compared with new energy sources be changed? We have no answer to this difficult question.

Perhaps the most appropriate conclusion is to observe that energy demand growth is partly a matter of choice. Our decisions about the quality of our natural environment, our material standards of living, and equity will influence our demand for energy and will, in turn, be affected by our use of energy.

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Nutrition and Mental Performance

Prenatal exposure to the Dutch famine of 1944–1945 seems not related to mental performance at age 19.

Zena Stein, Mervyn Susser, Gerhart Saenger, and Francis Marolla

Nutrition is one among the complex of factors embraced by social class that may account for the influence of social class on intelligence. Despite the attention given to the influence of malnutrition on mental performance through its effect on the developing brain (*1*), the evidence to establish this causal sequence in humans is lacking. Published studies have suffered from flaws in design or execution; many have not had adequate control groups; and both specifying and assessing nutritional intake in human populations is very difficult (*2*). The circumstances of the *hongerwinter* in the Netherlands in 1944–1945 have enabled us to isolate the experience of famine from other elements of the social environment. Here we relate material starvation during pregnancy to the mental status of the offspring in adult life.

The Dutch famine was remarkable in three respects: (i) Famine has seldom if ever struck where extensive, reliable, and valid data allow the effects to be analyzed within specified conditions of the social environment. (ii) The famine was sharply circumscribed in both time and place. (iii) The type and the degree of nutritional deprivation during the famine were known with a precision unequaled in any large human population before or since.

On 17 September 1944 British paratroops landed at Arnhem in an effort to force a bridgehead across the Rhine. At the same time, in response to a call from the Dutch government-in-exile in London, Dutch rail workers went on strike. The effort to take the bridgehead failed, and the Nazis in reprisal imposed a transport embargo on western Holland. A severe winter froze the barges in the canals, and soon no food was reaching the large cities (*3*).

Several indices attest to the severity of the famine in the cities of western Holland:

1) At their lowest point the official food rations reached 450 calories per day, a quarter of the minimum standard. In cities outside the famine area, rations almost never fell below 1300 calories per day (Table 1). The supply of food gradually declined during the first 6 weeks of the embargo, until in

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November 1944 the deficiency became severe. The famine continued into the first week in May 1945 when the Allied armies crossed the Rhine and liberated Holland. Fats, carbohydrates, and protein were concurrently and almost equally affected.

2) The death rate in the affected cities roses sharply, and many deaths were certified as due to starvation.

3) Clinical reports made during the famine noted a high frequency of hunger edema, osteomalacia, and frequent loss of as much as 25 percent of total body weight.

4) Sample surveys made immediately after the famine by specialist nutrition teams brought in by the liberating armies confirmed the severity of the effects reported during the famine.

Sources of Data and Study Design

The famine affected the large cities of western Holland. The people of rural areas and small towns were better off than those in cities because they could reach food-producing areas. In the Netherlands south of the Rhine the Allied armies were in occupation; the east and the north had better access to food. This geographic demarcation was used in our study design; we compared seven famine-stricken cities of the west (Amsterdam, Leiden, Haarlem, Utrecht, s'Gravenhage, Rotterdam, Delft) with 11 control cities in the south, east, and north (Maastricht, Heerlen, Breda, Tilburg, Eindhoven, Enschede, Helmond, Hengelo, Zwolle, Leeuwarden, Groningen). The study and control cities comprised all those in the affected and unaffected parts of the country with a population greater than 40,000 (except Arnhem and Nijmegen which, at the time of the famine, were disrupted by warfare). Three of the affected cities, but none of those unaffected, had populations greater than 500,000.

We chose to carry out a retrospective cohort study. This we did by reconstructing birth cohorts exposed to famine and comparing them with cohorts not so exposed. To execute this design we sought out epidemiologic checkpoints in the life arc of the affected individuals. The criteria for these checkpoints were three:

1) All the members of the cohort at risk who passed through the checkpoint could be identified in terms of an outcome variable of interest to the study.

