MCV/Q

MEDICAL COLLEGE OF VIRGINIA QUARTERLY
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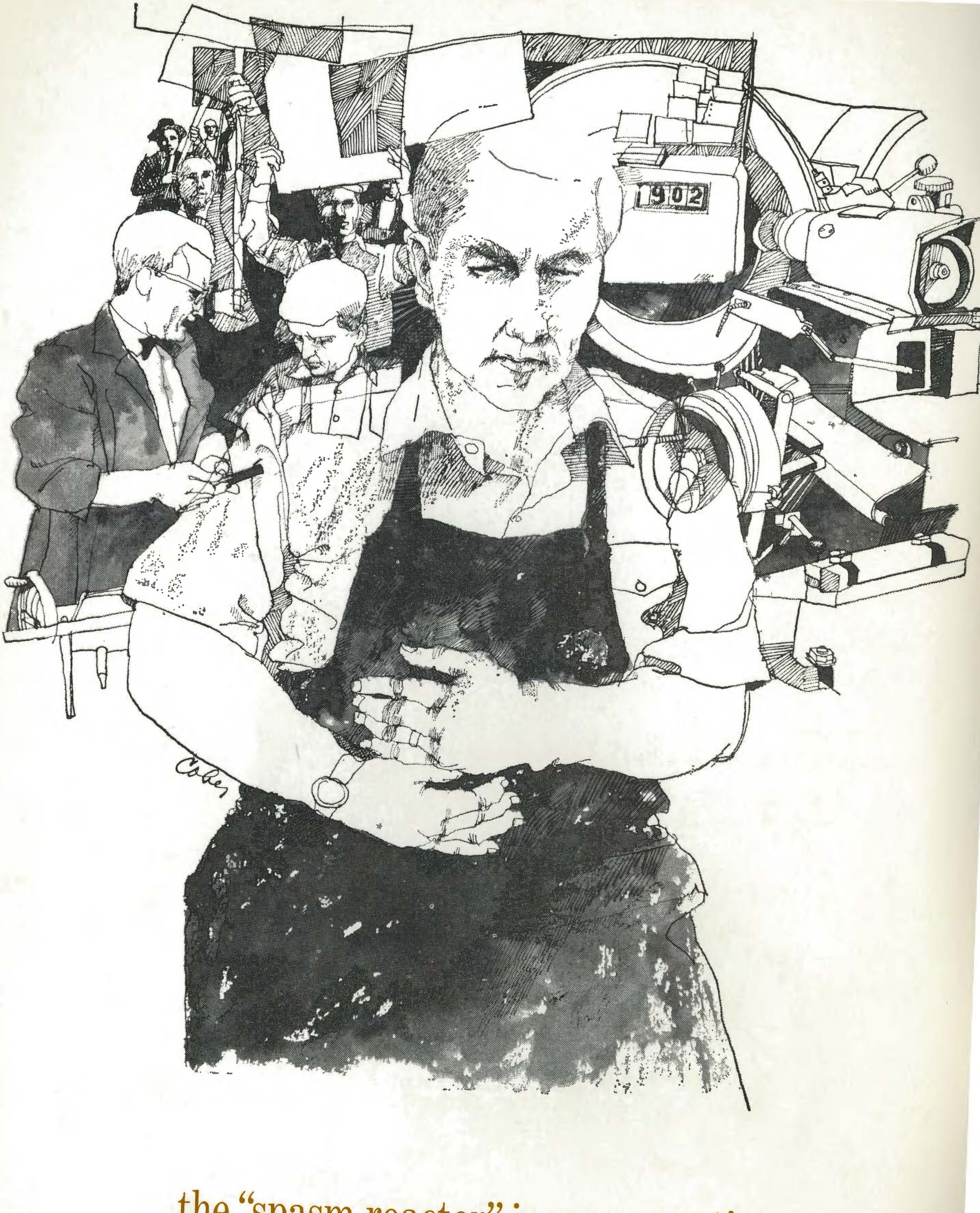

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MEDICAL COLLEGE OF VIRGINIA QUARTERLY

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CONTENTS

The MEDICAL COLLEGE OF VIRGINIA QUARTERLY is designed primarily for the postgraduate education of physicians. The QUARTERLY will publish results of original research in basic and clinical sciences, and report on seminars and symposiums held at the College. Contributions from outside the MCV faculty are invited.

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Lasting Biological Effects of Early Influences

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In his essay "Uses of Great Men" Ralph Waldo Emerson wrote a statement that has a direct bearing on the topic I wish to discuss in the present paper: "There are vices and follies incident to whole populations and ages. Men resemble their contemporaries even more than their progenitors."

As a moralist, Emerson was primarily concerned with the intellectual and moral attributes of human beings; his aphorism is just as valid for anatomic and physiological attributes. We resemble our progenitors because we derive from them our genetic endowment; but genes do not really determine the traits by which we know a person. They only govern the responses that the person makes to environmental stimuli. Individuality progressively emerges from these responses.

Whereas the genetic pool of a population remains essentially constant, the environment changes rapidly. We resemble our contemporaries, because the phenotypic expression of the genetic endowment is determined by the environmental forces that impinge more or less simultaneously on all the members of a given generation in a given social milieu.

The phenotype is constantly being molded by the environment throughout the whole life span. But early influences certainly play the most important role in converting genetic potentialities into phenotypic reality. As commonly used, the phrase "early influences" denotes the conditioning of behavior by the experiences of early life. Early experiences, however, do more than condition behavioral patterns; they also affect, profoundly and lastingly, other biological characteristics such as initial growth rate, efficiency in the utilization of food, anatomic structures, physiologic attributes, maximum adult size, resistance to infection, response to various forms of stimuli —in brief, almost every phenotypic expression of the adult.

A few examples from contemporary life will suffice to illustrate the effects of early influences on human populations.

Japanese teenagers are now much taller than their parents and differ in behavior from prewar teenagers, not as a result of genetic changes, but because the post-war environment in Japan is very different from what it was in the past. A similar phenomenon is observed in the settlements of Israeli kibbutz. The kibbutz children are given a diet and sanitary conditions as nearly optimum as can be devised. Early in their teens, as a result, they tower over their parents, who originated from crowded and unsanitary ghettos in Central and Eastern Europe.

The acceleration of growth in Japan and in the Israeli kibbutz constitutes but a particular case of a constant trend toward earlier maturation of children in Westernized countries. This is evidenced by greater weights and heights of children at each year of life and by the earlier age of the first menstrual period. In Norway, for example, the mean age of menarche has fallen from 17 years in 1850 to 13 in 1960; similar findings have been reported from Sweden, Great Britain, the United States, and other affluent countries.

Growth is not only being accelerated; the final adult heights and weights are greater as well as being attained earlier. Some 50 years ago, maximum stature was not being reached, in general, until the age of 29; commonly now it is reached about 19 in boys and 17 in girls. With regard to the age of puberty, the change seems to consist in the restoration of the developmental timing that had prevailed in the past and that had been greatly retarded by the ways of life at the beginning of the 19th century.

The factors responsible for these dramatic changes in the rate of anatomic and sexual maturation are not completely understood. There are good reasons to believe, however, that improvements in nutrition and control of childhood infections have played a large part in the acceleration of development, and that this change in turn has been responsible for the larger size achieved by adults.

I shall briefly describe experimental models that illustrate the effects of early influences on the development of laboratory animals.

Pioneering investigations on the lasting biological effects of early postnatal influences were carried out in England during the 1960's by R. A. McCance and Elsie M. Widdowson of Cambridge University. These investigators compared the growth of rats suckled in small litters (three young per lactating

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female) with that of comparable animals suckled in large litters (18 young per female). They found that the rats of the latter group became much smaller adults than those of the former group, even though the animals of both groups were given unlimited food after weaning. It can be assumed that the animals raised in small litters developed more rapidly than the others because they enjoyed a nutritional advantage during the lactation period. As McCance and Widdowson pointed out, however, the interpretation of their findings may be more complex than appears at first sight. The design of their experiments did not rule out the possibility that infectious and psychological disturbances occurred when lactating females had to feed unusually large numbers of young. Such disturbances might have played a role in the retardation of growth observed in this group.

In our own studies now to be described, an attempt was made to eliminate or minimize the disturbing effect of indirect, non-nutritional factors. To this end, the experiments were conducted with specific-pathogen-free (SPF) mice so as to avoid the activation of latent pathogens by nutritional deficiencies. In all cases, the litter size was reduced to eight young, which is physiologically normal for mice. Whenever possible the animals were put on the experimental diets two weeks before mating so as to eliminate the behavioral disturbances that commonly occur at the time of a dietary change.

The principle of the experiments consisted in introducing the conditioning factor (infection, nutritional deficiency, or behavioral disturbance) very early in the life of the animal—either during gestation or lactation, or both. Immediately after weaning, all young animals were placed under exactly the same optimum conditions of husbandry and kept undisturbed during their whole life span. This made it possible to recognize the lasting effects of the early manipulation on characteristics such as rate of growth, maximum adult size, longevity and resistance to various forms of stress.

SPF mice weigh more at weaning time than mice of the same genetic origin raised under less favorable conditions. Furthermore, they reach larger adult size and exhibit more desirable physiological characteristics as well as greater resistance to various forms of stress. It might be assumed that these differences are the result of unrecognized genetic changes that occurred during the development of the SPF colony. However, this explanation has been ruled out by several types of experiments.

In one type of experiment, newborn SPF mice were contaminated per os one or two days after birth with fecal material obtained from ordinary mice that had been raised on a commercial farm and were "healthy" according to usual criteria. The contamination could be so controlled that it did not cause any obvious sign of disease, not even diarrhea. Yet the contaminated animals were smaller than the uncontaminated controls at weaning time. Even more interestingly, they grew into smaller adults. Depression of weight was at times so profound that the contaminated animals were almost runts at the time of weaning.

The following facts strongly suggest that this growth-depressing effect is associated with viral multiplication in the intestinal tract. When SPF mice are contaminated per os shortly after birth with certain bacterial cultures isolated from the intestinal contents of adult ordinary mice, these bacteria multiply extensively throughout the gastrointestinal tract and persist at extremely high levels until weaning time. However, such bacterial infections do not affect significantly either weaning weight, growth rate, or maximum adult weight.

In contrast, weight depression could be consistently brought about by contaminating newborn SPF mice per os with bacteria-free filtrates of homogenates of intestines from ordinary mice. The weight-

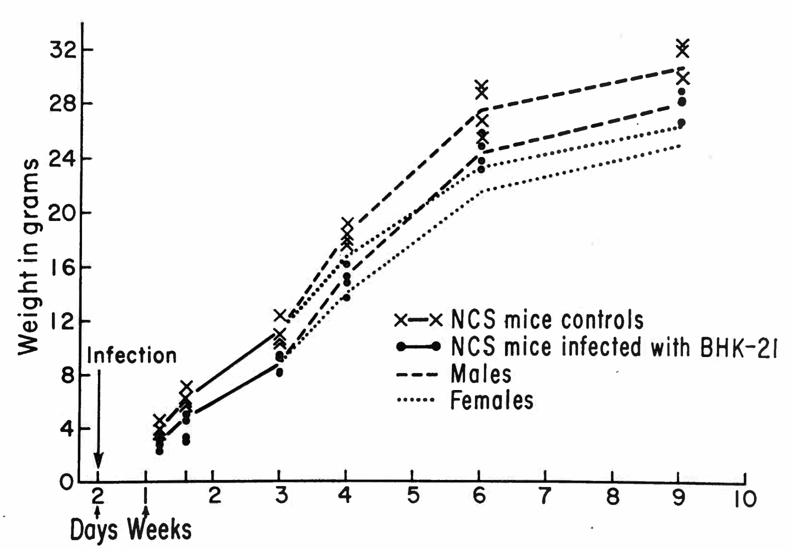

Fig. 1—Weight curves of SPF mice contaminated orally on second day of life with fifth passage of BHK-21 tissue culture infected with enteric virus.

Each point represents the average for each box of animals; each curve corresponds to averages for approximately 15–20 animals.

depressing agent passed through Millipore discs of 0.45μ and 0.22μ porosity but was held back at 0.10μ porosity.

On several occasions, but not consistently, bacteria-free filtrates capable of depressing the weight curve of SPF mice produced alterations in the appearance of tissue cultures of baby hamster kidney cells (BHK-21) and mouse embryo cells. When tissue cultures so infected were introduced into newborn SPF mice, the weight of these animals was depressed early and lastingly (Fig. 1 and 2).

Only very young SPF mice (preferably less than three days old) proved susceptible to the weight-depressing effect of the filtrates of intestine homogenates or of infected tissue cultures prepared therefrom. After oral contamination, it took approximately one week before the intestinal homogenate obtained from contaminated animals exhibited a high level of weight-depressing activity.

The growth-depressing effect could be transmitted from one generation to the next by mating SPF mice that had been contaminated shortly after birth and were consequently smaller than control SPF animals (Fig. 3).

A lasting effect on growth can be produced also in the absence of contamination by feeding the mouse dam a restricted or deficient diet, either during gestation or, after the birth of her young, during the lactation period.

Lasting depression of growth has been achieved, for example, by lowering the content of the dam's diet in magnesium, or in lysine and threonine. The growth-depressing effect so achieved persisted throughout the whole life span of the young, even though the latter were given, at weaning time and constantly thereafter, unlimited amounts of an optimum diet. These findings are relevant to human situations, since the diets of most underprivileged people consist chiefly of plant products,

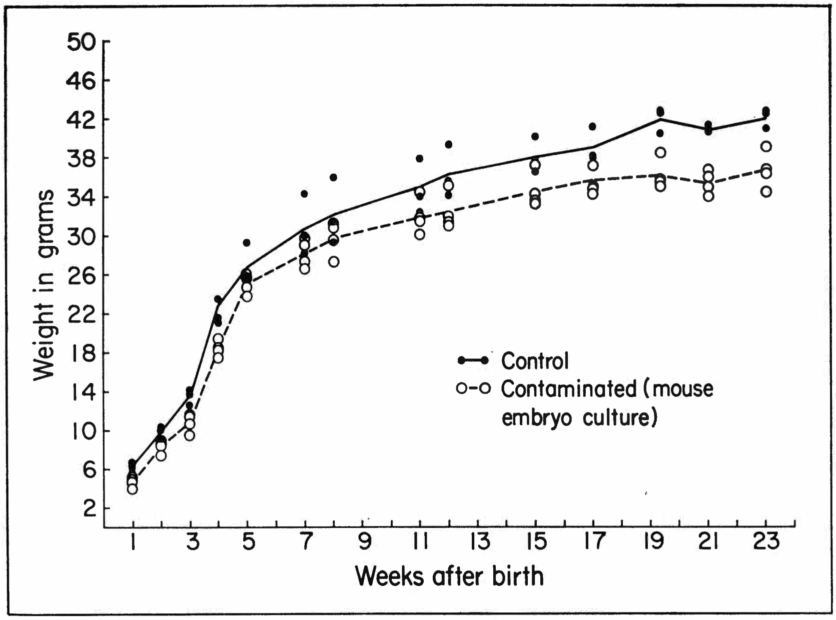

Fig. 2—Weight curves of SPF mice contaminated two days after birth with mouse embryo infected cells.

Each point represents the average weight for each box of animals; each curve corresponds to approximately 15–20 males.

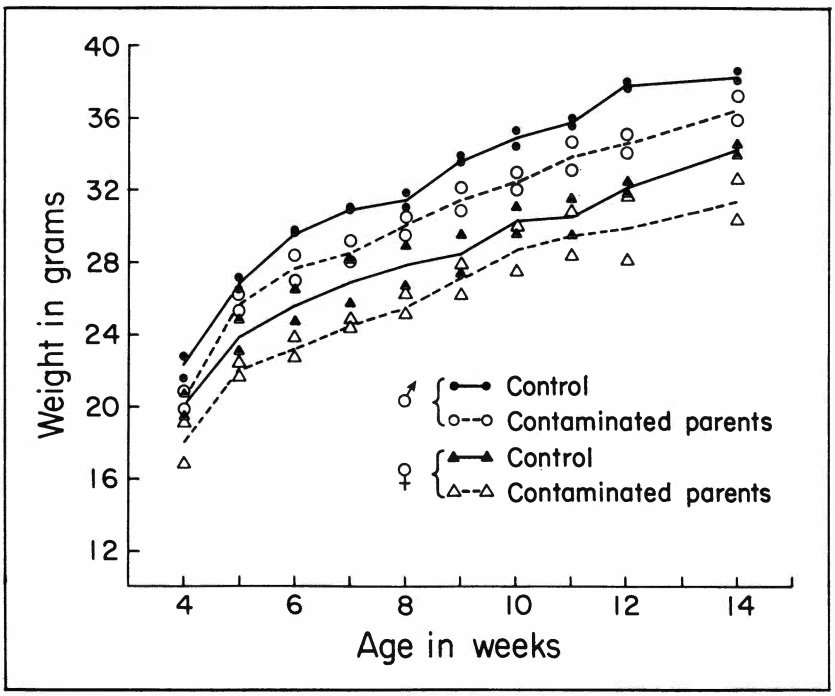

Fig. 3—Weight curves of SPF mice born from uncontaminated and contaminated parents.

Each point represents the average weight for each box of animals; each curve corresponds to approximately 20 animals.

which are commonly deficient in certain amino acids and minerals (Fig. 4 and 5).

Depression of growth resulting from lysine and threonine deficiency during gestation or lactation did not seem to affect adversely the health of the young, or to decrease their longevity. In fact, the results of two experiments in which the animals nursed by mothers on different diets were kept undisturbed and on optimum diets throughout their whole life span suggest that the smaller animals had a greater average life expectancy than the larger ones (Fig. 6).

Even in the absence of infection and of malnutrition, SPF mice naturally exhibit individual differences in weaning weight, growth rates, and adult size. We have observed, on the other hand, that the young of each particular mother are remarkably uniform in size. It was assumed that the differences from litter to litter, and the uniformity within each litter, were determined by the genetic endowment of the young. But this explanation does not account for the facts, as shown by the unexpected results of the following experiments.

Newborn SPF mice of exactly the same age were pooled one day after birth. They were then randomly reallocated to the various mothers, each foster mother receiving eight young born the same day. The foster mothers were all fed an optimum mixed natural diet and placed under favorable laboratory conditions. They readily accepted the young allocated to them, and these began to nurse immediately. Within a very few days, however, marked differences could be detected in the growth of the newborn mice. Contrary to expectation, the differences were small within each group nursed by a given foster mother, while they were much more pronounced from one group to the other (Fig. 7).

The pattern of differences was very obvious after two weeks and particularly at the time of weaning. Furthermore, the relative rank of weights remained the same after weaning, even though all mice received from then on the same optimum diet in the same room. Figure 7 illustrates the range of differences within litters and between litters at different periods after separation of the young from their foster mothers. Adult size, as well as weight during lactation and at weaning time, obviously reflected the experience of the very first days of life.

