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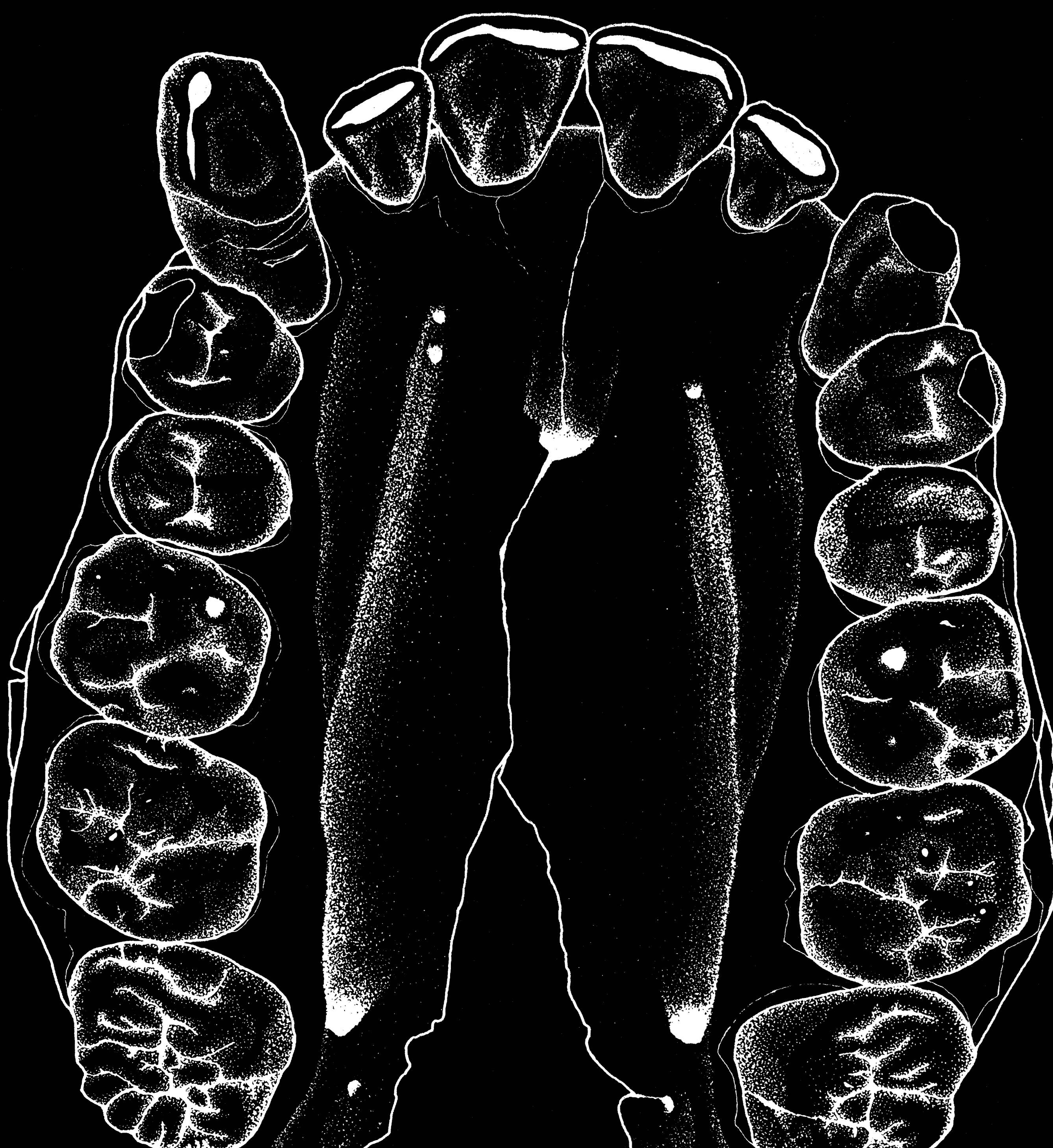