2) Date of birth was recorded for each individual.

Table 1. Rations of calories, protein, fats, and carbohydrates in 3-month averages for the period June 1944 to August 1946 inclusive.

Area	June–Aug. 1944	Sept.–Nov. 1944	Dec.–Feb. 1944–45	Mar.–May 1945	June–Aug. 1945	Sept.–Nov. 1945
			Calories			
West	1512	1414	740	670	1757	2083
North	1512	1450	1345	1392	1755	2083
South	1512	1403	1375	1692	1864	2083
			Protein (grams)			
West	42	40	21	14	55	61
North	42	42	38	43	53	61
South	42	42	44	50	58	61
			Fats (grams)			
West	32	25	15	12	54	50
North	32	26	23	26	39	50
South	32	25	21	28	38	50
			Carbohydrates (grams)			
West	275	253	127	119	268	333
North	275	259	237	237	283	333
South	275	251	245	300	317	333

3) The place of birth was recorded for each individual.

Given date and place of birth, we could assign individuals to exposed and unexposed groups. By far the best checkpoint proved to be military induction procedures of males at age 18. Routinely, all those eligible for induction and capable of appearing are medically examined and psychologically tested. Some 98 percent of males surviving and resident in the Netherlands are included in our study.

The study population comprises 125,000 males born in the selected famine and control cities in the 3-year period 1 January 1944 to 31 December 1946, who were inducted by the military at about 19 years of age. Twenty thousand of these, we inferred from their date of birth and place of birth, were exposed to the famine through maternal starvation.

Dependent Variables

Three dependent variables, all concerned with intellectual performance, are reported below.

1) Severe mental retardation. This variable is defined by the clinical diagnosis assigned at examinations, and coded according to the International Classification of Diseases Codes (1948) as 3250 (idiot), 3251 (imbecile), and 3254 (mongoloid).

2) Mild mental retardation. This variable is also defined by the clinical diagnosis assigned at examination and the International Classification of Diseases Code 3252 (debilitas mentis).

3) Intelligence quotient. This variable represents the score on the Raven Progressive Matrices (Dutch version). This test is the most sensitive measure of mental performance available for this study, and virtually every individual has a score. The data we used were scores grouped in six levels. Across the country the average proportions in each group, from highest to lowest scores, were 1, 17.7 percent; 2, 28.4 percent; 3, 20.2 percent; 4, 13.6 percent; 5, 9.9 percent; 6, 4.8 percent; and not known, 5.3 percent.

The clinical levels of severe and mild retardation are consistent with the usual standards; that is, a division around IQ 50 separates the two levels of severity. The data are derived from the military induction examinations. These examinations, carried out at seven centers in Holland, are standardized procedures which include clinical examination and physical, psychological, and educational tests. Ninety-five percent of those inducted had intelligence test scores coded from their records. Residents of institutions are not directly examined, but reports on them are obtained and included in the files. Rejections for any condition, including mental retardation, are the responsibility of the medical officer in charge of the induction center. He reviews every record, and where necessary obtains the clinical records of handicapped persons in institutions.

Independent Variables

The independent study variable, or hypothesized cause, was exposure to famine.

A postulated moderator variable was the stage of growth and development of the fetus on exposure to famine, namely, the fetal age of the cohort at the time of exposure. This variable has importance in terms of the hypothesis of crit-