The design of this type of experiment rules out the possibility that the differences in weights and growth rates from litter to litter could be caused by differences in genetic constitution among the young animals, since these had been pooled and randomized; neither could the differences in growth be traced to prenatal influences, since the animals had been randomized after birth. Uniformity within a litter and differences from litter to litter were due, therefore, to the influence of the foster mother during lactation. As far as can be judged, the quantity and quality of milk did not differ from mouse to mouse, but the foster mothers differed markedly in their "mothering" behavior (attention to the young, nest building, etc.). What is certain, in any case, is that the early experience derived from the foster mother conditioned the young so profoundly that the effects persisted long after the end of lactation into adult age.*

No systematic study has yet been made of the mechanisms through which early influences exert such profound and lasting effects. But a few facts point to useful working hypotheses.

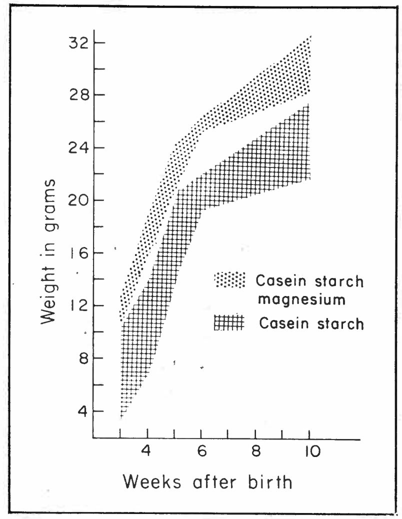

Fig. 4—SPF mice fed pellets until three days before delivery. From then on, and throughout lactation, half of them were fed casein-starch diet; the other half the same diet supplemented with magnesium chloride. All animals transferred to pellets after weaning.

The graphs show the weight range for each group (48 animals per group) until the fourth week of life, then for the males only.

Adult animals which have suffered from viral enteric infections or nutritional deprivation early in life exhibit a markedly decreased ability to absorb and utilize the food which is given them later; the incorporation of amino acids is particularly depressed. Such anabolic defects persist long after the early experience that caused them initially.

There is evidence also that certain viral infections, nutritional deficiencies and behavioral disturbances interfere with the synthesis

* The weight depression produced by the virus mentioned on pages 53 and 54 is still evident 18 months after oral contamination of the newborn animals. Furthermore, new experiments with the same virus preparation have resulted in a weight depression much more profound than that recorded in Figures 1, 2, and 3. The wall of the small intestine is very much thickened in these infected animals, which continue to exhibit malabsorption and deficiency in amino acid assimilation long after oral contamination.

Similar phenomena have been observed in germ-free chicks (Eyssen and De Somer, 1967). Also relevant to this study is a paper by Berg, Simms, and Everitt (1963), which demonstrates an effect of early nutrition on longevity.

of various hormones (growth hormone, for example) at critical periods of development.

Other preliminary studies have revealed that the numbers of certain types of cells are determined early in life and are conditioned by various influences. For example, mice and rats nursed by mothers fed a restricted or deficient diet appear to have unusually small numbers of lipogenic cells. This may explain why they do not become obese in old age, as is the tendency among animals produced and nursed by dams fed a rich diet, and also why they seem to have a long life span.

Early influences also affect the development of neural systems and of behavioral patterns, as can be readily demonstrated in many species of animals. The classical "imprinting" of birds is almost a caricature of this phenomenon; most techniques of animal training make practical use of the possibility to control behavioral organization during early life. The molding of the neural apparatus and associated conditioning of behavior are of particular importance in man, because the nervous system of the human brain is incompletely developed at birth. Mentally, the child develops as he responds to environmental stimuli.

In man, as in animals, there are critical periods of mental as well as physical development, but the timing and duration of these critical periods have not been defined. It is certain, in any case, that the manifestations of mental development are conditioned by the metabolic factors that govern anatomic and physiologic growth and by the nature of the stimuli to which the child is exposed. The social environment during early life, therefore, affects profoundly, and in most cases irreversibly, the fate of the person.

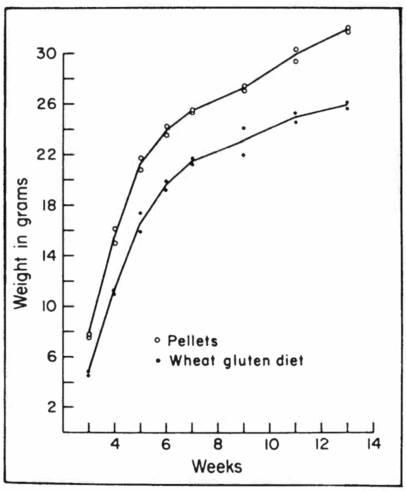

Fig. 5—SPF mice were fed pellets and mated. Approximately one week before delivery of the young, half of the pregnant animals were changed to wheat gluten diet and maintained on this diet until their young were weaned at three weeks of age. All the animals were then fed pellets for the rest of their lives.

The two graphs in this figure include males and females of the two progenies (two cages of 16 animals each per group). Males and females were separated after the fifth week of life, but the weights of all the animals from each cage were pooled and averaged until the 14th week of life.

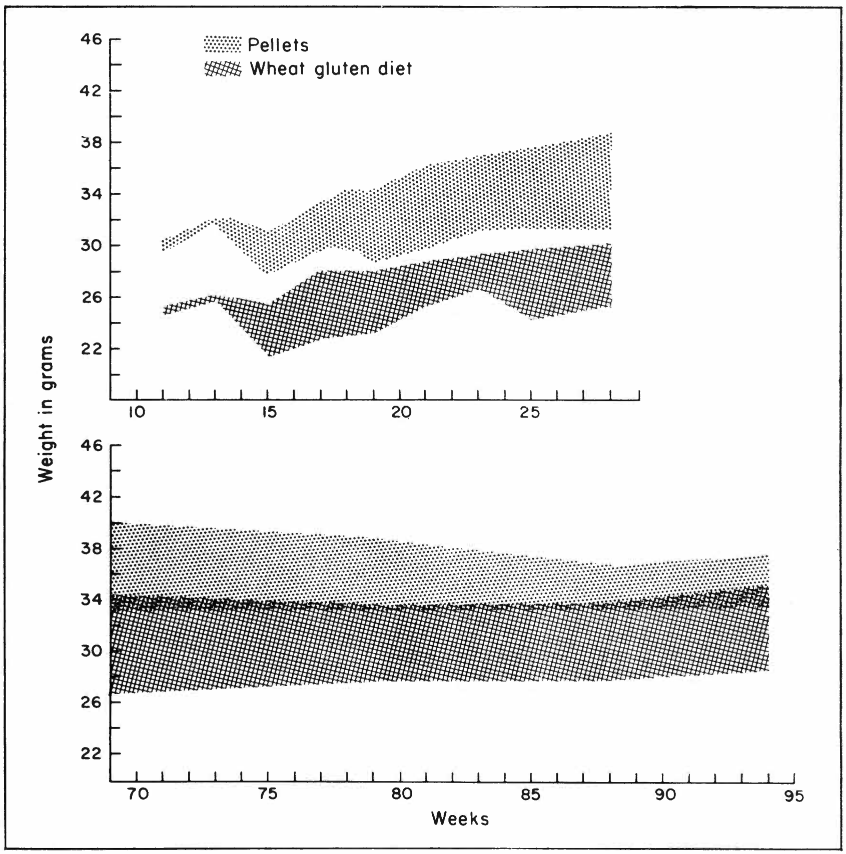

Fig. 6—This experiment is the same as that illustrated in the text—Figure 5; from the 14th week of life, the males were transferred to individual cages; the females were discarded.

The loss of weight in the 15th week was caused by the fact that the animals had been transferred to individual cages on wire grids. The fluctuations of the two curves thereafter express the effects of unidentified environmental factors.

The graphs indicate the range of weight variation for each of the two diet groups.

Deaths began to occur in the pellet groups after two years, the heaviest animals dying first. None of the animals survived beyond two years and seven months.

Experiments with animals have proven that an environment rich and diversified in stimuli affects neural and behavioral development, as measured by exploratory activity, learning ability, and even by chemical and enzymatic properties of the brain.

An impoverished environment results in behavioral deficiency. The same principles certainly apply to human beings.

Human potentialities, whether physical or mental, can be actualized only to the extent that circumstances favor their phenotypic expression. In consequence, diversity within a given society is an essential component of true functionalism. The latent potentialities of human beings have a better chance to emerge when the social environment is sufficiently diversified to provide a variety of stimulating experiences, especially for the young.

As more and more persons find it possible to express their biological endowments under a variety of conditions, society becomes richer, and civilizations continue to unfold. In contrast, if the surroundings and ways of life are highly stereotyped, the only components of man's nature that flourish are those adapted to the narrow range of prevailing conditions. Hence, the dangers of many modern housing developments—designed as if their only function was to provide disposable cubicles for dispensable people.

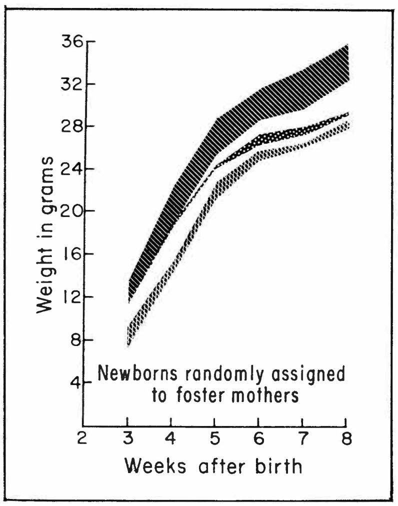

Fig. 7—SPF mice pooled on second day of life, then immediately allocated randomly to foster mothers (eight per mother). All animals fed pellets.

Irrespective of their genetic constitution, most young people raised in a featureless environment, and limited to a narrow range of life experiences, will be crippled intellectually and mentally. For this reason, we must shun uniformity of surroundings as much as absolute conformity in behavior. Creating diversified environments may result in some loss of efficiency; but diversity is vastly more important than efficiency, because it is essential to the germination of the seeds now dormant in man's nature.

In conclusion: The environment does more than affect our well-being in the here and now. It molds the young, physically and mentally, and thereby determines almost irreversibly their future and the evolution of society.

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THE AMBIENT AIR*

EDITH IGLAUER

In the universe, our earth is a mere dot, but it is still the only celestial body we know about that supports life, and a primary requirement of life on this planet is the mixture of gases that surrounds us, called air. We cannot be deprived of one of its ingredients, oxygen, for more than six minutes without suffering fatal brain damage. This gives us no chance to be fussy as we move through our daily lives, so we take the air pretty much as it comes. The air we normally breathe is made up of about one-fifth oxygen, a little less than four-fifths nitrogen, argon, and traces of other gases, of water vapor in varying amounts, and, finally, of all the poisons, waste products, and general trash we hurl into it as if it were not the thing most necessary to our existence. There is plenty of air—between five and six quadrillion tons—but because we don't know whether there is any more like it anyplace else, we have to be sure we can manage with what we have. And what we have is essentially an ocean, with vertical limits, and with enough oxygen for normal breathing only in the lowest fifteen thousand feet of the troposphere. Most of the air we use is in the first two thousand feet of this shallow layer, and what we ordinarily breathe is in the first seven feet.

The mechanisms that enable us to use air are the lungs, and their most striking feature is their ability to clear themselves of impurities. The nose, the mouth, and the throat are loaded with a rich assortment of bacteria; a few inches below them are the lungs—in a normal person sterile, beautifully designed structures that permit rapid and easy intake of air, from which oxygen is absorbed into the bloodstream in exchange for outgoing wastes. A few scientists have deliberately inhaled radioactive particles in order to map the path of impurities through the human body, and they have reported that impurities are normally cleared from the lungs in something between two and four hours. The marvellous cleansing devices without which the lungs would soon fill with lethal dust are cilia—small hairlike projections that are actually tiny pieces of tissue growing on the surface of the windpipe and the bronchial tubes. The cilia beat upward like small canoe paddles, pushing along a continuous stream of cohesive fluid—mucus—which carries impurities breathed in through the nose back up the throat to be swallowed into the digestive system.

The respiratory tract has been likened to a tree growing upside down in the human chest. The trunk is the windpipe, and the bronchi are the branches. Below the conducting airways are the primary functional units of the lungs—an abundant array of little air sacs called alveoli, which can be compared to the leaves of the tree. Here is where the real work of the lungs occurs; the entire blood supply of the body flows through this area, which is intricately interlaced with capillaries,

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and it is here that the oxygen breathed in joins the bloodstream and carbon dioxide is removed. Impurities that somehow evade the sweep of the cilia and enter these more distant reaches of the lungs are not readily cleansed from the air sacs. Bacteria invading the alveoli are ordinarily ingested by special cells called macrophages and dissolved there by enzymes, but solid particles find their way between or into the air sacs and then into the lymph channels in the walls of the bronchial tree, where they may remain for weeks or indefinitely. In each human lung, there are three hundred million alveoli, and the classic saw in medical schools is that the combined surface area of the alveoli would cover a tennis court. The walls of the air sacs are diaphanous membranes, thinner than paper. When these walls progressively break down, making breathing more and more of an effort, the unhappy owner of the lungs is suffering from a disease called emphysema. Or, in other cases, the walls of the bronchial tubes may become chronically inflamed, causing an increased flow of mucus and coughing; this is bronchitis. Either way, the lungs have ceased to be an efficient breathing machine. For many years, the medical profession was rather bored by emphysema and bronchitis, but in recent decades sharp increases in deaths from these ailments, together with an even greater rise in deaths from lung cancer, particularly in the United States and Great Britain, have caused an enormous upsurge in research into respiratory ailments. Emphysema is now the fastest-growing cause of death in the United States; in Great Britain there is so much bronchitis that it is regarded as the national disease, and the incidence of lung cancer there has increased about a hundredfold in the last sixty years. Physicians and other scientists, intensifying their efforts to explain these assaults on the lungs, are looking more and more closely into the effects of dirty air on the human body.

When scientists study a disease, they like to go after first a cause and then a cure, and to identify the disease and reproduce it in the laboratory. But there is no "air-pollution disease" to reproduce, and no set of symptoms that can be precisely attributed to air pollution alone. Thus, although discoveries are continuously made in the field of air pollution, scientists find difficulty in agreeing on their significance. It appears at this point that the increasing contamination of our air with the wastes from more fuel burned for more power, with the exhaust products from more internal-combustion engines, and with emissions from old and new industries in rapidly developing countries aggravates rather than causes respiratory disease. If there is a single obvious villain, it is in the form of personal air pollution that a victim creates for himself and breathes in high concentrations directly through his mouth into his lungs while smoking. However, it is known that the person who smokes amid the dirty air of a city has a greater chance of developing a pair of sick lungs than his compatriot who smokes in the country. This elusive difference is called "the urban factor"—which means that something in city living puts an extra burden on the lungs, increasing the risk of disease.

Although air pollution's role has not been precisely defined, any inquiry into its effects on the human body must start with one indisputable fact: When the supposedly benign ocean of air in which we live is overloaded with contaminants under certain adverse weather conditions, people in cities die—not just one or two people more than usual, but lots of them. This is the reality that has sent scientists by the hundred to work on air pollution; that has released millions of government dollars for research on thousands of guinea pigs, mice, rats, dogs, cats, chickens, rabbits, and even donkeys, which spend their lives breathing varied mixtures of noxious air or being painted with ugly extracts of automobile exhausts or tobacco fumes; that has impelled the British government to appropriate money from its scarce supply to finance a country-wide air-sampling network and to subsidize a change in the individual heating arrangements of an entire nation; and that is causing other governments, most notably that of Japan, to take long second looks at their own air before such disasters strike their heavily industrialized and heavily populated cities.

In urban areas of the Northern Hemisphere during the months from October to February, what are called temperature inversions —in which a layer of cool air is trapped under a layer of warm air —have caused lethal events that are referred to by experts on air pollution as "incidents," "acute episodes," or "disasters," depending on their severity. Each time, a blanket of warm air has for several days imprisoned heavily polluted cooler air over a densely populated surface area, and when the winds have cleared the stagnant air away it has been discovered that there were many more deaths than would normally have been expected. In December, 1930, a heavily industrialized section of the Meuse Valley, in Belgium, had a bad three-day fog during which hundreds of people became ill and sixty died—more than ten times the normal number of deaths. Shortly afterward, during a thick nine-day fog in January, 1931, five hundred and ninety-two people in the Manchester and Salford area of England died—again a large jump in the death rate. But to us in the United States these events seemed remote—until 1948, when, in Donora, Pennsylvania, a small mill town dominated by steel and chemical plants, a four-day fog filled with zinc sulphate and sulphur dioxide, among other pollutants, made almost half the fourteen thousand inhabitants sick. Twenty persons died. Ten years later, Donora residents who had been acutely ill during that episode were found to have a higher rate of sickness and to die at an earlier age than the average for all the townspeople.

The British, who have been complaining about the unpleasant effects of coal smoke since the year 1273, when it was termed "prejudicial to health," were recording air-pollution episodes as far back as 1873, when, during a London fog, two hundred and sixty-eight unexpected deaths from bronchitis were noted. But it was not until a great fog blanketed London in 1952 that the sinister potential of air pollution became fully apparent to everyone. This fog lasted from December 5th to December 8th, and ten days later, when the complete mortality reports had been evaluated, a shocked world learned that there had been an astonishing four thousand more deaths in Greater London during that period than would normally have been expected. During previous temperature inversions over London, the excess mortality had been among the elderly and infants under a year old, but in this disaster the percentage increase in mortality was similar for all age groups. In Donora, victims had not begun dying until the third smoggy day, but in London a number of the unexpected deaths occurred within the first twenty-four hours; then when the air cleared the rate fell abruptly. The statistics indicated that almost all those who died unexpectedly had records of bronchitis, emphysema, or heart trouble, and that people in the last category were most vulnerable. It was small comfort to conjecture that most of the people who died would probably not have lived much longer anyway. Again, in January, 1956, a thousand extra deaths in London were blamed on an extended fog. In that same year, Parliament passed a Clean Air Act, and Britain embarked on an extraordinary program to reduce the burning of soft coal. The effects of the program became apparent in 1962, for, in December of that year, London experienced a severe fog and inversion, and this time seven hundred excess deaths were recorded—still too many, of course, but an improvement over the previous figures. The lower mortality was attributed not only to less smoke but to generally better medical care (including wide use of antibiotics) and to greater public awareness—through newspaper, radio, and television coverage—of what was happening and of how to take precautions during a period of severe air pollution. Those with serious heart or respiratory ailments knew by then that they should stay indoors, that they must not smoke, that they should get plenty of rest, and that they should move slowly in order to decrease the demands on their respiratory systems. Frightening alarms were carefully avoided, yet far more than the normal number of people dropped dead in the streets from heart failure.

