these words: "*the welfare of humanity and the interest of the whole community of nations should be placed before the narrower interests of any individual nation.* Such a principle could scarcely be held to conflict with the objectivity of outlook which men of science endeavour to maintain"[57]. Objective inquiry was itself advanced as the

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## Disintegration of Uranium by Neutrons: a New Type of Nuclear Reaction

On bombarding uranium with neutrons, Fermi and collaborators[1] found that at least four radioactive substances were produced, to two of which atomic numbers larger than 92 were ascribed. Further investigations[2] demonstrated the existence of at least nine radioactive periods, six of which were assigned to elements beyond uranium, and nuclear isomerism had to be assumed in order to account for their chemical behaviour together with their genetic relations.

In making chemical assignments, it was always assumed that these radioactive bodies had atomic numbers near that of the element bombarded, since only particles with one or two charges were known to be emitted from nuclei. A body, for example, with similar properties to those of osmium was assumed to be eka-osmium ($Z = 94$) rather than osmium ($Z = 76$) or ruthenium ($Z = 44$).

Following up an observation of Curie and Savitch[3], Hahn and Strassmann[4] found that a group of at least three radioactive bodies, formed from uranium under neutron bombardment, were chemically similar to barium and, therefore, presumably isotopic with radium. Further investigation[5], however, showed that it was impossible to separate these bodies from barium (although mesothorium, an isotope of radium, was readily separated in the same experiment), so that Hahn and Strassmann were forced to conclude that *isotopes of barium ($Z = 56$) are formed as a consequence of the bombardment of uranium ($Z = 92$) with neutrons.*

At first sight, this result seems very hard to understand. The formation of elements much below uranium has been considered before, but was always rejected for physical reasons, so long as the chemical evidence was not entirely clear cut. The emission, within a short time, of a large number of charged particles may be regarded as excluded by the small penetrability of the 'Coulomb barrier', indicated by Gamov's theory of alpha decay.

On the basis, however, of present ideas about the behaviour of heavy nuclei[6], an entirely different and essentially classical picture of these new disintegration processes suggests itself. On account of their close packing and strong energy exchange, the particles in a heavy nucleus would be expected to move in a collective way which has some resemblance to the movement of a liquid drop. If the movement is made sufficiently violent by adding energy, such a drop may divide itself into two smaller drops.

It seems therefore possible that the uranium nucleus has only small stability of form, and may, after neutron capture, divide itself into two nuclei of roughly equal size (the precise ratio of sizes depending on finer structural features and perhaps partly on chance). These two nuclei will repel each other and should gain a total kinetic energy of *c.* 200 Mev., as calculated from nuclear radius and charge. This amount of energy may actually be expected to be available from the difference in packing fraction between uranium and the elements in the middle of the periodic system. The whole 'fission' process can thus be described in an essentially classical way, without having to consider quantum-mechanical best means of achieving calm "in the storm-tossed domain of international affairs"[58]. For example, the settlement of Japanese grievances in southern Manchuria through the good offices of the Institute of Pacific Relations was cited by Brightman in March of 1931 as having "transformed the menacing problem of the Pacific into one that promises to yield to treatment that is essentially scientific"[59].

As a corollary to the growth of the scientific outlook, *Nature* of course instanced the possible uses of previously neglected scientific knowledge. Such was the case of eugenics. (Note the attack on Parliament's "ignorance of biology" in ref. 60.) Gregory, himself a vice-president of Marie Stopes' Society for Constructive Birth Control and Racial Progress[61], published *Nature*'s first pro-eugenics leader in May of 1924[62]. What alarmed Sir Richard most was the differential birth rate between the professional and the working classes. As late as January 1936, his journal stated that "dock labourers and miners figure prominently in the over-production of children, and it is worthy of note that in both groups there is a large proportion of the Iberian element in our population from Wales and Ireland . . . it is the reproduction of this class that we wish to prevent"[63]. Yet "by our grandmotherly system of doles, maternity benefits, etc., we are doing our best to encourage" the reproduction of "the lowest and least-skilled section of the population"[64]. *Nature* thus supported both Major Church's bill which proposed to legalize voluntary sterilization (negative eugenics)[65] and R. A. Fisher's plan to stimulate the fertility of the middle classes through family allowances (positive eugenics)[66]. In fact the journal went beyond these measures to advocate compulsory sterilization "as a *punishment* for parents who have to resort to public assistance in order to support their children"[63]. Underlying such unalloyed social darwinism was the belief that "the future of the world lies with the race that is the first to apprehend the true causes of cultural decay and to resolve to eliminate these causes"[67].

Similar thoughts were of course being expressed in Germany, and the rise of the Nazis was one of two important factors in the decline of eugenics as a topic for *Nature*'s leaders. The passage of a compulsory sterilization law soon after the declaration of Hitler's dictatorship raised the question as to who would decide the "fitness" of an individual. In August of 1933 a concerned F. A. E. Crew found it impossible "to avoid the thought that here is provided a most frightful opportunity for the politically strong at present to outrage those politically oppressed"[68]. *Nature* eventually concluded that at the present level of knowledge the determination of such criteria would be made on political rather than on biological grounds[69]. The other element in the journal's retreat from eugenics was the increasing importance which some biologists attached to environmental conditioning of individual development[70]. One month after the leader supporting compulsory sterilization was published, Sir John Boyd

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'tunnel effects', which would actually be extremely small, on account of the large masses involved.

After division, the high neutron/proton ratio of uranium will tend to readjust itself by beta decay to the lower value suitable for lighter elements. Probably each part will thus give rise to a chain of disintegrations. If one of the parts is an isotope of barium[5], the other will be krypton ($Z = 92 - 56$), which might decay through rubidium, strontium and yttrium to zirconium. Perhaps one or two of the supposed barium-lanthanum-cerium chains are then actually strontium-yttrium-zirconium chains.

It is possible[5], and seems to us rather probable, that the periods which have been ascribed to elements beyond uranium are also due to light elements. From the chemical evidence, the two short periods (10 sec. and 40 sec.) so far ascribed to $^{239}$U might be masurium isotopes ($Z = 43$) decaying through ruthenium, rhodium, palladium and silver into cadmium.

In all these cases it might not be necessary to assume nuclear isomerism; but the different radioactive periods belonging to the same chemical element may then be attributed to different isotopes of this element, since varying proportions of neutrons may be given to the two parts of the uranium nucleus.

By bombarding thorium with neutrons, activities are obtained which have been ascribed to radium and actinium isotopes[8]. Some of these periods are approximately equal to periods of barium and lanthanum isotopes[5] resulting from the bombardment of uranium. We should therefore like to suggest that these periods are due to a 'fission' of thorium which is like that of uranium and results partly in the same products. Of course, it would be especially interesting if one could obtain one of these products from a light element, for example, by means of neutron capture.

It might be mentioned that the body with half-life 24 min.[2] which was chemically identified with uranium is probably really $^{239}$U, and goes over into an eka-rhenium which appears inactive but may decay slowly, probably with emission of alpha particles. (From inspection of the natural radioactive elements, $^{239}$U cannot be expected to give more than one or two beta decays; the long chain of observed decays has always puzzled us.) The formation of this body is a typical resonance process[9]; the compound state must have a life-time a million times longer than the time it would take the nucleus to divide itself. Perhaps this state corresponds to some highly symmetrical type of motion of nuclear matter which does not favour 'fission' of the nucleus.

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