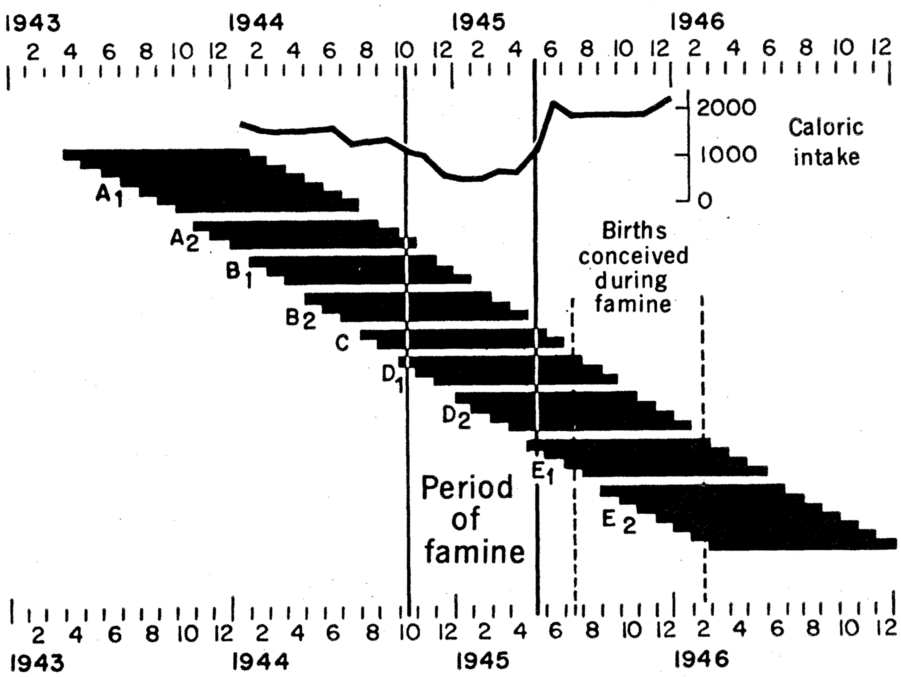


Fig. 1. Design of study. Cohorts by month of conception and month of birth, in the Netherlands, 1943 to 1946, related to calories in the rations of famine cities. Solid vertical lines bracket the period of famine, and broken vertical lines bracket the period of births conceived during famine.

ical periods. The hypothesis states that developing organ systems are most vulnerable at the period of maximum growth; interruption of development at a critical period (specifically, when cell number is increasing) is likely to be irreversible or, at the least, subsequent development is likely to be retarded (*4*). On this hypothesis, stage of growth is a moderator variable that specifies conditions in which interaction with the causal variable will be found. We therefore designated birth cohorts by their stage of gestation at the time of exposure to famine.

Figure 1 shows the basic elements in the design of the study. In Fig. 1, each horizontal bar represents a cohort of births in a 1-month period; the beginning of the bar represents the month of conception; the end of the bar, the month of birth. The dates of conception are inferred from dates of birth. The average error in these estimates is bound to be small because, on the average, the reduction in the duration of gestation during the famine was not more than 4 days (*5*).

The cohorts, grouped by the stage of gestation and exposure, are defined below.

Cohorts A1 (births between January and July 1944) and A2 (births between August and October 1944) were conceived and born before the famine.

Cohorts B1 (births between November 1944 and January 1945) and B2 (births between February and April 1945) were conceived before the famine and born during the famine; B1 was exposed for the third trimester of gestation, and B2 was exposed for the second trimester as well as the third.

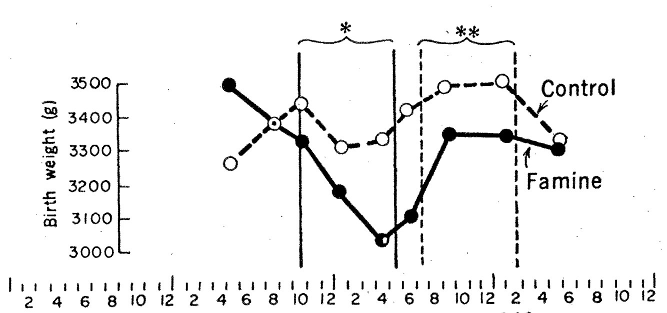
Cohort C (births in May or June 1945), conceived before and born after the famine, was exposed during the middle 6 months of gestation.

Cohort D1 (births between July and September 1945) and D2 (births between October 1945 and January 1946) were conceived during the famine; D1 was exposed during the first and second trimesters of gestation, D2 was exposed for only the first.