New York has the most severe air-pollution problem in the United States, but its air is still not as dirty as that of London, which has the reputation of being the cradle of air pollution. In November, 1953, early in 1963, and over the Thanksgiving weekend in 1966, New York had smog episodes that were bad, but not as deadly as London's. They have been carefully studied by Dr. Leonard Greenberg, who was New York City's first Commissioner of Air Pollution Control and is now Professor of Preventive Medicine at Albert Einstein College of Medicine, where he is working with a group of air-pollution specialists. He has calculated that there were approximately two hundred and twenty excess deaths owing to air pollution in 1953, three hundred to three hundred and fifty in 1963, and one hundred and sixty-eight in 1966. These episodes are a warning that the city's air supply has limits and must be protected before it becomes so contaminated that the normal prevailing winds cannot disperse the filth. New Yorkers wake up almost every morning to a temperature inversion that usually extends about a thousand feet above the ground and lasts from six to eight o'clock, though even in good weather it is not fully burned away by the sun until about ten. The brilliant red sunsets so much admired in New York and Los Angeles are caused by large particles in the air, most of them produced by incomplete combustion in the generation of heat and power. Meteorologists and air-pollution experts do not enjoy these sunsets, and they get really depressed when they consider how the tendency of our growing population to cluster in relatively small areas will affect the air and the climate of the future. They say that in twenty years, when population increases will have caused Philadelphia to merge into New York and New York into Boston, so that there will be one long city with no open spaces in between, the wind patterns will change and only people living on the edges of this huge sprawl will get any rural breezes. The fellow at the center will be living on what is called a "heat island"—a phenomenon that is already occurring in a small way in several cities. At street level, New York is now, on the average, from ten to fifteen degrees warmer at night than the Westchester suburbs, owing to the heating of the buildings in winter and the storage of solar heat in the asphalt and concrete in summer. In fifty years, the Westchester suburbanite may be able to grow tropical plants in his yard, but the great mass of air around him may be so polluted that he will scarcely dare step out into that yard.

In worldwide terms, the air is still clear. Pollutants, fortunately, are still subject to a huge natural removal cycle, which will operate as long as there is enough time or room for their dispersal. No one knows just when the limits of dispersal will be reached, but when they are, a slow worldwide buildup of background pollution levels in the air will begin. There is evidence of a tiny increase—something like two-tenths of one per cent—in the quantity of carbon dioxide in the atmosphere annually, because of the ever-mounting combustion of fuel. This has led to speculation about a possible "greenhouse effect," whereby the radiative property of carbon dioxide will cause the planet to warm up enough so that the ice caps will slowly begin to melt.

The average person, however, is not worrying about melting ice caps when he looks up at the murky sky but is simply wondering what the air is doing to *him*. He may notice that his eyes itch and are red and teary. The tears, a natural eyewash, protect his eyes from whatever is in the air; if he consults his ophthalmologist, he will be told that the danger is slight as long as he doesn't irritate his eyes further by rubbing them. People who find smoggy days distasteful—you can actually taste and smell the sulphur in the air with even as little as one part per million—are apt to say they find it hard to breathe, or feel a bit stuffy, or have a headache. For asthmatics, the feeling of pressure is real, because most of them seem to be particularly sensitive to sulphur compounds. The presence of enough sulphur in the air to be noticeable usually indicates that there are other pollutants as well: hydrocarbons, nitrogen oxides (which are responsible for the brown smog clouds so often seen over our cities), ozone, and so on. The most cursory knowledge of the damage to vegetables in Staten Island and New Jersey truck gardens near chemical industries, or to fruits and flowers exposed to California's highway smog, or to trees near smelters in Western states, coupled with the experience of discomfort in the eyes, throat, and chest when the air becomes overburdened and stagnant, makes us all wonder uneasily whether all living matter isn't being affected in ways we cannot see. Is there a relationship between emphysema and air pollution? Why do people who live in dirtier air get more colds and more bronchitis? Why is there more lung cancer in cities? No one knows what is happening to normal people continuously exposed, as all of us are, to varying levels of pollutants in what scientists poetically call the ambient air—another name for the everyday atmosphere—and the answers may be as elusive as the air itself.

The search for the pieces to this gigantic puzzle is being pursued through basic research on animals and human beings in the United States and Great Britain. In the United States, the Public Health Service directs a good part of the research in its own National Center for Air Pollution Control, and through contracts with university laboratories and special units as far away as Japan. The British, with a wistful look at the large sums of money available to their American colleagues, have assigned some of their investigations to a dozen or so handpicked scientists who form a group called the Air Pollution Research Unit, in London, and they have assigned other investigations to forty or so people who make their headquarters at the government's Warren Spring Laboratory, near the capital. In both the United States and Great Britain, the lab work is being reinforced by broad studies of the behavior of diseases in communities—studies that the British, with their talent for collecting and evaluating statistics, have developed into a fine art. If exact clinical proof of damage to human health from air pollution continues to be as shadowy and inconclusive as it is now, these studies may be the most important work of all.

A large part of the American biological work is done on animals, but the British place their research emphasis on man, partly because in England there are stringent regulations on animal experimentation—which in any case is expensive—and also because they are skeptical about assumptions concerning the complex physiology of man that are made on the basis of work done on the simpler and often not altogether similar mechanisms of lower animals. "Extrapolation," which in this context means inferring that results achieved from experiments on animals can be applied to man, is a fighting word in air-pollution circles. American scientists say that though most biological experimentation by necessity has to be conducted only on creatures other than man, the results *can* guide and suggest—that if a substance is found to be injurious to animals it seems advisable to expose man to the substance as little as possible. Final proof, if any, of the effects that our air has on our health will probably come about by relating laboratory findings to results of epidemiological investigations—studies of the distribution of disease among populations. This type of study is a sort of statistical embroidery, a matching and meshing of interrelated numbers—census figures, figures for deaths and illnesses, daily pollution and weather readings, employment statistics, hospital-admissions statistics, and the answers to special questionnaires that center on lung functions and smoking habits. Air pollution has at last become a fashionable worry, and local air problems are being examined everywhere—in such widely scattered spots as New Orleans, Genoa, Sheffield, and Osaka. Air does not halt at national borders, and neither do epidemiologists, who are engaging in more and more joint enterprises wherever two or more countries share a patch of murky heaven, or wherever something can be learned from comparisons. A study of the pollution in the air in the Detroit River area between Detroit, Michigan, and Windsor, Ontario, was undertaken in 1960 by a joint American and Canadian commission, and it revealed both causes and effects of the deteriorating air, which was blackened by hand-fired coal-burning ships and by more than six thousand industrial plants in the vicinity. Often, such studies produce unexpected findings. For instance, an epidemiological comparison of chronic respiratory disease was made in two towns chosen because they were very similar in every respect except that of air pollution—Berlin, New Hampshire, whose pulp and paper mills cast a blue haze over the community, and Chilliwack, British Columbia, a town with very clean air. The comparison led the epidemiologists to the conclusion that cigarette smoking was more harmful than the level of air pollution, and also to the discovery that men working in the paper mills of Berlin had less disease than anybody else covered in the study—primarily because if they weren't healthy they wouldn't be hired or be kept on.

An important epidemiological method is to study twins, especially identical twins, who have been separated and live in different environments. A few years ago, Dr. Rune Cederlöf, of Stockholm, first investigated the respiratory and heart ailments of twins in relation to the "urban factor" in his own country, and he is now making a similar investigation here of more than seven thousand pairs of male twins. His Swedish studies showed that when one twin lived in the country and the other in the city and both smoked, the city twin was more susceptible to bronchitis and angina pectoris than the country twin, and that, in his words, "the effect of being a smoker appears to be more pronounced when combined with exposure to air pollution. . . . There were no such noteworthy differences between non-smokers."

The urban factor is interrelated with so many other elements—smoking, occupation, economic class, and so on—that epidemiologists attempting to isolate it resort to all kinds of devices. In 1959, the Japanese tried the idea of systematically measuring the breathing capacities of schoolchildren ten and eleven years old who had not yet started either to smoke or to work. Epidemiologists went to Kawasaki, an industrial city between Tokyo and Yokohama, and chose children from two schools—one surrounded by industrial plants, the other on a hill twenty miles away in a rural environment. The breathing capacity of the schoolchildren in the industrial area was found to vary with levels of air pollution. They breathed to the full capacity of their lungs on days when the winds were doing their job of dispersing the pollutants, but when the air was still and the dustfall from metal-working factories, foundries, and electric-power plants in the area was so heavy that it soiled the books and papers in the classrooms, the children's breathing was much more shallow. In the rural neighborhood, there were no such variations; the children's breathing capacity simply increased with their size.

Startling differences in the ability to breathe the Japanese air, depending on its degree of pollution, began to be discovered by the United States Army in the late nineteen-forties during the occupation, when some of its personnel contracted a previously unknown ailment, originally called Yokohama Asthma and later renamed Tokyo-Yokohama Respiratory Disease. The industrialized Kanto Plain, where Tokyo and Yokohama are situated, is usually covered with smog, which is especially dense in winter, and a number of Americans stationed in this area who had no medical or family history of asthma suddenly began to display all the symptoms of severe asthmatic attacks when the air pollution was particularly bad. Among flying personnel with these symptoms, the disease seeemed to vanish when they flew to a height of five thousand feet or more above the contaminated area, but it returned again within minutes of their landing. Ninety-seven per cent of the six hundred and twenty individuals who were diagnosed as suffering from Tokyo-Yokohama Respiratory Disease were smokers, and all continued to have attacks as long as they remained in Japan. The attacks diminished or ceased when they left, but if they returned, even after as long as six years, the severe symptoms recommenced almost immediately. Biopsies showed the disease to be similar to the British form of bronchitis, and patients who had the ailment for some months, or during more than one tour of duty in Japan, developed permanent damage, progressing rapidly to emphysema. Lieutenant Colonel Harvey W. Phelps, a United States medical officer who has followed the history of the disease through the years, has decided that it is "induced . . . by the combined effects of cigarette smoking and the severe air pollution in the . . . area," and that the best treatment is early removal from Japan. When the United States Army sponsored a special investigation among the local population, no cases were found.

In San Marino, California, a suburb of Los Angeles, a high-school cross-country team was recently studied by the United States Public Health Service in an effort to discover whether variations in the purity of the air affected the performance of the runners in their gruelling two-mile races. The boys' records in competitive meets between 1959 and 1964 were compared with air-pollution measurements for the days the meets were held. Runners ordinarily improve their performance as the season goes on, and this team, throughout each season, did better at each succeeding meet except in four instances. The four days on which the team did worse than it had done at the preceding meet were the four worst days of smog. The study also indicated that it was specifically the oxidant compounds of Los Angeles' renowned photochemical smog that caused the trouble, since on those four days the levels of oxidants were high but the levels of carbon monoxide and of solid particles were not; in fact, the very worst day of all for the team was the one on which the carbon-monoxide reading was lowest. The performances of the athletes indicated, moreover, that they were affected by the lowest measurable quantity of air pollution—one part per hundred million units of air, which in Los Angeles is considered a clear day. The practical significance of such a study is that if a smoggy day makes a young athlete just a little more tired, an older man with cardiac trouble had better not run for his bus on such a day, or attempt any other exertion that might tax his injured heart.

On quiet Keppel Street, in London, in the somewhat austere quarters of the London School of Hygiene and Tropical Medicine, the school's professor of epidemiology, Dr. Donald Reid, an urbane Scot with a diplomat's manner, is developing a new line of research. Assisted by a group of younger men he has trained, he is conducting studies of respiratory disease among people in different parts of the world who are doing basically the same type of work. In 1960, Dr. Reid began an intensive study of respiratory ailments among British postal employees, and this is now being duplicated among postal workers in the United States and Japan. The British study revealed that post-office employees working outdoors as truck drivers and maintenance men in central London, where the foggy pollution was greatest, had much more serious chest illnesses than men doing the same jobs in relatively unpolluted areas. Men over fifty were most seriously affected, and among them especially, but not entirely, those who smoked. In outlying districts, men employed in the telephone branch of the post office were also included. In the United States, postal workers in New York City and telephone-company employees doing outdoor work in Washington, Baltimore, and Westchester have been investigated. The studies have established that in the past the British worker has run a much higher risk of serious lung trouble than his American counterpart.

Just how much worse the pollution of Britain's air has been nobody knows, but Americans have no cause for complacency. Recently, for instance, three University of Manitoba pathologists who had studied three hundred lungs from emphysema victims in St. Louis, where there is a relatively high degree of pollution, and three hundred more from victims in Winnipeg, where pollution is relatively light, reported that severe emphysema struck its sufferers (all of them cigarette smokers) earlier and killed them faster in St. Louis than it did in Winnipeg. A study made in Buffalo by a research group headed by Dr. Warren Winkelstein, of the University of Buffalo's School of Medicine, showed that between 1959 and 1961 deaths from all causes among men between fifty and sixty-nine on the same general economic level were a third higher in the section of the city with the highest level of pollution than they were in the least polluted part. Deaths from chronic respiratory diseases were twice as frequent, and similar findings by the late Dr. Louis Zeidberg in relation to acute respiratory diseases have been reported from Nashville, Tennessee. Buffalo and Nashville, though they are not exactly clean cities, are not America's dirtiest, either.

If Britain continues its vigorous national program to clean up the air and we continue our careless, localized policy in regard to air pollution, the British may ultimately win the game of who breathes cleaner air. The British government is partly subsidizing a shift to natural gas for home heating, and this fuel, thanks to recent discoveries of it under the North Sea, will eventually be cheaper than coal. At the same time, the nationalized Central Electricity Generating Board is building new nuclear-power stations in isolated places; the generation of nuclear power does not pollute the air, although even the slightest possibility of an accident makes officials wary of building atomic stations near populous areas. In any event, the development of techniques for transporting high-voltage electricity economically over long distances has made it unnecessary for power plants to be built in such areas.

According to Dr. Reid, British men between forty-five and fifty-four suffer twice as much lung cancer and five times as much general respiratory disease as their North American counterparts (although the latter have a greater chance of dying from heart disease). Women in the two countries follow similar, though less drastic, patterns. With the collaboration of the United States National Heart and Cancer Institutes and the Norwegian Cancer Registry, Dr. Reid is conducting another study, in which he keeps track of emigrants from England to the United States to see whether, in the generally cleaner American environment, the health of British respiratory systems improves, and in which he also collects data on Norwegian migrants here to see whether a group coming from a very pure atmosphere suffers more or less than the British group in the more polluted American environment. This study suggests that the migrant retains a residual advantage or disadvantage from childhood. So far, the Norwegian immigrants have turned out to have lower susceptibility to both lung cancer and chest diseases than native Americans, and the British migrants seem to have about a one-third greater chance of contracting lung cancer than native Americans. However, their chance of contracting a respiratory disease is only a fifth of what it would have been if they had remained in Great Britain. Other studies have indicated that Britons who migrate to the cleaner air of Australia, New Zealand, and South Africa follow much the same pattern.

How long must the human body be exposed to British air before the pollution leaves an indelible imprint on the lungs? Will the current British smoke-control program make any difference? Dr. Reid, speculating on these questions with an American visitor recently in his pleasant office (which has a gas burner in the fireplace), said, "What happens to the British emigrant in America means that we are not innately condemned to have chest disease. If the British environment can be brought up to American levels, the frequency and severity of chest illness among the British should fall."

British epidemiologists, like their Japanese colleagues, consider children admirable experimental subjects. Two studies of children—one conducted in the steel town of Sheffield and the other in rural Wales—showed that children living in heavily polluted areas have more frequent and more serious ailments of the middle ear and disorders of the lower respiratory tract. This lead is being followed up by Dr. Reid and Dr. John Colley in a survey of twelve thousand children in parts of the country with widely different pollution levels. The most extraordinary of the recent studies involving children, however, was made by one of Dr. Reid's younger associates, Dr. Walter Holland, of St. Thomas' Hospital Medical School in London, among fifteen thousand schoolchildren in a county in southeastern England. The purpose of Dr. Holland's study was to account for variations in the lung functions and breathing levels of children. He discovered, unsurprisingly, that the children who breathed best lived in an unpolluted country atmosphere, that children from well-to-do homes breathed better and more deeply than poor children, and that children who had had severe diseases like pneumonia and bronchitis early in life were worse off than those who hadn't had them. What did surprise Dr. Holland was the answers the children gave to standard questions about smoking. Children between eleven and sixteen who smoked cigarettes had two to three times as many symptoms of respiratory trouble—coughing, phlegm, wheezing—as children who did not smoke, with youthful ex-smokers somewhere in between. Children who smoked five or more cigarettes a day had four times as many respiratory symptoms as non-smokers; in fact, they had already given themselves respiratory conditions comparable to those suffered by smokers in their forties. Dr. Holland defines a "smoker" as an adult who smokes a cigarette a day for a year or a child who smokes a cigarette a week for a year. Among the children he studied who were between the ages of nine and thirteen, nineteen per cent of the boys and five per cent of the girls said that they smoked regularly, and a third of the boys and not quite a quarter of the girls had started smoking but had given it up. In the fourteen-to-sixteen age group, twenty-seven per cent of the boys and thirty per cent of the girls smoked regularly, and almost half the boys and eight per cent of the girls smoked five or more cigarettes a day. Children of poorer parents smoked more than children from wealthier families, and children who had lost a parent or who came from broken homes smoked most. "I never expected that we would show the difference in children between smokers and non-smokers and light and heavy smokers as clearly as we have," Dr. Holland commented as he read from his reports to a visitor. He still looked a trifle surprised by his findings. "Obviously, these children can't have been smoking very long, so the effect on their respiratory systems was produced over a very short period of time." Dr. Holland will next check the results, if any, that the extensive British propaganda campaign against smoking and the ban on television cigarette advertising are having on the statistics of the child smokers. "We are really trying to see if we can identify individuals who are particularly susceptible to disease and prevent its development," Dr. Holland explained. "Once it starts, there's nothing you can do about it. In any case, our findings about smoking certainly show that we can't single out air pollution as the one villain."

Among the many things that nobody knows about air pollution is exactly how many pollutants are dangerous. After the 1952 catastrophe, one pollutant that the British realized must be removed as fast as possible was the black smoke that poured from the millions of chimney pots on the roofs of their island's towns, where millions of small open fireplaces were burning soft coal. The almost unbelievable effort to change, in a few years, the habits of centuries in a democratic country is some sort of monument to human intelligence. It began in 1956, with the Clean Air Act, which established national jurisdiction over all domestic and industrial smoke and gave local authorities the power to create smoke-control areas. Since then, each local authority has been encouraged to draw up a program allowing everyone plenty of time to convert from soft coal to natural gas, to electric heating, or to fuels manufactured from coal that have had the volatile, or "tarry-smoke," matter removed. (Oil is classified as "unauthorized fuel" but may be used for home heating if the local authorities approve.) The conversion from coal usually costs about twenty-five pounds, or sixty dollars, and when it has been completed and has been approved by the local public-health inspector, who is a very important man in an English town, seventy per cent of the expense is paid back to the homeowner by the local authority, which is, in turn, reimbursed for more than half of the amount by the central government. Because the old-fashioned coal-burning open fire is one of the most inefficient forms of heating known to man—about eighty per cent of the fuel is wasted—the conversions represent a sizable financial saving to homeowners in the long run. (Coal miners, however, who get some of their coal free and the rest at very low cost, don't like switching to another fuel, and are a very sticky problem.)