Finally, cohorts E1 (births between February and May 1946) and E2 (births between June and December 1946) were never exposed to famine.

Early postnatal exposure to famine can be examined as well as prenatal exposure by comparisons among the birth cohorts for which the postwar period and unaffected areas are used as controls.

Birth weight is a second potential moderator variable of importance to this study. The period crucial for birth weight, the third trimester, is also a time of high velocity of brain growth in the human infant (*6*). Although our own studies, among others, show that the role of birth weight in perinatal mortality is a strong one (*7*), its role in child development is still obscure (*8*). The Dutch famine afforded an opportunity to try to elucidate this role. The mean birth weight curve in Fig. 2 is drawn from data on 851 singleton births taken from hospitals in Heerlen (control city), and 862 singleton births from hospitals in Rotterdam (famine city). The famine curve is much the same in the data reported by Smith, by Sindram, and by Stroink (*5*). Because most births took place at home, birth weights could not be obtained for the individual members of the military induction cohorts. These data therefore serve as collateral



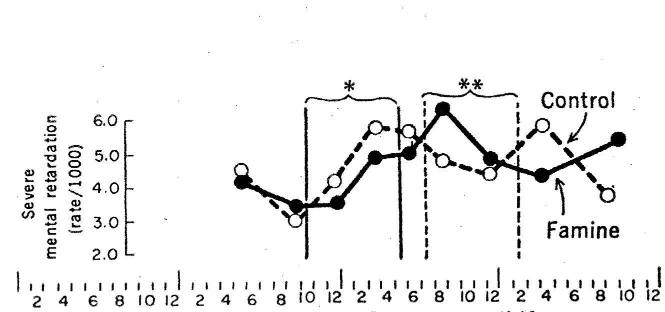


Fig. 2 (left). Mean birth weight in maternity hospitals selected from famine and control cities (Rotterdam and Heerlen, respectively), by cohort of birth. Solid vertical lines bracket the period of famine, and broken vertical lines show the period of births conceived during famine. Fig. 3 (right). Rates of severe mental retardation in Netherlands men examined at age 19, by cohort of birth in famine and control cities. Solid vertical lines bracket period of famine, and broken vertical lines show the period of births conceived during famine.

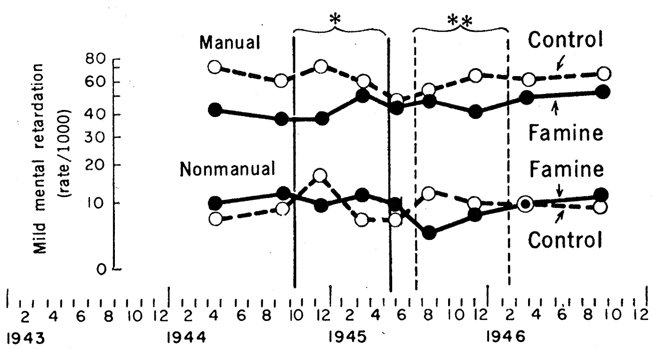
indicators of their experience. The social attributes of home and hospital births are not known, but the hospital births include all social classes and the results are consistent between hospitals in both affected and unaffected areas.

Two confounding variables, fertility and social class, have been controlled in analysis. A marked decline in fertility occurred in the famine cities but was absent in control cities. We found that the decline affected all social classes at more or less the same time, but the loss of fertility in each social class was different in degree. Manual workers were affected more than nonmanual workers. The consequence was to produce proportions of social classes among the birth cohorts that differed according to their time of exposure to famine. This difference was not found for the control cities.

The distribution by social class of births conceived in the postwar period reverses the distribution found for births conceived during the famine. This is the mirror image of the famine period; it is evidently a rebound phenomenon which, in epidemiological terms, represents the effect of a greater risk for conception; that is, it is the consequence of susceptibility to pregnancy in the postwar period that differed among the social classes because of their different rates of fertility during the famine.