While the provisions for enforcement of the Clean Air Act include a threat of court action, gentle persuasion, locally and nationally, has worked wonders. The government periodically publishes lists of areas that have taken little or no action in conversion from coal, and invariably there is a sharp increase in activity shortly afterward. Initially, the regions with the heaviest smoke pollution were labelled Black Areas, and target dates for achieving smoke-free zones were generally set in the nineteen-eighties. But when word began to get around that with smoke control the sun seemed to be shining more often, the program gained momentum, and now many target dates have been advanced into the nineteen-seventies. Although coal still accounts for almost all of Britain's electric-power production, and a soot-free Britain is still far in the future, the phasing out of coal for the heating of individual homes has been further hastened by the building of many new apartment buildings with efficient central-heating plants. Perhaps the greatest miracle is what has happened in London. Greater London leads the country in smoke control, with almost sixty per cent of its area smoke-free, and with emissions and ground-level concentrations of smoke about a third of what they were ten years ago. The famous square mile that is the old City of London is nearly free of smoke, and lately London, aware that they won't quickly get dirty again, has begun to wash the faces of its public buildings, revealing handsome stone exteriors that look gleaming white to those who remember the old blackness.

To epidemiologists, the most significant fact about London's clean-up is that during smog episodes there is now much less of an increase in sickness and death. In 1959 and 1960, in an effort to determine the effects of the Clean Air Act on human health, the government's Air Pollution Research scientists, who work under the direction of Dr. Patrick Lawther, handed out little pocket diaries to a thousand bronchitis patients in London and asked them to make a one-word notation every day for one winter, stating merely whether they felt better or worse than they felt the day before, or just the same. There turned out to be an extremely close correlation between the reports of feeling worse on certain days and high levels of pollution in the air. When the study was repeated five years later, this correlation was much less marked. Mr. Robert Waller, Dr. Lawther's chief colleague, who helped conduct the two studies and expects to conduct another in 1969 and 1970, is a cautious man, who hesitates to say whether this improvement can be attributed to better air or to the patients' increased knowledge of how to care for themselves, but he does permit himself to describe the findings as "not bad," and even "encouraging." He is also pleased by the fact that there has been a decline in hospital admissions for diseases commonly associated with air pollution.

A visitor to London can actually observe the contrast between air that has been cleaned up and air that is still polluted. From the roof of the Town Hall of the Borough of Southwark, south of the Thames in the center of Greater London, he can look out on a smoke-free zone to the south, where the air is clear, and then, turning slightly to the east, he can see a yet-to-be converted Black Area, distinctly marked by low puffs of smoke rising from rows of chimney pots. To the north, beside the Thames, he can also see a great white plume from the smokestack of Bankside Power Station. London's Bankside and Battersea stations, the former oil-burning, the latter coal-burning, are the only large power plants in the world where sulphur dioxide is literally washed out. Water from the Thames, to which an alkali—common chalk—has been added, is used to wash the gases before they are discharged, and in the resulting chemical reaction the sulphur dioxide in the smoke is turned into calcium sulphate, in solid particles, which are discharged, with the water, into the river. The process requires huge quantities of water, and there is a distinct limit to the amount of calcium sulphate that even as large a river as the Thames can carry away safely, so no more such installations will be built on this stretch of the river. Meanwhile, the Central Electricity Generating Board is experimenting with towering smokestacks, one of them more than eight hundred feet high, to dissipate the emissions over as wide an area as possible. The big stacks have helped to prevent any increase in ground-level concentrations of sulphur dioxide despite a substantial increase in fuel consumption, and at some sites outside London there has even been a decrease.

A National Survey of Smoke and Sulphur Dioxide has been conducted throughout England and Wales by the government's laboratory at Warren Spring, an hour's drive north of London. For the past five and a half years, under the supervision of an immensely energetic physician named Dr. Marjorie Clifton, the staff has been evaluating reams of statistics that have poured in daily from six hundred locations throughout the country. Although the survey's intensive-sampling period has ended, regular measurements will continue to come in from key sites, and Dr. Clifton hopes, with the aid of a giant computer, to predict levels of pollution in British communities in time for them to take steps to avert disasters.

Back in London, the Air Pollution Research Unit is based at the Medical College of St. Bartholomew's Hospital, one of the world's great medical-instruction centers and the city's oldest hospital, dating back to the twelfth century. Among ancient buildings surrounding a grassy courtyard, where medical students play croquet on sunny days, the Unit works in a set of extremely modern laboratories behind a set of double doors over which an enormous "No Smoking" sign is mounted. Here, Dr. Lawther devises endless experiments—to be conducted on himself, on his staff, and on the people of London in general. The rooms include physics, chemistry, and physiology laboratories, and a workshop where a trained mechanic constructs and repairs delicate equipment for monitoring air and for measuring human respiratory reactions. Two prominent features of the physiology laboratory are a low green leather couch, where human subjects can lie down while they breathe carbon monoxide into their systems, and a glass-walled smoke chamber—a room inside a room—which contains a desk and chairs, where one or two people can sit and work while they inhale smoke released through a blackened overhead vent from a small iron coal stove nearby. The predominating spirit around the place, one of quiet efficiency, is often jolted by the wild figure of the director, who, his laboratory smock flapping and his prematurely white hair in disarray, rushes through on the run between meetings, clinic hours, and speeches on the dangers of air pollution. Dr. Lawther is disturbed by the thought that a great deal of money is being spent around the world for what he regards as very bad air-pollution research when free coöperation is readily available from any sensible person who wants to breathe clean air. All London is Dr. Lawther's outdoor laboratory, and he and his staff have analyzed the street-level air pollution in places likes busy Fleet Street, where they have shown that during maximum-traffic hours on weekdays the air in the middle of the street contains three times as much smoke and four times as much lead as the air in London's quieter neighborhoods, and also that carbon monoxide periodically reaches the maximum acceptable limit for industrial plants—one hundred parts per million units of air.

Dr. Lawther's favorite experimental animal is himself, and next is his colleague Waller, who is particularly sensitive to sulphur dioxide. When the sulphur dioxide in the air reaches ten parts per million, Waller wheezes audibly, like an asthmatic, in a consistently severe reaction. Dr. Lawther also uses other members of his staff for "double-blind" experiments, in which neither the subject nor the technician knows exactly what is going on. If the subject knew what substances he was breathing, Dr. Lawther believes, there could be a psychological reaction that would affect his respiration, and if the technician knew what substances he was administering, he might unwittingly weight his findings. The experiments are fitted in with the daily routine, and it is not uncommon for a staff member to interrupt a conversation in the middle of a sentence, look at his watch, disappear without a word, and reappear a few minutes later to resume speaking as if nothing had happened. Every morning, Dr. Lawther and Waller, who live in the same borough, take trains fifteen minutes apart to London Bridge, cross it, and walk for twenty minutes through the same city streets to the laboratory, Dr. Lawther arriving at nine-fifteen and Waller at nine-thirty. The object is to measure the effect of air pollution on the breathing of individuals who have just walked through an ordinary city street. Immediately after his arrival, each man enters a booth-like transparent-plastic chamber called a body plethysmograph, which is equipped to measure the respiration of its occupant. One morning some weeks ago, a visitor watched the two men follow each other into the plethysmograph, and they presented an interesting contrast. Dr. Lawther, who had already put on his white working coat, rushed into the chamber, sat down on a stool, and, even before a girl technician could close the door, began to read mail from a manila folder he was carrying. The Doctor continued to read from the folder as he waited briefly to acclimatize himself, put on a nose-clip so that he would be breathing entirely through his mouth, and took hold of a mouthpiece, through which he breathed ten times. He was still reading as the technician opened the door and he departed. Waller arrived on the dot of nine-thirty, took off his jacket, and entered the plethysmograph in his shirtsleeves, sat down on the stool with his heels caught in the lower rungs so that his long legs were out of the way, and folded his hands in his lap. He waited patiently until it was time to start breathing into the machine, then adjusted the nose-clip and carefully breathed into the mouthpiece. When he came out of the box, he told the watching visitor that in Dr. Lawther's case the results of the daily tests had shown a relationship between his "airway resistance," or difficulty in breathing, and the concentration of pollutants in the outdoor atmosphere, his airway resistance increasing when the pollution was higher than average. "In my case, the association with air pollution is not striking at all—unless the suphur-dioxide level is particularly high," Waller continued. "I am a more variable creature, and my airway resistance changes very readily, in response to all kinds of things. A long series of measurements made with a portable device called a Peak Flow Meter have shown that colds, emotional disturbances, pretty girls, and situations of undue stress such as driving in central-London traffic or having to give a lecture affect the results. Some people breathe more easily when a little excitement releases adrenalin or some other substance that reduces any bronchial spasm that exists. We have found that exercise doesn't seem to affect us particularly. We've tried long runs through the city streets and long swims in a pool. Provided the air pollution was not exceptionally high, these activities didn't have any effect. Running during periods of high pollution did."

One of the Unit's main findings has been that the effects of pollution on breathing wear off just minutes or seconds after the subject removes himself from the polluted atmosphere. "You may wonder whether the pollution really matters," Waller said. "But if the subject stays in the pollution, it doesn't wear off." One reaction that the Air Pollution Research Unit watches for is a bronchospasm—a contraction of the airways to the lungs when certain substances are breathed. The problem, Waller said, is to identify the substances precisely. "It's rather easy to see what *doesn't* affect us but hard to identify what does, and although we have this glorious mixture of air pollutants in London, we're not sure which components we're after," he explained. "We do have abundant evidence in our epidemiological studies that the sharp peaks of mortality and hospital morbidity that we see on our charts are caused by air pollution of some kind, rather than just by unusual weather conditions. But when you try to tackle *which* pollutant it is, you are really in deep water. Our studies have indicated that although there are members of the population who, like me, are very sensitive to sulphur dioxide, the majority do not react to low concentrations of it."

Recently, the Unit has been studying the possible effects on human behavior of exposure to carbon monoxide in quantities so small that it induces no perceptible symptoms. When carbon monoxide is inhaled, it attaches itself more readily to the red blood cells than oxygen does, and detaches itself less readily, and while it rides around through the bloodstream it reduces the blood's ability to absorb oxygen. Temporarily, anyone with carbon monoxide in his blood becomes slightly anemic. It has been established that when we breathe air containing as much as a thousand parts of carbon monoxide per million our mental processes and nervous system are seriously affected and we suffer impairment of vision and severe headache, but many people believe that at lower levels our efficiency may be reduced somewhat. In busy streets, drivers and others may be exposed to concentrations in the range of ten to one hundred parts of carbon monoxide per million, and while nobody knows whether these relatively low concentrations have any effect, everybody is beginning to wonder. Dr. Brian Commins, who heads Dr. Lawther's chemistry laboratory, has recently perfected a new technique for making carbon-monoxide measurements from a blood sample as small as that from a pricked finger. (A syringeful of blood used to be needed.) The Unit scientists are now taking samples of their own blood after they walk through busy streets or as they drive their cars. One fact that has emerged is that the amount of carbon monoxide breathed during exposure to traffic fumes is less than the amount breathed while smoking a cigarette. Dr. Commins and other experimenters are wondering whether a person who smokes while he is driving may not expose himself to sufficient carbon monoxide to suffer minor behavioral distortions.

Some of the answers to the questions being asked at London's Air Pollution Research Unit may be coming before long from a toxicology laboratory at the Harvard University School of Public Health, in Boston. There, eighteen years ago, a young biochemist named Dr. Mary Amdur began inquiring into the toxicity of sulphuric-acid mist by exposing guinea pigs to it in different doses and combinations. Sulphur dioxide is the air pollutant we hear most about, because it is easy to measure and the amount of it in the air tells the experts that a lot of other pollutants are there, too, but laboratory experiments in which both animals and human beings have been exposed to doses of sulphur dioxide by itself, administered in the amounts found in the ambient air, have seemed to show that it's harmless except to the small percentage of sensitive people like Waller. Yet, especially during smoggy periods, something injurious to human lungs is in the air, and people die. The key to the puzzle probably lies in the fact that sulphur dioxide is an unstable compound. It combines with other substances, and, at a rate depending on atmospheric conditions, it oxidizes into sulphuric-acid mist. There is always some sulphuric-acid mist around wherever sulphur dioxide is produced, even in a clear, dry climate, but the conversion to sulphuric-acid mist is much greater in regions or periods of high humidity. When scientists talk about sulphur dioxide as a hazard, they really mean that the hazard is probably sulphuric-acid mist.

Dr. Amdur, a small, willowy woman who is now associate professor of toxicology in the school's Department of Physiology, became interested in sulphuric-acid mist when she and some of her co-workers at Harvard began studying its toxicity after the 1948 Donora smog episode. She told a visitor recently, "We began by exposing guinea pigs for eight hours to various concentrations of sulphuric-acid mist to find what toxicologists call the L.D. 50, meaning the lethal dose fifty per cent—the point at which you kill fifty per cent of the animals. You start there as a standard procedure with any new chemical, and then you examine the pathology—the nature and extent of the fatal organic damage. The next step is to find out what level produces such damage but doesn't kill. Finally, you look at the subtle biological changes produced when you neither kill the animal nor seriously damage its lungs—changes that would occur in industrial or air-pollution situations."

Dr. Amdur explained that she works with guinea pigs because their sensitivity to sulphuric-acid mist, especially in the low concentrations that exist in our air, is higher than that of rats or rabbits, and their reactions to it are not dissimilar to those shown by human beings in far more limited experiments. "Rats can breathe huge quantities of the mist without batting an eyelash, and rabbits are quite happy with amounts that would do a guinea pig in," she said. When irritants are introduced into the atmosphere that the guinea pig breathes, its bronchial tubes constrict. This means that more effort is required for it to breathe, which could help to explain the extra deaths—especially among infants, the sick, and the aged—during air-pollution episodes. Any categorical statement of a possible association between such animal experiments and human experience is, however, considered by Dr. Amdur and her colleagues unwarranted extrapolation.

One finding that has particularly interested Dr. Amdur is that her animals' airway resistance increased only slightly when they inhaled sulphur dioxide by itself but increased by four hundred per cent when the sulphur dioxide was combined with sulphuric-acid mist or with droplets of water containing small particles of sulphates of vanadium, iron, and manganese. This appears to be a classic example of a synergistic effect—one in which a combination of substances produces a greater effect than could have been expected on the basis of their individual effects. Dr. Amdur also noticed such a synergistic effect when she combined sulphur dioxide with zinc-ammonium sulphate—a compound that had been found on the filter of an air-conditioner during the Donora fog. Dr. Amdur believes that water droplets are essential to this synergism, and fogs, of course, provide plenty of droplets.

Evidence from several other laboratories has suggested that microscopic particles may elude our protective mechanisms and, acting not only as irritants themselves but as carriers of other irritants, invade and lodge in the lower lungs, where the protection is haphazard compared to the wonderful action of the cilia and mucus in the conducting airways. Dr. Amdur has found that when she gives her guinea pigs a dose of irritant particles, the animals' breathing returns to normal more slowly than it does when they have been exposed to irritant gases, and their recovery is slower still when they have received a combination of both particles and gases. Dr. Amdur does not know what happens to the particles in her guinea pigs' lungs, but she has lately discovered that the irritant responses, or airway resistances, increase as the particles' size decreases. She has used particles as small as three-tenths of a micron—a micron is a thousandth of a millimetre—and plans to use even smaller ones as soon as she figures out the mechanics of producing and measuring them.

Although Dr. Amdur's experiments have focussed on acute air-pollution episodes, in which her guinea pigs are exposed to irritants for definite periods rather than continuously, she is one of the few experts willing to stick their necks out and try to help set some standards for sulphur-dioxide levels in the ambient air. In 1959, California health officials who wanted to set such standards asked her for a report. After carefully describing the relative toxicities of sulphuric acid and sulphur dioxide alone, as well as the factors of particle size and synergism, she suggested some tentative numerical standards—although California finally adopted more conservative ones. "Someone had to be first to give some numbers," she said. "At least, we've got data to use as a basis for thinking about air-pollution criteria. Certainly it seems evident that we cannot judge entirely on the basis of sulphur dioxide. The coal and power people have tried frantically to say that sulphur dioxide does no harm, but I've pointed out that this is deliberately avoiding the issue, because I don't think synergism can be dismissed. I know it's cheaper to pollute the air, but do we have to put the burden of irrefutable proof on the Public Health Service that somebody killed Grandma before they are allowed to set up controls?"

In the spring of 1967, in fact, the United States Public Health Service, in an act of sheer heroism, published a fat document entitled "Air Quality Criteria for

Sulphur Oxides," giving the levels at which its scientists believed that sulphur compounds "begin to harm our health and foul our environment," and expressing the hope that these criteria would "set the levels we must aim for in our drive for clean, breathable air." Outdoor conditions differ from laboratory conditions in that sulphur dioxide is always present with particulate matter and sulphuric-acid droplets; experiments like Dr. Amdur's have shown that sulphur dioxide is considerably more toxic when accompanied by other such pollutants. Therefore, the government criteria, which are based on epidemiological studies of actual situations in large cities such as Nashville, suggest much lower acceptable levels of sulphur dioxide than might be expected—less than one-tenth part sulphur dioxide per million parts of air as a daily average. The regulations for the control of sulphur-dioxide emissions from federal buildings are based on comparable levels. At the first hints of national standard-setting—although no actual standards had been drawn up—the anticipated howls were heard from a wide range of industries and their spokesmen, since sulphur compounds are produced in very many basic-industrial processes. The fight has just begun, but the American Petroleum Institute, the Edison Electric Institute, the National Coal Association, the National Coal Policy Conference, and the United Mine Workers have expressed their displeasure with the Public Health Service recommendations in the sharpest possible terms.

Rigid controls may very well have to be set up before we know how, and how much, air pollutants harm us, but sometimes facts do fall into place. A classic case occurred not long ago in Reading, Pennsylvania, where a smelter was refining the metal beryllium, which is used in various alloys. Beryllium is well known to be toxic to human beings who are exposed to it at high levels, for then it causes berylliosis, a chronic and debilitating lung disease in which the sufferer simply wastes away. An argument had been going on intermittently through the nineteen-forties over whether smokestack emissions from processes in which beryllium was involved were toxic at the relatively low levels that prevailed when the fumes were diffused in the atmosphere. On the basis of small-scale experiments with animals, the United States Public Health Service at first put no controls on emissions of beryllium, but an accumulation of alarming evidence finally caused the Atomic Energy Commission, which used the metal in reactors and was therefore a large purchaser, to notify its contractors that in the future their factories would have to meet certain safety standards. The smelter in Reading refused to comply, and although it received no more contracts from the Atomic Energy Commission, it continued to produce beryllium for private industry. The Pennsylvania health authorities went on record as saying that on the basis of the federal data available there was no danger. But by 1959 twenty-five cases of berylliosis had been reported around Reading, and all concerned were forced to change their minds. A number of victims have sued the company, and one has been awarded damages of more than a hundred thousand dollars. The Pennsylvania health authorities have tightened their standards for safeguards to be used in refining beryllium, and the Reading plant has complied. The Reading berylliosis cases are particularly interesting to air-pollution experts because they show that even supposedly low-level emissions of a known toxic pollutant can be exceedingly dangerous.

The techniques of working with particles, developed by Dr. Amdur in Boston and Dr. Lawther and his staff in London, among others, have been further developed at New York University's Institute of Environmental Medicine, which has a laboratory in Sterling Forest, a planned recreational, educational, and residential community in the foothills of the Ramapos, an hour from New York City. There, Dr. Roy Albert uses iron-oxide particles of uniform size and puts a minute radioactive tag on them that gives off gamma rays, enabling a detector to follow their journey through the chest of an experimental animal and measure the factors that govern the body's rejection or retention of them. He has found that some particles move through the lungs and into the stomach in from two to four hours, others remain in the lungs for many weeks, and those that penetrate beyond the bronchial tubes into the alveoli stay longest of all. Dr. Albert, who also conducts experiments on human beings in the city, works at Sterling Forest with donkeys—eleven of them. One evening about two years ago, he happened to be watching a TV commercial that featured a little old winemaker and a donkey; after observing the docility of the donkey under somewhat trying circumstances, the Doctor bought one for the Institute—a female named Abby. He later bought two more females, and then he picked up Anthony, a male, which was so much easier to handle that the Institute bought seven more males. Donkeys have about the same weight and lung size as humans (although their lungs seem to clear out impurities more rapidly), but their special virtue as laboratory animals is their ability to stand still for hours without sedation. Dr. Albert has devised a mask that resembles a feed bag with a hose on each side, through which the donkeys breathe a special mixture of radiated particles of a certain size and concentration. Detectors attached to the donkeys' sides follow the course of the particles in their chests and abdomens. In one experimental session, after half-hour exposures to sulphur dioxide at from six to seven hundred parts per million—relatively large doses—during which mucus poured from the animals' noses and eyes, the donkeys developed coughs that lasted several days and persistent defects in lung clearance.

In the same laboratory where the donkeys are tested are rows of steel-and-glass chambers containing albino rats, which are handled by means of rubber gloves built into trapdoors, so that no bare hand ever has to be put inside the cages. Here, Dr. Norton Nelson has been testing the cancer-inducing qualities of a worrisome compound that scientists have christened benzo(a)pyrene, which is produced in city air by the inefficient combustion of fuel—particularly automobile fuel—and is also found in cigarette smoke. Thirty rats have been continuously exposed to what Dr. Nelson refers to as "pure mountain air"—the regular outdoor air of Sterling Forest—and thirty others to "contaminated air," containing heavy concentrations of sulphur dioxide. Both groups of rats have also been exposed, for an hour a day five days a week, to benzo(a)pyrene dust. The question is: Does the sulphur dioxide increase the carcinogenic effect of the benzo(a)-pyrene sufficiently to give the animals lung cancer? The animals were put into the chambers when they were six weeks old, and both groups remained healthy throughout the first year. But at fifteen months one of the rats in the "city" air developed cancer, and there have since been two more cases—three out of thirty, or ten per cent. Dr. Nelson recently explained, "The inhalation of benzo(a)pyrene without sulphur dioxide failed to produce lung cancer, even though the concentration was raised to the point at which skin cancer was produced. Furthermore, the lung cancer that has been produced in the current experiments is of the type most frequently found in man."

At the Sloan-Kettering Institute for Cancer Research, in New York, Dr. Ernest Wynder and Dr. Dietrich Hoffmann, who pioneered in investigating the role of cigarettes in lung cancer, have collected particulate matter from polluted air in Detroit, Los Angeles, and the New York area for tests on experimental animals. Their samples, which are in solution form, are bottles of ugly-looking dark-brown liquid labelled according to place of origin, and they represent every kind of combustion emission, collected in various commercial areas and at busy street intersections. These are pure extracts of poison, and are, of course, much more toxic than the same substances diffused in the atmosphere. Dr. Wynder and Dr. Hoffmann have applied these liquids—or "tar extracts"—in very high concentrations to the skins of mice and in a good many cases eventually produced tumors. The most carcinogenic tar was from Detroit, the least toxic was from Scarsdale. Despite these experiments, the two doctors do not suggest that there is any major correlation between air pollution and lung cancer. They remain convinced that cigarettes are the major cause of the disease. "The final proof can come only from epidemiological data," Dr. Wynder says. "I am sure we are surrounded by carcinogens in what we breathe and eat, but most of these are in minute amounts that we can handle reasonably well. I think our lungs can handle reasonably well whatever we inhale in cities. But cigarettes bypass the protective mechanism of the nasal passage and overwhelm our lungs with smoke."

Dr. Wynder and Dr. Hoffmann have carried out several comparative studies of smoking and air pollution as factors in the production of lung cancer. The benzene extract of a gasoline-engine exhaust produces more skin tumors in mice than tobacco does, but Dr. Wynder warns that this does not necessarily mean that the exhaust gases will produce cancer in man. The exhaust gases, he points out, are diluted several thousand times in the air before they reach the lungs, whereas the lungs are directly exposed to undiluted tobacco smoke. One of the effects of tobacco smoke that has been demonstrated by the Wynder-Hoffmann experiments and others is a slowing down or cessation of the beating movement of the cilia and the flow of mucus—both vital guardians of the lungs.

Dr. Wynder's firm belief that air pollution plays a very minor role in lung cancer is reinforced by epidemiological findings. He cites the fact that lung cancer in the United States is six times as prevalent among men as among women although both sexes are similarly exposed to general air pollution. A possible explanation of this disparity is the longer record of heavy-smoking habits among men. In Los Angeles, Dr. Wynder made a study of Seventh-Day Adventists, whose religion does not permit smoking or drinking, and found them to have only ten per cent as much lung cancer as the rest of the population in that polluted city. This ratio also applied to cancer of the mouth, the larynx, and the esophagus—occupational hazards for those who make a lifework of heavy drinking—but all other cancers occurred among Seventh-Day Adventists in Los Angeles with the same frequency as they did among the general population. A more recent California study, made by state health officials, has further confirmed Dr. Wynder's beliefs. This report, based on data from various parts of the state, indicates that whereas smokers have five times as much chance of dying from lung cancer as non-smokers, when allowances are made for smoking habits, age, and length of residence, fewer people generally die of lung cancer in smoggy Los Angeles than in the relatively cleaner air of San Francisco and San Diego. In Italy, with two Italian doctors, Dr. Wynder himself examined the population of a city peculiarly free from general air pollution—the city of Venice, where there are neither automobiles nor any large manufacturing establishments, except some glass factories on a nearby island. In Venice, lung cancer is the most common cause of death among men but is not at all common among women—a reflection of the national smoking pattern in Italy, where more than half the men over sixteen smoke cigarettes regularly and ninety per cent of the women over sixteen don't smoke at all. In both Italy and the United States, and elsewhere, too, the rate of lung cancer is higher among city dwellers generally, a condition that Dr. Wynder attributes to a number of factors —that people living in cities tend to smoke more, that sufferers from lung cancer often move to a city for treatment shortly before they die, that cancer is more commonly reported in cities, and that occupations common in cities expose workers directly to particles that may contribute to the development of cancer, such as metal and wood dust and particles of paint, asbestos, and chromate. The fact that there is more than twice as much lung cancer among men in Great Britain as there is among men in the United States Dr. Wynder attributes primarily to national differences in smoking habits and preferences. The British take more puffs per cigarette and also smoke a cigarette farther down—and the butt of a cigarette is known to contain more smoke condensate. Also, the British prefer cigarettes made of tobacco that is flue-cured and that experiments have shown to be more carcinogenic than air-cured tobacco, which is used in American cigarettes.

Whatever the relative roles of smoking and general air pollution may be, there are unquestionably increasing amounts of very toxic substances floating about. High on the list are asbestos and lead. Smokers working where they are exposed to asbestos dust have a rate of lung cancer eight times that of the general population, according to Dr. Cuyler Hammond, director of the American Cancer Society. Asbestos is used for brake linings, and some asbestos is given off every time the brakes are applied on an automobile. Although there is no evidence that inhalation of such fractional amounts hurts anybody, Dr. Hammond has written, "With the rapid growth of asbestos utilization (the five hundred thousand tons per year world production in 1930 has risen to four million tons per year now), it may be difficult for cigarette smokers to avoid inhaling air contaminated with asbestos." Lead, too, is under close scrutiny. It has always been one of the "body burdens"—a favorite scientific phrase—that all of us carry around with us, because it settles in our bones. Our supplies of food and water contain twenty times as much lead as they did in primitive days, but, as far as anybody knows, our intake of lead is still well below that associated with lead poisoning. However, in the last few decades the levels of lead not only in our food and water but in our air have been rising so steadily that scientists are beginning to wonder if this added lead burden may be contributing to some unidentified illnesses, or even to diseases we know about already. Some experts believe that the whole toxicology of lead needs reëvaluation. Almost all gasolines are now leaded, and the lead is emitted from car exhausts in very fine particles, which the gasoline and lead companies would very much like to have us believe are harmless. Who knows? Nobody.

Air pollution has been a matter of official concern to the federal government only since 1955, when Congress gave the United States Public Health Service a small appropriation for systematic research on the subject. In the years immediately after that, most of the research was done under contract in non-government laboratories, although work that had been started in what was formerly called the Sanitary Engineering Center, in Cincinnati, was continued. One of the more important experiments was conducted in California by Dr. Leslie Chambers, who installed a colony of mice right next to a Los Angeles freeway and concluded that lung cells destroyed by the prevalent smog could be regenerated by younger mice but not by older ones. In 1960, the Public Health Service created a Division of Air Pollution to supervise its medical and engineering programs. In 1967, the Division was reorganized and named the National Center for Air Pollution Control, with headquarters in Washington and laboratories in Cincinnati; Durham, North Carolina; and Ypsilanti, Michigan.

In Cincinnati, two six-cylinder automobile engines have been set up to run so that they simulate the average pattern of everyday driving, and pipes collect the exhaust gas, some of which is inhaled directly by experimental animals and some of which is piped into two huge steel boxes, each more than six hundred cubic feet in volume. Here, the gas is irradiated with light to produce the sort of photochemical smog that was once believed to be distinctive to Los Angeles but is now seen increasingly in other traffic-clogged cities. A whiff of this synthetic smog from a briefly opened valve has the sickening smell of the exhaust fumes from an old bus. One of the scientists conducting experiments with this synthetic smog is a veterinarian, Dr. David Coffin, who is chief of the Experimental Pathology Unit at the Cincinnati laboratory, and whose special interest is the interaction of air pollutants and infectious bacteria. Dr. Coffin has observed that animals that have been exposed to various pollutants are more susceptible to bacteria than animals that have breathed normal air. When, for example, mice have been exposed first to ozone—a common pollutant from auto exhausts that is toxic to human beings—and then to streptococcus-pneumonia organisms, they have been more likely to develop pneumonia. Dr. Coffin has also learned from postmortems that animals exposed to bacteria but not to polluted air had no streptococci left in their lungs about six hours after exposure, whereas animals exposed to the combination of smog and bacteria eliminated the bacteria so slowly that the streptococci had a chance to grow and infect the lungs.

In another section of the Cincinnati laboratory, a biochemist named Dr. F. G. Hueter has since 1962 been exposing rodents to raw tail-pipe exhaust diluted with clean air in various proportions and to different concentrations of photochemical smog. Dr. Hueter has observed that guinea pigs that inhale smog are more susceptible to pulmonary infections and pneumonia, and that mice breathing photochemical smog exhibit signs of chronic disease (reflected in an elevated white-blood-cell count) after eighteen months of exposure in the latter third of their life-span. A group of mice exposed to irradiated exhaust during their fertile period had lower fertility rates—fewer females had litters, those that did had them less frequently—and the rate of survival of baby mice between the first and the tenth days was markedly reduced. Rats exposed either to raw exhaust or to smog developed abnormal, nonfunctioning lung tissue, which was not present in control animals living in clean air. Finally, mice exposed to either raw exhaust or irradiated air were less active for a period of time but then adapted themselves to the mixture and resumed their normal behavior. The mice exposed to the raw exhaust made the adaptation in twelve days, but it took the mice who inhaled irradiated air twenty-four days to readjust themselves. In a new series of experiments, Dr. Hueter is going to study the effects on monkeys of inhaled lead from gasoline additives, and of systematic exposure to tail-pipe exhausts (irradiated and non-irradiated), to atmospheres containing sulphur dioxide and sulphuric-acid mist like those produced by heating and power plants, and to mixtures of nitrogen compounds. The laboratory is also studying the effects on eighty-six beagles of low levels of the sort of pollution that is regularly found in the average city air.

The trio of ailments in which general air pollution is believed to play at least an aggravating role—bronchitis, emphysema, and lung cancer—do not promise such obvious clues as, for instance, the Reading beryllosis cases. Nobody is sure at the moment quite how to evaluate the fact that nitrogen dioxide, which, like sulphur dioxide, is always present in our urban atmosphere and at low levels does not, as far as is known, affect human beings, has produced emphysema-like enlargements of the air sacs in the lungs of rats that have inhaled it at low levels over a fairly long period in a California laboratory. High concentrations of nitrogen dioxide to which human beings have been exposed accidentally—for example, in fires involving X-ray film—have caused pneumonia and death. Both cigarette smoke and automobile exhaust contain several hundred parts of nitrogen dioxide per million—concentrations that would be fatal in a continuous exposure. Nitrogen oxides are among the principal compounds earmarked for further research, particularly because they are employed in many new chemical processes and in secret gasoline additives of unknown toxicity.

Dogs, rats, mice, guinea pigs, donkeys, men, women, and children—a whole world breathing, and nobody knows exactly what we are breathing or exactly how it affects us. Dr. Robert Horton, an epidemiologist who was formerly a professor at the University of Michigan and now presides, from a desk in Cincinnati, over the government's Health Effects Research Program, spent several hours discussing the progress of air-pollution research with a caller not long ago, and then, in a matter-of-fact voice, said, "The British reduced cholera and typhoid in the nineteenth century before they knew bacteria existed, and we may have to regulate our air supply before we have complete knowledge about air pollution. The methods we have for detecting excess deaths are so crude that there has to be a pretty big excess for us to realize that it's there at all. What we *do* know is that people get killed by air pollution, and I don't see any excuse for there being enough air pollution to kill people. Do you?"

A Psychiatrist Listens to Dental Complaints*

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When your chairman invited me to meet with you to discuss some issues connecting psychiatry and dentistry, my immediate response was both intense and almost reflexive. I experienced an immediate strong uneasiness and desire to avoid facing you. This reaction impressed me as being neither rational nor appropriate, since my more sensible side could see good reasons for an exchange of views between dentists and psychiatrists. Therefore, as is the custom of most of us working in psychiatry, I tried to examine my own reaction, and in doing so came upon thoughts and feelings which indicated that I do not take a very objective, logical, or consistent attitude toward my dental colleagues and their work. So, before discussing how a psychiatrist listens to dental complaints, I thought it appropriate to share with you how this psychiatrist reacts to dentistry.

On a conscious and thinking level, I am all for dentistry. It would be folly to argue with the wisdom of the daily scrubbing of one's teeth with any one of the delightfully flavored pastes now offered, and of complying with the advice of the American Dental Association to make a friendly call on the family dentist once or twice each year. In all honesty, I find that I have followed only part of these recommendations in dutifully scouring my teeth daily, but, through a variety of excuses, delays, rationalizations, etc., I manage to avoid semiannual or annual visits to a dentist. I find that, whenever the impulse strikes me to arrange a dental examination, I am suddenly swamped with work, my own appointments, meetings, lectures, patients, and so on, so that I can justify my own neglect.

Now, I credit myself with being a somewhat reasonable man, who, in recent years, has not experienced unusual discomfort in a dentist's chair and who has enjoyed pleasant personal friendship with dentists. Therefore, I had to dig deeper into my thoughts, memories, and feelings to understand my wanting to avoid you. With some mental "foot dragging," I finally came upon the following.

I remember from my early childhood having been hoodwinked by two otherwise extremely reliable persons—my mother and my maternal grandmother—into a visit to an old-fashioned dentist who brooked no nonsense from children. There was a confusion of feelings consisting of fear of this ogre who inflicted some pain and scolding, of chagrin and resentment toward two fine ladies whom I had trusted thoroughly until this particular deception, and of guilt over my anger toward them. The main issue of this early episode seemed to be some disenchantment with my mother and grandmother, for which I partly blamed the dentist, who undoubtedly had nothing to do with it.

A later memory concerned the painful chipping of a tooth in a

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sandlot football game in which I had played despite a rule of my school forbidding such games. Again pain, fear, anger and guilt were mixed in this memory. As I recall it, the pain from the chipped tooth forced me to ask for help, and some of my guilt was increased by a scolding lecture from my parents and the dentist.

My third memory revolves about an incident during my military service in World War II, when I had to accept dental care prior to going on terminal leave after five years of service. I was most eager to return to civilian life, but one condition was my leaving the service with a mouthful of good teeth. The dental officer at the separation center was also impatiently awaiting separation and showed his disgruntled attitude in a rather severe attack upon my molars. In one nightmarish session, he broke several drills in his eagerness to have done with me. I, in turn, selected him as the symbol of army "snafu," and at the end of the session we both gained some emotional relief by a hot exchange of opinions in which he made some choice observations about the Army Medical Corps.

Add to this the tension and unhappiness experienced for a time in my family, when one of our children was undergoing orthodontic treatment and had to be disciplined from time to time about braces, rubber bands, and avoiding chewing gum and other goodies.

Although I am sure that this does not exhaust the factors entering into my initial impulse to turn down your chairman's invitation, I did realize that a fair amount of important emotion in me seemed to be associated with dentists and dental experiences. Therefore, it was becoming clear to me that it might be quite interesting to discuss with you some of the emotional responses to dental care that I have encountered in patients in my psychiatric practice. If I felt uneasy just to be with you in this auditorium, imagine how much feeling might be experienced or is experienced in the presence of drills, probes, and the awesome paraphernalia of your offices!

It might be convenient for clarity to discuss the following matters: (1) dental pain, (2) loss of teeth by accident or extraction, (3) drilling. To begin, then, let us talk about dental pain. As with any pain, tooth pain has a fluctuating threshold which seems related to the emotional state of the patient. It is not uncommon to learn from a patient that he has had long periods of freedom from dental pain, interspersed with episodes of quite distressing pain. This finding would not be noteworthy, except that it is often obtained from patients with chronic dental caries for which they rarely have had dental attention. In other words, we find a fairly steady state of dental decay in certain patients who only periodically experience discomfort. In some patients in my own practice, the periods of pain often occur during episodes of guilt reactions in which pain is accepted as a proper penalty for wrongdoing. Moreover, when the patient submits to dental treatment at such times, he seems to welcome inflicted pain to expiate his guilt. It is my impression that phantom dental pain following the extraction of a hurting tooth is similar to other varieties of phantom pain in which we find guilty emotions playing a dominant part.

For many years psychiatrists stressed the importance of oral activity in the early emotional development of all human beings. One of the basic, primary human satisfactions—the relief of hunger—is accomplished through oral activity. In the psychology of emotion, being deprived of such satisfaction may be equated with punishment, so that discomfort in the oral region interfering with oral satisfaction is frequently tinged with uneasy guilt feelings. Still further, many persons in early childhood, after dentition occurs, express their anger by biting. This method of attack is frowned upon, prohibited, and usually punished, even in so direct a fashion as a sharp slap to the offending mouth.