Results

Table 2 sets out the rates of severe and mild mental retardation, the mean score on the matrices, the numbers at risk in two classes of father's occupation, and the total numbers at risk for



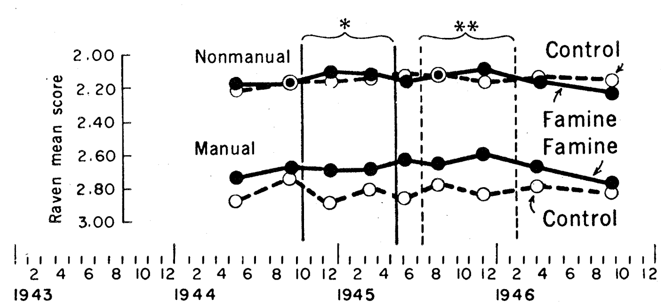


Fig. 4 (left). Rates of mild mental retardation in Netherlands men examined at age 19, for manual and nonmanual classes according to father's occupation, by cohort of birth in famine and control cities. Solid vertical lines bracket period of famine, and broken vertical lines show the period of births conceived during famine. Fig. 5 (right). Mean grouped scores on Raven progressive matrices test of Netherlands men examined at age 19, for manual and nonmanual classes according to father's occupation, by cohort of birth in famine cities and control cities. Solid vertical lines bracket period of famine, and broken vertical lines show the period of births conceived during famine.

Table 2. Results of a survey of mental performance in male birth cohorts from famine and control cities, at age 19. The categories Manual and Nonmanual refer to occupational status of the fathers. These comprise 92.6 percent of the birth cohorts at military induction. The total includes also those others with fathers in agricultural occupations (1.6 percent), fathers dead more than 6 years (2.6 percent), and those with no known occupations of fathers (3.2 percent). The cohorts are defined in the text.

Category	Group	Birth cohorts								
		A1	A2	B1	B2	C	D1	D2	E1	E2
		Mental retardation by grade of severity (rates per thousand)								
Severe										
Total	Famine	3.11	2.40	2.55	3.83	4.02	5.29	3.76	3.33	4.37
	Control	3.49	2.00	3.18	4.79	4.66	3.75	3.41	4.85	2.94
Mild										
Manual	Famine	42.2	37.9	39.2	51.2	45.1	48.3	42.4	49.9	54.7
	Control	71.1	61.1	69.5	60.4	46.9	53.8	64.6	62.7	67.6
Nonmanual	Famine	10.4	11.8	10.0	11.5	9.9	5.1	8.0	10.3	12.0
	Control	7.1	8.8	16.6	7.2	6.8	12.0	10.3	9.9	10.3
Total	Famine	34.90	32.68	31.44	37.75	36.19	35.70	31.40	36.89	40.16
	Control	55.20	45.58	59.04	47.94	39.58	40.90	52.93	47.65	52.14
		Mean scores of the cohorts on Raven progressive matrices test								
Manual	Famine	2.74	2.67	2.67	2.67	2.61	2.63	2.58	2.65	2.74
	Control	2.86	2.73	2.87	2.79	2.84	2.77	2.81	2.76	2.79
Nonmanual	Famine	2.17	2.15	2.10	2.11	2.13	2.10	2.06	2.13	2.19
	Control	2.19	2.15	2.14	2.13	2.11	2.10	2.14	2.11	2.12
Total	Famine	2.54	2.48	2.47	2.45	2.43	2.45	2.38	2.45	2.52
	Control	2.67	2.56	2.65	2.60	2.60	2.56	2.62	2.54	2.57
		Numbers at risk								
Manual	Famine	6,856	2,980	2,856	2,772	1,750	2,050	1,889	6,371	10,272
	Control	1,683	800	663	839	588	837	1,071	1,612	2,322
Nonmanual	Famine	4,437	1,956	1,805	2,001	1,212	1,377	1,493	4,566	7,778
	Control	3,486	1,474	1,353	1,605	959	1,579	2,075	2,663	4,054
Total	Famine	12,522	5,416	5,089	5,219	3,233	3,781	3,726	12,008	19,920
	Control	5,725	2,501	2,202	2,712	1,718	2,665	3,514	4,743	7,134

each birth cohort, in famine and control cities (Figs. 3 to 5).