All of us have seen patients who seem to continue to struggle with the desire to bite when angry. It is a commonplace to recognize anger in the twitching tightness observed in masseter and temporal muscles when certain persons gnash their teeth in anger. I have treated several patients who complained of tension headaches bilaterally in the temporal areas at times when they have been told by their spouses that they have been grinding their teeth in their sleep. Upon psychiatric interview of such a patient, I have found that such teeth grinding is associated with the patient's dreaming assaultive, aggressive themes during his sleep.

This tendency toward expressing anger in a primitive biting fashion underlies some dental pain, and it is associated with guilt. It is my impression, from a small sample of patients with intense rage, that they are able to sharply criticize dentists after the dentists have symbolically attacked them. It is as though they can release some of their anger toward persons who hurt them. It would be an interesting study to survey a dental clinic population for any significant correlation between direct negative criticism of the dental staff and oral aggressive, biting tendencies in the critics.

Now let us consider some psychiatric thinking about the significance of loss of teeth.

For many reasons, the loss of teeth through trauma, aging, or surgical extraction seems to be associated symbolically with high levels of emotion. Themes of losing teeth occur with great frequency in the dreams of most human beings. It has been through the methodical study of such dreams that the symbolic meaning of losing teeth has been somewhat clarified. That greatest of all psychiatrists, Sigmund Freud, was especially intrigued with dental dreams and felt that, to a large extent, they were related to childhood fears of physical mutilation, that is, to loss of body parts as a penalty for antisocial impulses of a hostile and/or perverse sexual nature. This particular insight has been confirmed many times by other psychiatrists.

Dreams of losing teeth are frequent among women, who are not so preoccupied with so-called castration anxiety. It has been found that women's dreams of the loss of teeth are frequently related to a host of emotions about pregnancy and labor. For example, during the past year a young woman patient related to me a nightmare in which she had suddenly spit out a large, badly infected molar, but then, to her distress, found that she had developed, as she said, " a dread disease" of her mouth. An older woman appeared in the dream and told her that she, the patient, would die for having spit out her molar. The patient began to cry and was then tapped on the forehead by a gray-haired man who told her she would live.

In dissecting this dream with the patient, we found that she had wanted to discuss with me an earlier event over which she felt anxious, guilty and ashamed; it was that a year or so before consulting me she had submitted to an illegal abortion. (Fortunately, she had developed no post-abortion infection.) However, she had worried from then on that she had incurred permanent damage of her uterus and would never bear children. She was able to interpret the dream in the following way: Spitting out of the teeth symbolized, for her, the illegal abortion. The dread disease of her mouth she equated with a sterile uterus. The older woman who told her she would die—that is, not be associated with life—was her conscience. The gray-haired man who tapped her on the forehead and reassured her that she would live represented me administering psychotherapy. After this important psychological material was presented and focused upon in her psychotherapy, this patient made considerable progress. I cite this case as an example of a dental dream in which losing a tooth symbolized some other process.

When writing about this patient's dream and the association of pregnancy, sex, and teeth, I remembered the following: Author, Ben Hecht, when he was a young cub reporter on the Chicago "Daily News," scored a journalistic coup on one of his early assignments. He was assigned to cover a story about an alleged rape of a patient by her dentist. In one highly prized early evening edition, which was quickly corrected, Hecht was able to have printed over his story the intriguing headline "Southside Dentist Fills Wrong Cavity."

Possibly the real association between dental problems and pregnancy may reinforce or determine the use of dental dreams to symbolize pregnancy.

In my practice, I have noted an interesting relationship between total dental extractions and the onset of severe mental depression. At one time, by coincidence, in a matter of a few months I saw four severely depressed patients, young adults, who had had all teeth removed about four to six weeks before the onset of deep melancholia. At first I felt that the depressive psychoses were reactions to the loss of the teeth, and I was ready to accuse my dental colleagues of causing serious mental illness. However, on detailed study of these cases, I learned that in each instance the patient had "shopped around" for several weeks before finding a dentist who would oblige the request for total extraction of essentially healthy teeth. In each instance, the patient complained of generalized tooth discomfort, gained no relief from ordinary dental care, and insisted on being rid of all of his teeth. As I mentioned, eventually each patient found a dentist who could be persuaded against his better judgment to comply with the patient's request. It impressed me how many dentists refused to comply with this unusual demand. In discussing these patients and their cases with colleagues, I finally concluded that the first symptom of the melancholia was the request for such extensive damage and loss to one's body. What had appeared a cause now seemed an early symptom. From this experience, I would urge you to refer such patients to a psychiatric clinic rather than comply with their unusual requests. It might interest you to know that one of the emotional reasons for such a request was the patient's increasing fear and guilt over unconscious impulses to bite. In his attempt to ward off overwhelming guilt, he seemed to be asking various dentists to render him an innocent, harmless, toothless baby who could do no one any damage. Such matters are not logical, but they are quite psychological.

One other significant, symbolic meaning that many persons attach to the loss of teeth is the great biological process of aging. In our early years there is the awesome situation of losing one set of teeth and gaining a more sturdy, handsome, and admirable second set. Just think of the many mixed feelings most of us have had during this time when we have whistled through the gaps created by the loss of baby teeth; when we have put a tooth under our pillows in the hope of reward in the morning; when parents have clumsily, but gently, relieved us of these remnants of babyhood; when, to our delight, we saw the first white edge of the new tooth appearing. As adults, we tend to put such childish memories far from our daily thoughts. Yet they can come forth in unguarded moments such as sleep to serve once again as reminders that life does not stand still; that the body does decay; that we all grow older. Reinforcing the symbolism of lost teeth as a sign of inevitable aging and utter senility is the image of a toothless old crone. In a sense, then the loss of teeth is a reminder of one's mortality and can be associated with the dread of aging. Conversely, and especially in our own society, one of the major symbols of vigorous young manhood or womanhood is found in the beaming smile revealing a set of formidable, glistening, noncarious, properly aligned "choppers." In fact, we are bombarded through advertising media telling us that there is magic in possessing such perfect sets of teeth. Good jobs, happy marriages, sexual adventures, manly prowess, etc., are some of the dividends that we are asked to believe are associated with a full, healthy set of teeth. In the symbolic sense, this may be true, since such moments of dental perfection or health probably occur in the noonday of life when youth stretches its arms out to embrace all of life, and, I guess, to take great bites out of it. (The indigestion from such experiences comes shortly thereafter.)

One other matter of high emotional importance in regard to one's teeth is the overreaction, both in reality and in fantasy, to dental drilling. It seems to be almost a stereotype for most persons to anticipate being tortured in the dental chair, the chief instrument of torture being the dental drill. This stereotype persists despite tremendous advances with superspeed drills and the extensive use of local anesthetics. This sort of irrational anxiety is similar to that experienced when receiving hypodermic injections in any area of the body. To understand this particular aversion to violation of the boundaries of one's body, psychiatrists and psychologists have devoted considerable attention to it in recent years. There seems to be a basic fear of any part of the environment suddenly imploding into one's body. Infants will vigorously squirm and refuse the bottle or breast thrust at them. Children are besieged with fantasies of bugs and small creatures invading them through any and all orifices of the body. At one time, under the persuasion of Dr. Freud, these anxieties were all equated with the disguised desire to be attacked sexually. However, in more recent years it is felt that the fantasy of sexual attack is a variant of a general revulsion against violation by penetration of any part of the body.

Now, to return to you gentlemen and your work,—it is necessary that you perform your excavations in order to preserve dental health. And yet, in this very well intentioned work, you are touching upon one of the primitive or, we might almost say, species-bound anxieties of all human beings. You seem to be violating a basic biological taboo and to some extent will probably always be considered miscreants for doing so. Fortunately, human beings also have, in addition to their illogical and primitive fears, a strong antidote in persons who gradually acquire a reliable amount of good sense and a healthy respect for reality in place of childish fantasy. If this were not the case, your practices would indeed suffer seriously.

To counteract the basic revulsion about drilling and its affiliated notion that he who violates another's body boundaries is a scoundrel, it is of great importance that you show all possible respect to your patients in other ways. Thus, by heavily loading the scales on the side of respect, the single act of disrespect inherent in drilling will be neutralized and overcome. This seems to close the circle, returning to my own early memory in which my first experience of being drilled was associated with a contemptuous attitude on the part of the dentist toward me as a four-year-old nuisance. Possibly, had he respected me to some degree, I would have forgiven him his act of disrespect through drilling. In any event, your respectful attention during this rambling account has gone far toward allaying my fears of you as drillers. On this note of my friendliness to you, I should like to close, hoping for a merciful reciprocity when next I seat myself under the shadow of one of your whirling instruments.

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A Brief History of the Taxonomy of Mammals

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The mammals are an ancient division of the animal kingdom. They probably developed from reptile-like creatures in the early Triassic period, about 200 million years ago. Ever since then they have been changing to meet different and varying conditions of climate, enemies, and many other factors. Of the more than one million animals known in the entire animal kingdom, the 4,000 or so species of mammals represent a small minority.

Mammals are characterized by being warm-blooded, having two pairs of appendages, and having hair at some stage of their development. They all bring forth their young alive except two egg-laying mammals (the Australian platypus and the echidna), and their brain is large in proportion to body size. Mammals also have a vertebral column; they have seven cervical vertebrae with the exception of the two-toed sloth which has six, the three-toed sloth which has nine, and the manatee which has eight. The word "mammal" is derived from the Latin *mamma,* for breast, since mammals nourish their young by breast-feeding them milk. Inasmuch as mammals are efficient in their way of life and adaptable to different environmental conditions, they have risen to the highest stratum of Nature's social order; and, as a class, they are more intelligent than the other vertebrates.

The science of mammalogy originated from the archaic study of medicine. Man wanted to know more about his body and soul relation, but because of ancient customs that arose from superstition and mysticism and forbade dissection of the human body, man turned to the study of animals.

These studies began in the form of comparisons of the exterior and interior parts of the animal body. Early taxonomy made use of this type of classification. Centuries later, the study of fossil remains shed some light on previously existing mammals. The study of taxonomy thus embraces many fields of endeavor, each demanding a different approach but all inseparably related. Essentially, taxonomy gathers together, utilizes, summarizes, and implements everything that is known about animals involving comparative, gross, and microscopic anatomy; biochemistry; physiology; geology; and paleontology. From a humanitarian standpoint, man experiments on animals using humane conditions and controls. Certain knowledge cannot be gained unless experiments are made on living animals, and, in order to evaluate results, the experimentalist needs to know, taxonomically, the animal on which he is performing experiments.

The oldest and most obvious system of classifying animals was according to their mode of life, adaptations to their environment, and their associations. To this end Aristotle (384–322 B.C.) attempted the first classification of animals. Even earlier, however, there was a listing and arrangement of names of animals in a systematic manner in Leviticus 11: 1–47 and in the old Assyrian inscriptions taken from the library of Ashurbanipal (ca. 688 B.C.). Aristotle recognized some natural groups of animals, and in his work *On Animals,* he designated groups of animals as the *genos,* and individual animals or species as the *eidos.* His work also included an incipient theory of evolution; that is, there was a general graduation from polyp to man.

From the time of Aristotle until the rise of scholasticism in the 11th Century, Europe was too preoccupied with barbaric invasions to devote much time to natural science. With St. Thomas Aquinas (1225–1274) and St. Albertus Magnus (1206–1280), scholasticism reached its peak in the 13th Century. These two churchmen aroused and perpetuated interest in Aristotle's analyses. Not only the concept of genus and species was kept alive, but also the method of division, which was a forerunner of modern classification. Through their insistence on the use of Latin in the church teachings as well as in the pulpit, Latin became the scientific language after the Renaissance.

With the coming of the Renaissance to Europe in the 16th Century, reasoning started to be empirical, science started to separate from the church and mythical speculation, and the idea of natural classification of animals gained acceptance. Science, however, was slower in developing than literature, politics, and astronomy (Nordenskiöld, 1928; Singer, 1950).

Influential in the rebirth of learning was Konrad von Gesner (1516–1565). His main contribution was the work entitled *Historia Animalium,* in which he attempted to separate truth from error by assembling from many sources known materials on animals. He used illustrated descriptions of animals which initiated the systematic work of the coming generations.

Along with the development of mammalogy in regard to taxonomy, botany classification received its share of taxonomic researchers. One of these was Andrea Cesalpino (1519–1603). His main work, *De Plantis,* published in Florence in 1583, was botanical; but he endeavored to associate parts of animals with parts of plants. His system of classification was his most important contribution.

John Ray (1627–1705), an Englishman called the "Father of Systematic Zoology," in 1693 published *Synopsis Methodica Animalium Quadrupedum et Serpentini Generis.* In this work he organized previous systems of descriptions of animals into a reasonable, systematic arrangement that became the basis for the taxonomic work in the following century by Carolus Linnaeus (Carl von Linné). Linnaeus (1707–1778) was a Swedish botanist who devoted his life to taxonomic research. He listed the whole animal kingdom in an orderly, systematic manner in the tenth edition of his great work *Systema Naturae.* There were 12 editions of this work, the word "mammalia" appearing for the first time in the tenth edition of 1758. The 1758 edition is taken as the zero point for zoological nomenclature. The names and contents remain much the same today. Linnaeus is responsible for the binomial nomenclature employed in taxonomic work, which used a Latin noun for the genus and a descriptive adjective for the species in the animal description.

Claude Perrault (1613–1688), a Parisian, is remembered more for the designs of beautiful buildings than for his *Mémoires pour Servir à l'Histoire Naturelle des Animaux,* published in 1731, but his work was important in that it was a prelude to the more extensive work of Louis Jean Marie Daubenton. Perrault's classification was based on the external appearance and anatomy of animals. Daubenton (1716–1799), in collaboration with George Louis Leclerc, Comte de Buffon, published the series of volumes of the *Histoire Naturelle* issued between 1753 and 1767. Each animal was described more or less as an independent unit; the authors did not give any groupings.

In 1762 Mathurin Brisson (1723–1806) published the second edition of *Regnum Animale.* In this book he divided the animal kingdom into nine classes, basing his taxonomic study on Ray.

In 1777 Giovanni Scopoli (1723–1788) published a classification which was an adaptation of the work of Ray and Linnaeus. Entitled *Introductio ad Historium Naturalem Sistens Genera Lapidum, Plantarum et Animalium,* it was conservatively and intelligently arranged. Two years after Scopoli's classification was published, Johann Friedrich Blumenbach (1752–1840), often called the "Father of Anthropology," sent to press his *Handbuch der Naturgeschichte,* a taxonomic study that embodied many features of Linnaeus' work and foreshadowed the Cuvierian system. In the "Handbuch," which had excellent illustrations, there was a natural transition between certain adjacent orders. In 1792 Felix Vicq-d'Azyr (1748–1794) published his *Système Anatomique des Quadrupèdes.* His taxonomic study was based on strict anatomical observation and critical comparison. Much of his work was based on that of Linnaeus and Blumenbach.

In 1795 Étienne Geoffroy Saint-Hilaire (1772–1844) and Baron Georges Léopold Chrétien Frédéric Dagobert Cuvier (1769–1832) published their clasification of mammals in volume 6 of the *Magasin Encyclopédique.* It contained their account of the Australian marsupials and the monotremes. Saint-Hilaire confined himself to monographic work thereafter. Therefore, later changes in the classification were made by Cuvier according to his Principle of Correlation. In 1798 he published his original classification *Tableau Elémentaire de l'Histoire Naturelle des Animaux,* in which the term "family" first appeared as a division of an order.

One year later, in 1799, Bernard Germain Étienne de la Ville, Comte de Lacépède (1756–1825), published *Tableau des Divisions,* in which he grouped all the marine mammals. He followed Brisson's classification in having a large number of orders based on the number and kinds of teeth.

The following year Cuvier published *Leçons d'Anatomie Comparée,* which improved the classification set forth in his volume of 1798; a great number of new genera which had been described by various authors were included therein.

Another system of mammalian classification was proposed by Johann Karl Wilhelm Illiger (1775–1813) in 1811 in a treatise entitled *Prodromus Mammalium et Avium.* Based on foot structure, it contained little that was new in principle.

Henri Marie Ducrotay de Blainville (1777–1850) drew his criteria for taxonomy from the reproductive system and the skull and was the first to use the term "subclass" in its modern sense. Like most other taxonomists prior to Huxley, de Blainville began his classification with the primates. He attempted to progress from a lower to a more advanced archetype. This new taxonomic study was published in 1816 in *Prodrome d'une Nouvelle Distribution Systématique du Règne Animal.*

In 1817 Cuvier published the first edition of *Le Règne Animal,* which became as popular as Linnaeus' *Systema Naturae.* It contained a new arrangement of the carnivores and became the standard work on natural history.

In 1821 John Edward Gray (1824–1875), during a long term of service at the British Museum, described in the *London Medical Repository* the first application of the term-ending idea for families of mammals. The ending had been suggested for the families of insects by William Kirby in 1815. Gray's classification contained several new generic names and divided the Cetacea into two new suborders, Denticete and Mysticeti.

In 1834 de Blainville presented a classification superior to any then extant. He separated the monotremes from the marsupials and improved the arrangement of the carnivores. He divided the Mammalia into three subclasses, which he called the Ornithodelphia, the Didelphia, and the Monodelphia. Though his terms have been largely superseded, the underlying idea is still retained in modern form.

In 1838 Prince Charles Lucien Bonaparte (1775–1840), the next younger brother of Emperor Napoleon I, published his *New Systematic Arrangement of Vertebrated Animals* in which the classification was based on brain evolution.

In 1855 Christoph Gottfried Andreas (1820–1881), curator for the museum at the University of Halle, published *Odontographie,* in which he devised a classification based on teeth.

In 1864 de Blainville's work *Osteographie* was published containing a classification based upon the study of bone structure. This work was supported by Charles Darwin (1809–1882) whose *Origin of Species* (1859) stressed skeletal similarity and progressions.

In 1868 Sir Richard Owen (1804–1892) published a nonformal classification based upon Bonaparte's taxonomic study of 1837. The work was entitled *On the Anatomy of Vertebrates, Volume III—Mammals,* and selection was based on animal reproduction.

Thomas Henry Huxley (1825–1895) in 1869 proposed the name "Hypotheria" for the class of Mammalia, a name suggested because of speculations about the origin of the class. Huxley's work in taxonomy, *A Manual of the Anatomy of Vertebrate Animals,* followed de Blainville's threefold division of the Mammalia. It was published in 1872.

In the same year, Theodore Nicolas Gill (1837–1914) published his work, *The Relations of the Orders of Mammals.* It was a simplified classification containing the best features of earlier systems. For example, it improved de Blainville's plan by reducing the primary division from three subclasses to two: 1) Prototheria (Ornithodelphia), and 2) Eutheria (Didelphia and Monodelphia).

Huxley, in 1880, published a classification, *On the Application of the Laws of Evolution to the Arrangement of the Vertebrata, and More Particularly, of the Mammalia.* He inserted another subclass, Metatheria, between the Prototheria and Eutheria in Gill's classification. The most important feature of Huxley's classification was that the main divisions were not founded upon traditional criteria, such as the number of digits or teeth, but upon deep-seated anatomical characters having little relationship to particular life habits.