The frequency of severe mental retardation among survivors of the birth cohorts is related neither to conception nor to birth during the famine (Fig. 3). A slight rise in frequency of severe mental retardation in the famine cities parallels the decline in birth weight, but must be discounted as an effect of the famine in the west, because a concurrent rise in frequency occurred in the control cities. The rise in the D1 cohort, we found, was almost entirely due to Down's syndrome. The famine was mild at the time of D1 conceptions, when the chromosomes might have been vulnerable to insult, and the distribution of the syndrome across the whole period does not suggest that the cluster in the D1 cohort was due to the famine.

The frequency of mild mental retardation too is related neither to conception nor to birth during the famine (Table 2). Control city rates are always higher than famine city rates. Although the rise in the total frequency of mild mental retardation in famine cities during the famine is parallel to the decline in birth weights of cohorts B2 and C, the rise is far exceeded among births conceived after the famine and born in 1946.

The D2 cohort, conceived at the height of the famine, actually shows a decline in the rate of mild mental retardation. This decline in frequency can be explained by the confounding due to the differential fertility among the social classes referred to above. Frequencies by father's occupation show, as expected, that sons of fathers in manual work have a far higher rate of mild mental retardation than sons of fathers in nonmanual work (Fig. 4). No systematic relation with prenatal famine experience is seen in the two occupational classes, and the decline in the D2 cohort seen in the total rate almost disappears.

The later postwar rise in the frequency of mild mental retardation in cohorts E1 and E2 can be accounted for partly by the rebound fertility of the lower classes after the famine.

For the Raven matrices data, a numerically higher score signifies a poorer performance, according to the Dutch method of scoring. Once more we failed to find an association with the period of famine (Table 2).

By far the most striking variation is between mean grouped scores of the nonmanual and manual classes (Fig. 5). The influence of the social class variable is further underlined by the sensitivity of the measure to differential fertility among the social classes referred to above. Again, for the D2 cohort, conceived at the height of the famine, there is a slight rise in intelligence (that is, a lower numerical score). An anaylsis within nine occupational classes, however, removed almost all of this rise in IQ. This supports the explanation that this rise reflects an underrepresentation of the manual classes among the births of the D2 cohort.

Interpretation

A number of reservations must be considered before inferences are drawn from the above results.

1) Completeness of the birth cohorts examined in the military sample at induction. For the purpose of validation, we made a follow-up through the records of the local population registers of a randomly selected 2000 births, all from two separate cities. Ninety-six percent were located in records of death, migration, or military induction.

2) Ecological fallacies. The exposure to famine can be determined from rations for groups defined by time and place of birth, and the analysis must rely on group performance related to group exposures. Where variations in performance within groups are considered, uniformity or variation in exposure to famine can only be assumed.

3) The comparability of the famine and control cities. There are differences other than exposure to the famine between the famine and control cities, particularly in size, religion, and occupational composition. It is conceivable, but we believe most unlikely, that some factors related to the differences acted only during the period of the famine to suppress or distort the results among the survivors.

4) Adequancy of measures of mental ability. The extensive literature on IQ's need not be reviewed here. In our view, IQ's are more reliable than most epidemiologic measures, despite their limitations. The matrices scores and the clinical criteria are consistent for the particular range of abilities they reflect.

5) Adequacy of the military induction examinations. We personally observed examinations at one of the seven centers. They were carried out in a standard fashion, and with the large number of subjects involved they seem adequate for our purposes.

6) The use of males alone as subjects. By most developmental criteria, females are less sensitive to insult than males. It is unlikely, although possible, that they would show effects where males did not.

7) Nature of the nutritional insult. In our study we examine the effects of acute starvation involving all components of the diet in a population of pregnant mothers previously reasonably well nourished. The results should not be generalized to the effects of chronic malnutrition with a different set of dietary deficiencies such as often occurs in developing countries, nor to nutritional insult in postnatal life.

Taking all these reservations into account, we believe that the results point to three conclusions about the measures of adult mental performance described. (i) Starvation during pregnancy had no detectable effects on the adult mental performance of surviving male offspring. (ii) Mental performance in surviving adult males from a total population had no clear association with changing levels of mean birth weight in a selected hospital sample of that population. (iii) The association of social class with mental performance was strong.

Alternative hypotheses to explain the absence of detectable effects of famine on mental performance must be considered.

Selective survival. Survivors of the famine-affected cohorts might have been selected from fetuses unimpaired by maternal starvation, whereas the deaths in the affected cohorts were selected from those who were impaired. This hypothesis implies an all-or-none effect; the exposed fetus either survived unimpaired or died from the insult. In support of the hypothesis one might cite the high death rates of mentally retarded populations early in life, and the sensitivity of these rates to environment. An analysis of deaths undertaken to examine this interpretation is yet to be completed.

Compensatory experience. Postnatal learning in the period from birth to military induction might have compensated for neurological impairment of the fetus induced in utero by the famine. This hypothesis, if proved correct, would controvert the critical period hypothesis. Since postnatal learning seems closely related to social environment, on this hypothesis we might expect to find interaction between the effects of social environment and famine. None was evident in the data relating mental performance to social class and exposure to famine.

The results are positive in two respects. First, they point either to a high order of protection afforded the fetus in utero, or to great resilience of the fetus in the face of nutritional insult, or to both. Second, the results affirm the association of social environment and mental performance. Among these birth cohorts there are considerable variations, not reported here, on the matrices and in the frequency of mild mental retardation between large cities and small, between town and country, between religious groups, and between birth orders. These variations in mental performance point to effects of postnatal experience that are likely to be crucial and demand continued testing.

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Politicalization in Science

Joseph Haberer

In this article I elaborate on some of the profound impacts and consequences of three significant transformations of modern science that have occurred in the last century: first, the politicalization of science, then the shift from an international to a national orientation of the scientific enterprise, and finally, the professionalization of the community of science. Such an undertaking may help us to better understand (i) the emergence of social responsibility as an item of major concern among scientists and others; (ii) the pattern of "prudential acquiescence" that characterized science during most of its history; and (iii) the pervasive influence that the belief in a partnership between science and government has had upon the study of science and its relation to the political order.

Politicalization

For science, the age of innocence is over. That innocence to which J. Robert Oppenheimer alluded in his famous, if somewhat enigmatic, remark that "scientists have known sin" (*1*), began to disintegrate some decades before the blinding flash at Alamogordo brought to full consciousness the recognition that the knowledge produced by scientists contained within it the seeds of an awesome power. Implementation of the Baconian ideal of science was predicated on the notion that knowledge is power—power over nature that could be used for the improvement of the human condition. Ironically, the Baconian model reached its first full expression in the Manhattan Project, that massive team of scientists and engineers whose efforts culminated in the destruction of two cities. Yet the overweening optimism of the founders of modern science threatens to turn their dreams into nightmares.

The belief, based on a faith in science, that progress is inevitable and beneficial, began to turn to ashes when it became evident that science as power was also an agent of destruction and death. None of this surprises us today. Yet, notwithstanding the increased social consciousness among segments of the American scientific community, even before the outbreak of World War II, that innocence, that optimism, remained the dominant outlook among American scientists well into the 1950's. Indeed, it may be that most scientists are still wedded to the conviction that the solution to our social, political, and human problems lies in applying to them the instruments of modern science and technology.

In contrast, European scientists were much less likely to operate under a belief that the scientific fraternity was somehow sheltered from the vagaries of the surrounding social and political order. For them, the age of innocence ended soon after the first shots rang out at Sarajevo. The rallying of scientists to national banners and the utilization of scientists as a national resource created in the international community of science a schism that ex-

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