In 1883 Sir William Henry Flower (1831–1899) published a classification which dealt only with existing orders and combined the best of Cuvier, de Blainville, Owen, Gill, and Huxley.

In 1891, Edward Drinker Cope (1840–1897) published part 3 of his *Syllabus of Lectures on Geology and Paleontology.* In 1898 part 4 was published. This syllabus was Cope's final attempt to express the taxonomic relationships of all the recent and fossil orders (Gregory, 1910).

In 1904 Max Weber (1864–1920), published *Die Säugetiere.* In this taxonomic study he tried to recognize and discount the misleading interpretations of parallel and convergent evolution, which in earlier classification had caused animals of widely different derivations to be grouped in the same order.

Most of the more complete classifications have originated in the United States. An excellent example is *The Age of Mammals* by

Henry Fairfield Osborn (1857–1935). This work contained a complete review of mammalian study, incorporating the latest knowledge of classification up to 1910. William Berryman Scott (1858–1947) published a *History of Land Mammals of the Western Hemisphere* (1937) which, like Osborn's *The Age of Mammals,* was very thorough. Parker, Haswell, and Cooper (1940) wrote a zoology textbook which gave an excellent, illustrated description of each mammalian order.

George Gaylord Simpson (1945) published *The Principles of Classification and a Classification of Mammals*. This treatise contained a complete classification of living and fossil mammals arranged so that one could tell at a glance who first proposed the name for a particular taxonomic group and when it was proposed. For the fossil mammals there was also a description of where the animal was found in geological time. The cohort Ferungulata replaced the older cohort Ungulata; in the former the order Carnivora is listed along with the rest of the orders formerly assigned to the latter.

With the publication of the *List of North American Recent Mammals* (Miller and Kellogg, 1955), the results of taxonomic studies of North American mammals were summarized.

Interrelated with the study of mammalian taxonomy is the preparation of keys for identifying a specimen. Among the published taxonomic keys for mammals which have had extensive usage are: *A Field Guide to the Mammals* (Burt and Grossenheider, 1952) and W. F. Blair's "Mammals" in *Vertebrates of the United States* (Blair, et al., 1957).

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A Histochemical Study of Skin Wounds

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The process of the healing of wounds has been investigated extensively (Blair, Slome and Walter, 1961). It is obvious that several changes take place during this process. The wound shrinks to smaller dimensions as healing advances, and biochemical substances increase or decrease at various stages of repair. The physical alterations or histological changes do not appear until several hours from the time of infliction of a wound. Investigations concerning the biochemical changes taking place in wounds have revealed no advance over the conventional histological methods in the detection of early reactions (Needham, 1952; Patterson, 1959). Nevertheless, it is logical to assume that some changes must be occurring in wounds from the time they are inflicted. A review by Raekallio (1961) of the physical, histological and biochemical methods showed that these methods can only detect vital changes in wounds more than eight hours after they are inflicted. Using histochemical methods in guinea pigs, Raekallio was able to detect enzyme changes as early as one hour after the infliction of a wound. In view of his striking findings, I decided to employ enzyme histochemical methods to study skin wounds in guinea pigs as well as in humans. Wounds inflicted after death were also examined for the presence of enzymatic reaction. Histologically, the skin of guinea pigs resembles that of humans, and the growth of hair in the two species is also similar. In guinea pig and in man, the growth cycle of each hair is independent of its neighbor, whereas in other animals, e.g., rat, mouse and rabbit, the hairs in one area are at the same phase of growth at any particular time (Rook, 1965).

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Materials and Methods

I used 50 healthy guinea pigs, both males and females, weighing 500–800 gm. The animals were anesthetized with ether, and the skin on the front and the back of the trunks and the limbs was shaved. Using sharp scissors, circular wounds about 1 cm in diameter were inflicted on the right half of the front and back of the trunk and on the right limbs, at 1, 5, and 10 minutes and ¼, ½, ¾, 1, 2, 3, 4, 8, 16, 32, and 64 hours before the animal was killed with ether. At identical periods after death, wounds were inflicted on the left half of the trunk and the left limb. Five sets of antemortem and postmortem wounds inflicted at these time periods were produced.

The human skin wounds were obtained from the autopsy room and the operating theater. In operations where removal of skin was a necessary procedure, a portion of skin was removed at 0, ¼, ½, ¾, 1, 2, and 3 hours after the infliction of the initial incision. These specimens were obtained from operative sites on the chest, abdomen and limbs of white male and female adults. One wound was inflicted on each person, and one set of skin samples was obtained from each wound, a total of five sets being obtained. Skin samples from wounds inflicted more than three hours before death were obtained at autopsy from white adults dying after a variety of surgical procedures. Five sets of postmortem wounds inflicted at corresponding intervals were obtained from the anterior, lateral and posterior aspects of amputated human legs.

One portion of each wound was frozen fresh with solid carbon dioxide immediately after removal. Sections were cut in a cryostat at −20° C and stained to demonstrate leucine aminopeptidase. Another portion was fixed in neutral-buffered 10% formalin at +4° C for 10-16 hours. Sections were cut in a cryostat at −20° C and stained to demonstrate non-specific esterase, acid phosphatase and alkaline phosphatase. Sections from a third portion were used to study histological changes and ribonucleic acid and desoxyribonucleic acid reactions. The details of the staining methods have been described by Pearse (1960).

Results

In the guinea pig skin wounds, the first unequivocal and constant histological change was an obvious leukocytic infiltration, in the form of a well-defined band, 100μ to 300μ thick, in the wound edge. This was seen from four hours onward. The nucleic acid reactions corresponded in time of appearance to the leukocytic infiltration seen in the histological preparations. Alkaline phosphatase and leucine aminopeptidase started to appear from three hours, acid phosphatase from one hour, and the non-specific esterase from ten minutes after the infliction of a vital wound. The enzyme reaction, when present, was in the form of a gradually thickening band of staining, 100μ to 400μ wide, in the wound edge (Fig. 1).

In the human skin wounds, the first definite change in the histological preparations was the leukocytic infiltration in the eight-hour vital wounds, when the DNA and the RNA reactions also became obvious. Acid phosphatase started to appear after six hours, alkaline phosphatase and leucine and aminopeptidase after four hours, and the non-specific esterase after 30 minutes from the time of infliction of an antemortem wound (Fatteh, 1966a).

None of the postmortem wounds showed any histological or nucleic acid change or the enzyme reaction.

Conclusions

The experimental results in guinea pigs confirm Raekallio's findings. It is clear from the results that the enzyme reactions are the earliest detectable changes in the healing wounds. The non-specific esterase gives earlier staining reaction than any other enzyme studied so far. It is quite possible that a study of other enzymes may reveal even earlier detectable reactions.

The earliest appearance of the enzyme in the wound edge is probably due to the spillage of the intracellular enzyme following damage to the cells. A further noticeable increase of the enzyme may be accounted for by contribution from the blood stream with the increase of serum in the wound edges. It is also possible that local synthesis of the enzyme within the cells in response to trauma, and enzyme carried by the infiltrating leukocytes to the damaged area, are responsible for the increased reactions with the lapse of time.

It seems that the accumulation of the enzymes in the wounded zone is a defense mechanism. Enzymes appear in the wound edge earlier than the leukocytes. The infiltration by leukocytes in an area where the enzymes are already accumulating indicates that the enzymes may act as chemotactic substances and thus play a part in the healing process.

In both guinea pig and man, the wounds inflicted after death were completely devoid of any reactions. This fact is of medicolegal significance, as a positive enzyme reaction in a wound would help to label it as an antemortem wound (Fatteh, 1966b).

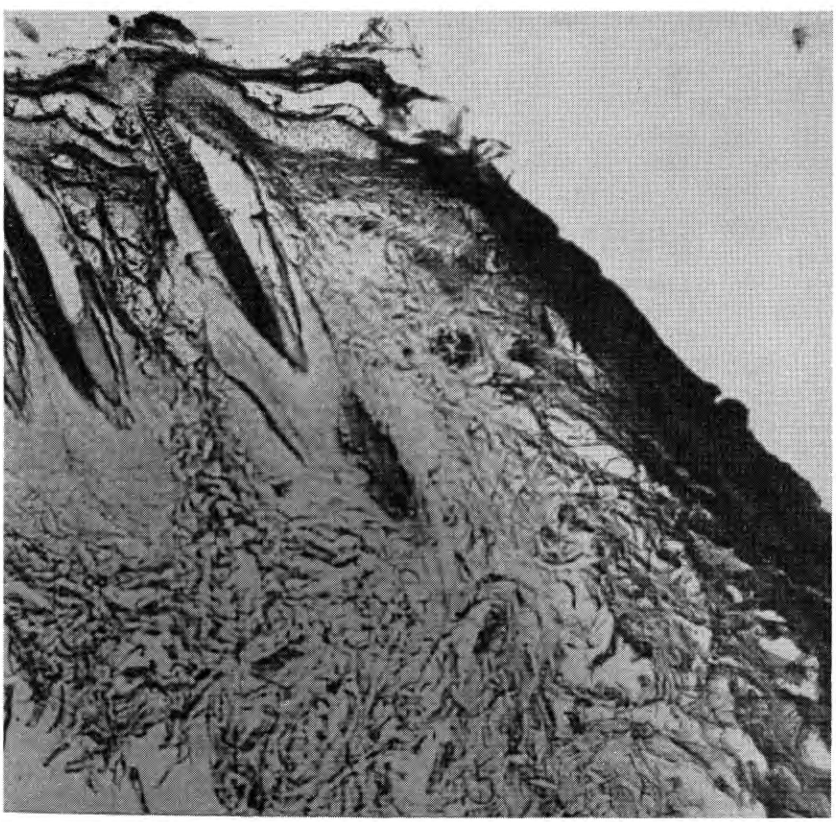

Fig. 1—Acid phosphatase staining of eight-hour antemortem wound of guinea pig skin.

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Abortion: Medical and Moral Aspects*

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Every country in the world has its abortion problem, and no country seems satisfied with legislation on therapeutic abortion. In the United States, where the matter is purely a state problem, a similar situation prevails.

The attitudes toward therapeutic abortions, and here the term therapeutic is used in the widest sense to indicate any legal abortion, are as follows:

1. No formal indication;
2. Medical indications only;
3. Medical indications supported by socioeconomic grounds;
4. Socioeconomic indications occasionally supported by medical grounds; and
5. Abortion on demand.

There are some countries which permit abortion on demand, a notable example being Japan, but this is not widespread, and no state in the United States permits abortions on demand. As a matter of fact, until quite recently there were only two attitudes toward therapeutic abortion in the United States: either no formal indication or medical indication (disease) only. Recently this country has moved in the direction of medical indications supported by socioeconomic grounds, a number of states adopting this type of statute. The states that have done this are Colorado, North Carolina and California. The first two approved abortion for maternal, fetal, and legal indications. The California statute became law after a provision authorizing abortion in cases of possible deformity or mental impairment of the fetus was deleted.

Virginia Law

Under Virginia law, it is necessary that the abortion be done only for the purposes of saving the life of the mother or the unborn child. On truly medical grounds it is difficult to imagine the situation in which an abortion would save the life of an unborn child. I would not think that the usual postmortem Caesarian section would come under this category. A number of years ago the Attorney General for Virginia ruled that the words "saving the life of the mother" did not mean that it had to be absolutely certain that she would die if the abortion was not performed, but that an abortion was lawful if it was for the purpose of preventing a progression of her present disease or was necessary to maintain her present state of health (written communication, Feb. 28, 1952). Still, this did not provide for those cases in which the female had been subjected to rape and was impregnated thereby, nor was it interpreted as covering mental disease.

Definition of Therapeutic Abortion

I think it becomes perfectly apparent that it is impossible to define precisely what constitutes grounds

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for a therapeutic abortion. In the final analysis, the decision will have to be made by the profession, within limits, of course. It is obvious that the frequency of abortions varies from area to area depending upon the consensus of thinking in the area as to what constitutes a therapeutic abortion. I know of a number of areas where the physicians have felt very strongly that a young girl, say, under the age of 16, who has been subjected to criminal violence and has been made pregnant thereby, is entitled to a therapeutic abortion on the grounds that her present state of health will be affected. Other areas are quite adamant and refuse to consider these grounds valid for therapeutic indication. What I am trying to say is that, in the long run, regardless of the law, the definition of what constitutes an abortion will often be a matter of personal judgment for the physician or a group of physicians who are practicing in a particular area. I have seen this develop in Virginia during my practice. As I have said previously, Virginia law does not cover impairment of mental health as an indication for therapeutic abortion. However, there has been a gradual change in the thinking of physicians and, indeed, in my own thinking. I now advise the physicians that *if* they in good faith are convinced that the continuation of a pregnancy is likely to result in an impairment of the patient's mental health, apart from physical considerations, then I feel this is a lawful indication for therapeutic abortion. One of the problems is that physicians, like all other people, are conditioned by their training and environment. This results in physicians who will have nothing to do with abortions under any circumstances, no matter what the indications. Other physicians take a very liberal view on what constitutes a therapeutic abortion and are prepared, quite ethically, of course, to abort a patient on what some of us would consider rather tenuous grounds. Thus, a physician, when faced with the problem of abortion, has to battle, first, with his own conscience and, secondly, with the conscience of his fellow practitioners in the community.

Change in Law

The question arises as to how the law should be in view of our current moral and ethical thinking with respect to abortions. Naturally, opinion ranges all the way from people who think there should be an absolute prohibition, to people like myself who feel that an abortion is a completely personal matter between a female and her physician and has nothing to do with anybody else. To me it is not a legal, moral or ethical issue. I am ready to admit that my personal opinion is an extremely radical one and certainly is not supported by the majority of laymen and physicians at this time. I am confident that in the future, albeit far in the future, this eventually will be the legal, moral and ethical thinking of people in general. I am the first to admit that it will not be in my lifetime and, perhaps, not in my children's lifetime. I must say, however—modestly, of course—that this has been the lot of radical thinkers since time immemorial.

Change in Attitude

In any event there is, I think, considerable ground swell for liberalization of abortions from a legal point of view. I get the feeling that, even among the most conservative thinkers, there is a relaxation of the strict moral concept against abortion. This is just a feeling and I may be wrong, but I can not help feeling that it is true. Why this change in attitude? It is difficult to say.

I think that all our views on social and economic problems tend to become more liberal as time goes on. The necessity for populating the country and the world has given way to some real concern that we are, in fact, becoming overcrowded. I think that, to a degree, respect for human life has diminished, as evidenced by the frequency of bloodletting in twentieth century wars, pogroms, etc. Radical innovations in human organ transplants have produced, in some ways, a cohesiveness among people, gradually replacing the concept of the individual being completely sufficient unto himself. These are all factors which, I believe, have subtly changed our views.

Statement of Policy by Medical Society of Virginia

The new laws in Colorado and North Carolina reflect, in part, changing opinion. The winds of change are certainly moving throughout the land. The AMA has relaxed its stand on abortion after a period of 96 years and now recognizes both the mother's health and the possibility of fetal deformities as indications for terminating a pregnancy. Virginia will certainly follow the trend; a statement of policy on abortions was issued by the Medical Society of Virginia on October 21, 1967. The statement, which recommended that the law be amended to include further indications for abortion, reads as follows:

(1) There is documented medical evidence that continuance of the pregnancy is likely to threaten the health or life of the mother; or
(2) There is documented medical evidence that the infant is likely to be born with incapacitating physical deformity or mental deficiency; or
(3) There is documented medical evidence that the continuance of a pregnancy resulting from legally established statutory or forceful rape or incest is likely to constitute a threat to the mental or physical health of the patient.

Furthermore, the circumstances described above shall be recognized as valid indications for induced abortion only when:

(1) Two physicians (other than the attending) be consulted and because of their recognized professional competence have examined the patient and have concurred in writing; and
(2) The procedure be performed in a hospital accredited by the Joint Commission on Accreditation of Hospitals.

The Society further recommended that, if there is any legislation enacted in accordance with these provisions, it should clearly exempt from liability for malpractice the physician who, on moral or religious grounds, refuses to either perform or recommend therapeutic abortion.

Lack of Socioeconomic Grounds

The legislation to liberalize the abortion laws which was introduced at the 1968 session of the General Aseembly and closely incorporated the above recommendations was referred to the Virginia Advisory Legislative Council for study. They will bring in recommendations prior to the next session. A glance at this statement of policy will show that there is no provision whatsoever for socioeconomic considerations. This is strange in view of the fact that Virginia has a radical sterilization statute which permits sterilization merely on request. I would have thought there would also have been some inclusion of socioeconomic grounds for abortions. All doctors are familiar with the fact that socioeconomic grounds are probably the primary basis for non-therapeutic or illegal abortions. Of the mass number of abortions done each year in this country, the greater number are performed on married women who are seeking the abortion purely for socioeconomic reasons. They simply feel that they cannot support an additional child and will seek any means they can to obtain the necessary operation. I think it rather interesting that Great Britain, which has recently modified its abortion laws, has taken into account socioeconomic pressures. Their law permits the physician to allow the mother's "total social environment" to be taken into account in considering an abortion. It may well be, of course, that the law which comes out of the General Assembly will have some such provision.

Rape or Incest

In any event, even with the liberalization of the current law, the problems of abortion will vary from community to community, depending upon the medical community's opinion as to what constitutes dangers to the health or life of the mother or the unborn infant. With respect to the Medical Society's recommendation on pregnancy induced by rape or incest, I am not sure that I quite understand what they mean by "legally established statutory or forced rape." I take it that they intend that the incest or rape must be followed by a conviction for the offense before an abortion could be induced. With the usual delays in the law now prevailing, this is likely to prove lethal to any hope of getting abortions performed on rape or incest victims, since the long delays would permit a woman to be para 5, gravida 5 before we are likely to get any legal judication.

Conclusion

In any event, all abortion laws —especially the newer laws—are rather elastic. I presume that they will be applied rigidly or leniently depending upon the attitude of the physician. Given a liberal attitude, I suppose the deciding factor would be whether the woman concerned wishes to have the baby or prefers to terminate the pregnancy. I have a feeling that any woman in the United States today who takes the latter attitude will have an abortion, therapeutic or non-therapeutic, medical or lay. In the long run, legislation against abortions is like any legislation against sin; it is commendable but ineffectual.

Abortion: Legal Aspects*

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Because an abortion is the interruption of pregnancy at any time previous to the attainment of viability by the fetus, it is of legal as well as social, economic, moral, and religious interest. Abortions are divided into three classifications: spontaneous, therapeutic, and unlawful or criminal. The first involves no specific legal problem in itself, but the law relating to the criteria for a therapeutic abortion and what distinguishes it from a criminal one confronts the physician and hospital frequently.

Statutory Provisions

The statutes in the 50 states and the District of Columbia define the offense of abortion with certain exception provisions in 47 states. Louisiana has no exception to the crime of abortion. Massachusetts and Pennsylvania statutes provide that a willful or unlawful abortion is a crime, without any specific exception. The Virginia Code defines the felony of abortion as follows:

Section 18.1-62. Producing abortion or miscarriage. If any person administer to, or cause to be taken by a woman, any drug or other thing, or use means, with intent to destroy her unborn child, or to produce abortion or miscarriage, and thereby destroy such child or produce such abortion or miscarriage, shall be confined in the penitentiary not less than one nor more than ten years. No person, by reason of any act mentioned in this section, shall be punishable when such act is done in good faith, with the intention of saving the life of such woman and child.

The West Virginia law has the same provisions as the Virginia statute. Twenty-three states permit the abortion to preserve the life of the mother;[1] six states provide for an abortion to save the life of the mother;[2] seven states allow an abortion to preserve the life of the mother or that of her child;[3] three jurisdictions authorize an abortion to preserve the life or health of the mother;[4] and the New Mexico statute provides an abortion to preserve the mother's life or prevent serious bodily injury. The Code of New Jersey states that any abortion that is malicious or without justification is a crime. In Denmark, Finland, Iceland, Norway, Russia, Sweden and Eastern Europe a pregnancy may be interrupted when necessary to avoid serious danger

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[1] Alaska, Delaware, Florida, Idaho, Illinois, Indiana, Kansas, Kentucky, Maine, Michigan, Mississippi, Montana, Nebraska, New Hampshire, North Dakota, Ohio, Oklahoma, Rhode Island, South Dakota, Tennessee, Utah, Vermont, and Wyoming.

[2] Arizona, Arkansas, Hawaii, Iowa, Texas, and Wisconsin.

[3] Connecticut, Minnesota, Missouri, Nevada, New York, South Carolina, and Washington.

[4] Alabama, District of Columbia, and Oregon.

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to the physical or mental health of the mother (Moore, 1963).

Need for Change

When these abortion laws were enacted, there was no anxiety in the nation regarding birth control. Our nation was expanding westward and with it the desire to increase its population. Over the years, public opinion on abortion has changed, but the laws have remained virtually unchanged. Today medical science can predict that a child may be afflicted with blindness, deaf-mutism, physical deformity, or insanity. Therapeutic abortion has come to be based more on medical opinion than on the strict provisions of the law. Psychiatric recommendations for the termination of pregnancy have become a frequent indication for therapeutic abortion (Wasmuth, 1966). In view of the lack of success in preventing abortions and the fact that women often are forced to procure abortions outside an optimal hospital environment, the American Medical Association last year revised its thinking with this negative phrase: "the AMA is opposed to induced abortion except when . . ." Under this new policy, medical indications for abortion include (1) a threat to the health or life of the mother, (2) evidence that "the infant may be born with incapacitating physical deformity or mental deficiency," and (3) a pregnancy resulting from rape or incest.

Broadening of Provisions for Therapeutic Abortion

In 1967 the abortion laws were rewritten in three states—Colorado, North Carolina, and California. Bills were unsuccessfully introduced in 28 other states (Medical World News, 1967). Colorado and North Carolina laws approved abortion for maternal, fetal, and legal indications. The California law does not authorize abortion in cases of possible deformity or mental impairment of the fetus. A candidate for abortion in North Carolina must have been a resident for four months. Both North Carolina and Colorado statutes make it mandatory that a committee of three physicians certify that the medical and legal requirements of the procedure have been met. There is an additional restriction in Colorado which requires that the procedure be performed in an accredited hospital. These statutory revisions have the effect of legalizing what some physicians in consultation and in good faith have already done, or what others felt should be done but did not do because of the questionable "gray area" involving what properly constitutes a therapeutic abortion.

This year, the Virginia legislature considered revising its abortion statute but, instead, referred the matter to the Virginia Advisory Legislative Council for a complete study. The Council is to submit its recommendations at the next session of the General Assembly. In March, Georgia became the fourth state to revise its abortion laws. The provisions are similar to those of North Carolina and Colorado. In addition, the Georgia statute requires three separate physicians to examine the woman requesting the abortion, and each must give a written statement setting forth the reasons for which he deems an abortion necessary. Maryland revised its abortion laws in April to conform substantially to those of Georgia, North Carolina, and Colorado. The abortion must be approved by the hospital's review authority, but may not be performed after the 26th week of gestation unless the mother's life is in jeopardy.

Criminal Abortions

Generally, the performance of any abortion solely for social, economic, or humanitarian reasons is illegal. At the present time, in the absence of a permitting statute, an abortion to prevent financial burden on a family or the public welfare, or where pregnancy is a result of rape, incest, immorality, or mental deficiency would be considered criminal and subject the offender to prosecution. The offense is considered to be a felony. In most jurisdictions, a physician who has been convicted of a felony in any jurisdiction would be subject to the revocation of his license to practice medicine by his respective State Board of Medical Examiners or other similar regulatory administrative body.

On occasion the hospital will receive a patient who has recently aborted or has only partially aborted. There is the probability that the abortion has been induced accidentally or criminally. The hospital should make every effort to obtain a complete history from the patient and make a record of any and all persons who accompany her to the hospital; and where possible, a statement should be obtained to the effect that the patient's condition occurred before admission to the hospital. This would relieve any accusation that the hospital was aiding or abetting the performance of a criminal abortion. It is presumed that an abortion performed in the hospital is for therapeutic purposes unless proven to the contrary (Jordan and Mann, 1962).

Criminal and Civil Liability

The performance or the aiding in the performance of an abortion that by definition does not come within the respective state statutory provisions constitutes a criminal act, and all contributing parties cognizant of the criminal intent are equally guilty. The written consent of the patient gives no relief to a criminal charge against the parties for performing a non-therapeutic abortion. The consent form may be used by the physician as a defense in a civil action brought by the patient; but generally the physician will be held civilly liable for negligence in the methods or procedures used, or for the death of the patient resulting from such unlawful operation.

Neither the physician nor the hospital will be subjected to any liability where, in good faith, either reports to the police any information concerning the commission of a crime. Any communication made to the physician or hospital personnel by the patient, a relative, or other person, who requests assistance in obtaining an abortion or an admission to the hospital for one already aborted or partially aborted, is not privileged. Furthermore, such information may be released to the local law enforcement agency without fear of being sued subsequently (Jordan and Mann, 1962).

What is the liability of the physician who had a pregnant patient that has rubella (measles) in the first trimester, and failed to tell her that her child may be defective, thereby precluding the possibility of obtaining a questionable therapeutic abortion, and such child was born with speech, hearing and sight defects? Last year two New Jersey physicians were sued by the mother on behalf of her 7-year-old child for just such an occurrence. Both doctors were charged with failing to inform the mother that the infant might be born with physical and mental defects. The court held for the defendant physicians and said that there is no contention that anything the defendants could have done would have decreased the likelihood of the infant being born with defects. The issue is not that the child would have been born without defects, but that he should not have been born at all. The court continued, "We cannot weigh the value of life with impairment against the nonexistence of life itself" (Gleitman v. Cosgrove, 1967).

This case indicates a further need for revision of the abortion laws. The overcautious physician, in failing to advise the patient of a potential indication for an abortion, may be subjected several years later to the harassment of a civil suit by the infant with birth defects. Then, too, if the oversympathetic physician does advise his patient that there is a substantial risk of the child's being deformed and does perform an abortion at the request of the mother, he may be subjected to action by the State Board of Medical Examiners in all but four states, i.e., North Carolina, Colorado, Georgia, and Maryland. This year two California physicians were publicly reprimanded by the California State Board of Medical Examiners. The board charged that they had participated in illegal abortions during the period 1963 to 1965 on women who had had rubella.

It should be noted that the statute of limitations for personal injury usually doesn't begin to apply for an infant until he reaches his majority (generally 21 years of age). It should also be noted that many states permit a cause of action for prenatal injury provided such fetus is born alive (Sylvia v. Gobeille, 1966).

Conclusion: Criteria for Therapeutic Abortion

The line between the criteria that classify an abortion as therapeutic and those which consider it to be criminal can be so fine that a decision is often left to the conscience of the physicians confronted with the problem of a patient desiring to terminate her pregnancy. If the physicians in consultation and in good faith rule in favor of the abortion, then, in the absence of any collusion, it will be considered to be for therapeutic purposes. If the physicians decide that the abortion would not be for therapeutic purposes under the definition of an abortion by the respective state statute, then any subsequent abortion obtained by other means would probably be criminal. For every crime there must be a complainant, but persons involved in a criminal abortion are not likely to talk, particularly to prosecutors. So without a complainant, there will be no prosecution.

Until such time as each state broadens its laws to conform more nearly to those suggested by the AMA, the hospital administrator and physician are advised that, whenever they are confronted with the problem of an abortion, criteria should be established to determine whether it is for therapeutic purposes. A therapeutic abortion may be indicated where two or more physicians (one should be a member of the medical staff, and another may be a psychiatrist) in good faith and as a result of consultation have concluded that in accordance with the provisions of the respective state statute the procedure is necessary to preserve or save the life of the mother or that of the child. The question of whether the abortion is therapeutic in nature becomes more difficult where pregnancy has caused the patient mental disturbance. Are there sufficient grounds for an abortion being held therapeutic when the patient, married or unmarried, takes an overdose of sleeping pills as a method of attempting to commit suicide presumably because she is pregnant? Though the respective state statute may require that the procedure must be necessary to preserve or save the life of the mother, it does not mean that the physicians in consultation must feel that without the abortion it would be a medical certainty that the patient would die. Nevertheless, the therapeutic nature should not be interpreted to apply to every emotionally upset patient. To do so would permit every unmarried female or unhappily married wife, who becomes pregnant against her desire, to have an abortion merely by threatening suicide. This problem as to the legality of a given abortion will exist until the time when more permissive statutes are enacted.

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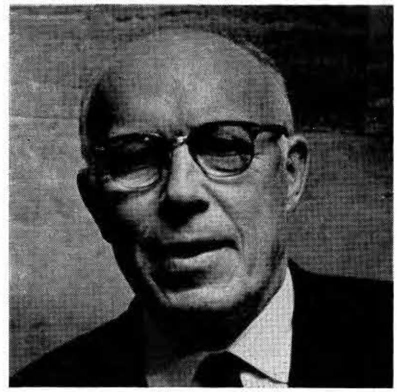

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Edith Iglauer (*The Ambient Air*), born in Cleveland, Ohio, graduated from Wellesley College and the Columbia University School of Journalism. She has written not only for "The New Yorker," but also for "The Cleveland News," "The Christian Science Monitor," "Harper's," and "Maclean's Magazine." *The Ambient Air* is Miss Iglauer's second piece on air pollution. Her first was concerned with air pollution in New York City. Its publication in 1964 was instrumental in the drafting of an air pollution bill signed into law in 1967. Her only published book, "The New People," concerns the changing North and the Eskimo's attempts to adjust to modern civilization.

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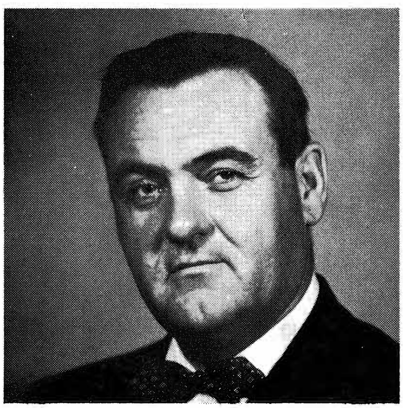
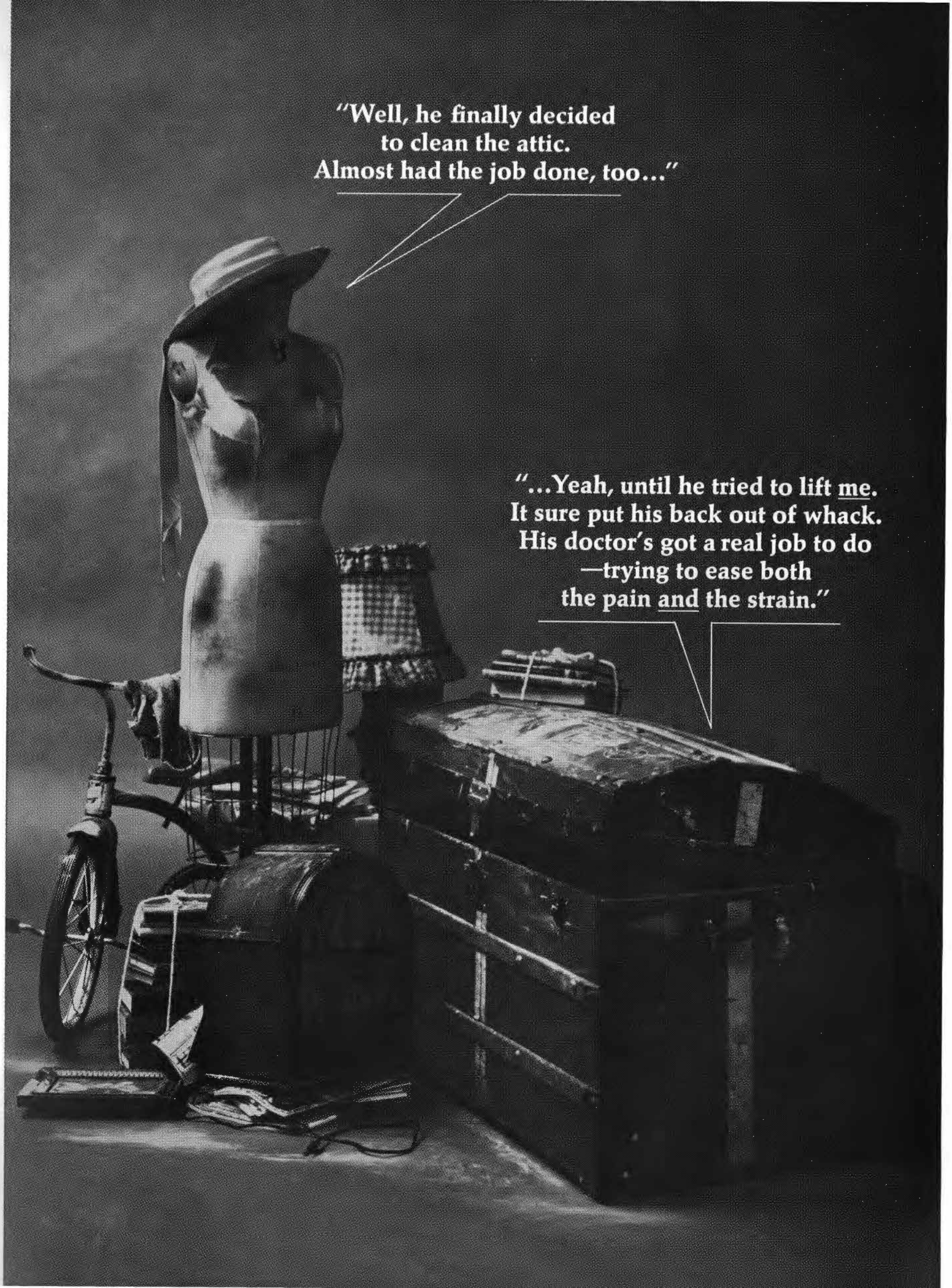
Henry D. Lederer (*A Psychiatrist Listens to Dental Complaints*), chairman of the department of psychiatry at the Medical College of Virginia, received his premedical education at the University of Chicago and his M.D. degree from Rush Medical College of that school. After completing his internship at the Cincinnati General Hospital and his residency at the University of Cincinnati School of Medicine, he served in the U.S. Army as a psychiatrist and neurologist. Before coming to MCV, he was professor of psychiatry at Georgetown University School of Medicine. One of his main interests is psychosomatic medicine and psychotherapy of ambulatory patients.



Geoffrey T. Mann (*Abortion: Medical and Moral Aspects*), a native of Canada, is Chief Medical Examiner for the Commonwealth of Virginia. He is also professor of forensic pathology and chairman of the department of legal medicine at the Medical College of Virginia. He received his B.A. and LL.B. degrees from the University of Saskatchewan and his M.D. degree from the University of Manitoba. Dr. Mann is a lecturer in legal medicine at the University of Virginia and a consultant for the Federal Aviation Agency and the Armed Forces Institute of Pathology. He is a fellow of the American Academy of Forensic Sciences and the Royal College of Pathologists (England) and the author of a textbook of legal medicine.


"Well, he finally decided to clean the attic. Almost had the job done, too..."
"...Yeah, until he tried to lift me. It sure put his back out of whack. His doctor's got a real job to do —trying to ease both the pain and the strain."

Whenever anxiety induces or intensifies clinical symptoms

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Before prescribing, please consult complete product information, a summary of which follows:

Indications: Indicated when anxiety, tension and apprehension are significant components of the clinical profile.

Contraindications: Patients with known hypersensitivity to the drug.

Warnings: Caution patients about possible combined effects with alcohol and other CNS depressants. As with all CNS-acting drugs, caution patients against hazardous occupations requiring complete mental alertness (*e.g.*, operating machinery, driving). Though physical and psychological dependence have rarely been reported on recommended doses, use caution in administering to addiction-prone individuals or those who might increase dosage; withdrawal symptoms (including convulsions), following discontinuation of the drug and similar to those seen with barbiturates, have been reported. Use of any drug in pregnancy, lactation, or in women of childbearing age requires that its potential benefits be weighed against its possible hazards.

Precautions: In the elderly and debilitated, and in children over six, limit to smallest effective dosage (initially 10 mg or less per day) to preclude ataxia or oversedation, increasing gradually as needed and tolerated. Not recommended in children under six. Though generally not recommended, if combination therapy with other psychotropics seems indicated, carefully consider individual pharmacologic effects, particularly in use of potentiating drugs such as MAO inhibitors and phenothiazines. Observe usual precautions in presence of impaired renal or hepatic function. Paradoxical reactions (*e.g.*, excitement, stimulation and acute rage) have been reported in psychiatric patients and hyperactive aggressive children. Employ usual precautions in treatment of anxiety states with evidence of impending depression; suicidal tendencies may be present and protective measures necessary. Variable effects on blood coagulation have been reported very rarely in patients receiving the drug and oral anticoagulants; causal relationship has not been established clinically.

Adverse Reactions: Drowsiness, ataxia and confusion may occur, especially in the elderly and debilitated. These are reversible in most instances by proper dosage adjustment, but are also occasionally observed at the lower dosage ranges. In a few instances syncope has been reported. Also encountered are isolated instances of skin eruptions, edema, minor menstrual irregularities, nausea and constipation, extrapyramidal symptoms, increased and decreased libido—all infrequent and generally controlled with dosage reduction; changes in EEG patterns (low-voltage fast activity) may appear during and after treatment; blood dyscrasias (including agranulocytosis), jaundice and hepatic dysfunction have been reported occasionally, making periodic blood counts and liver function tests advisable during protracted therapy.

Usual Daily Dosage: Individualize for maximum beneficial effects. *Oral*—Adults: Mild and moderate anxiety and tension, 5 or 10 mg t.i.d. or q.i.d.; severe states, 20 or 25 mg t.i.d. or q.i.d. Geriatric patients: 5 mg b.i.d. to q.i.d. (See Precautions.)

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