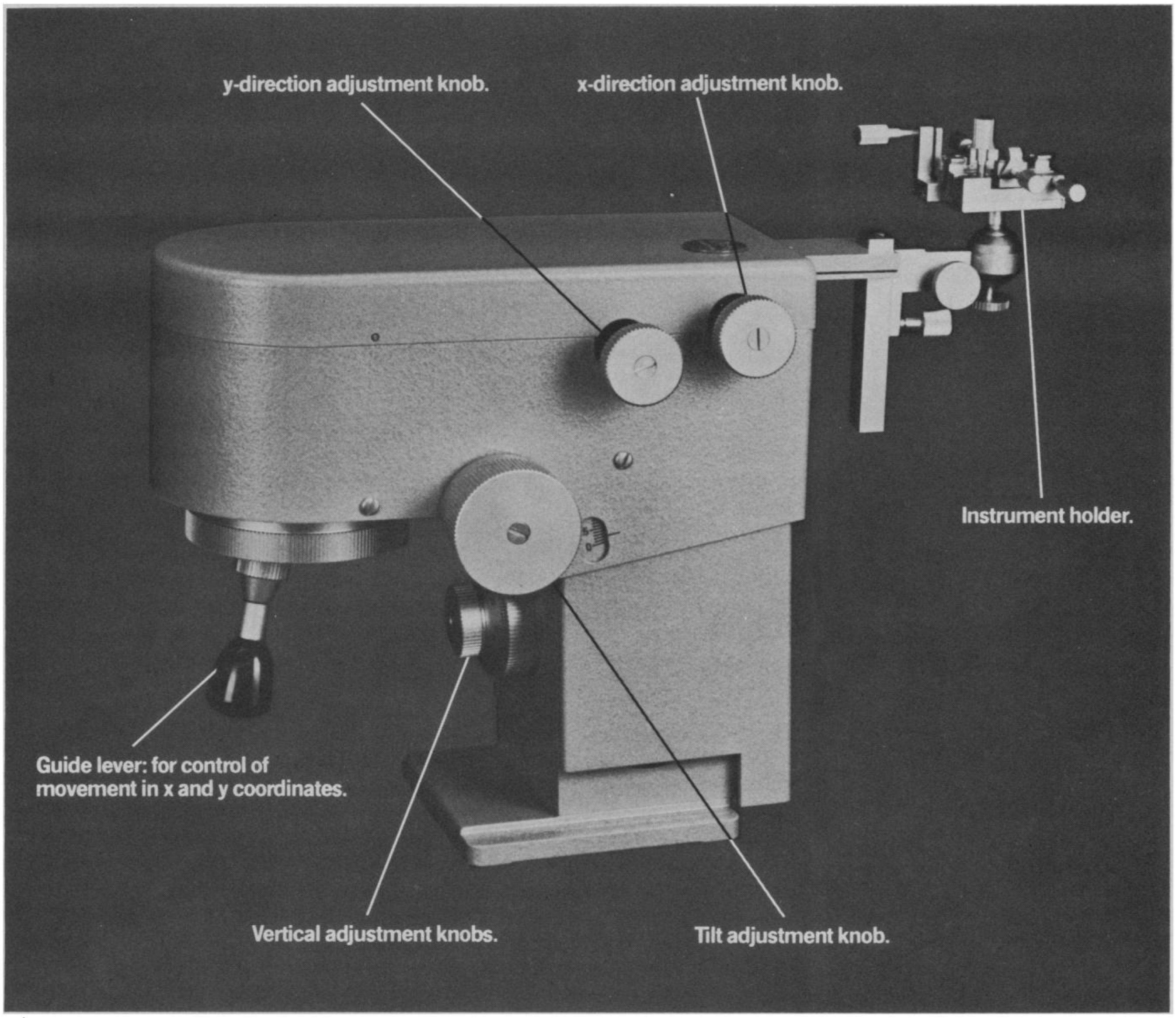

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COVER

This well-preserved and complete hominid upper jaw exhibits some of the primitive morphology diagnostic of the newly described species, *Australopithecus afarensis*, Johanson, White and Coppens, 1978. The specimen (A.L. 200-1a) is from the site of Hadar in Ethiopia and is dated to about 3.2 million years. The right canine is fossilized partially out of its socket. See page 321. [Drawing by Luba Dmytryk, Laboratory of Physical Anthropology, Cleveland Museum of Natural History]

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Recombinant DNA Policy

Eliot Marshall's article (News and Comment, 22 Dec. 1978, p. 1265) on the changing relationship between environmentalists and scientists resulting from the federal debate on recombinant DNA research leaves the reader with a number of misconceptions.

The claim by certain scientists that those of us involved in the recombinant DNA debate were spinning out "procedural fluff" to keep ourselves busy is patent nonsense. Those involved in the debate at the Environmental Defense Fund (EDF) are interested in this issue because of the potential for harm and because its solution will be a precedent for future regulatory approaches to research and technology. Few would deny that there is a recognized need to regulate certain recombinant DNA activities, for example, those currently prohibited or sanctioned only under stringent controls. The task of delineating a workable system for regulating recombinant DNA research, contrary to Maxine Singer's claim, is little different from the other tasks we face.

EDF is not anti-science or anti-technology; nor are we secretly yearning for a return to a simpler age. We *are* interested in ensuring that the potential harmful effects of new technologies are identified and factored into policy decisions.

EDF wanted the National Institutes of Health (NIH) guidelines to ensure (i) public disclosure of information essential for oversight of the regulators and the regulated, (ii) participation on policy and oversight boards by individuals representing a range of responsible interests, and (iii) compliance with the guidelines by those carrying on recombinant DNA activities. At no time did EDF try to put itself on these committees or claim to solely represent the public. Rather, EDF has sought to ensure that a spectrum of individuals, for example, laboratory personnel and local public health officials, be given access to decision-makers. The scientific community, with a clearly vested interest in government regulation of recombinant DNA activities and established contacts within NIH and the Department of Health, Education, and Welfare (HEW), already has that access. Indeed, they had been the sole source of nongovernment input into the NIH decision-making process.

That our concerns were not adequately addressed in NIH's proposed guidelines of July 1978 is indicated by HEW Secretary Califano's convening of an extraordinary panel to review the guidelines. This panel adopted many of the suggestions we raised.

Marshall's article creates the impression that the recombinant DNA debate has caused a substantial reduction in scientists' support for environmentalists' goals generally. However, in most cases criticism has come only from a small number of scientists who have been intimately involved in recombinant DNA research. Only the most vindictive of scientists have extrapolated from their disagreement with EDF over our recombinant DNA policy to the other issues, such as energy, preservation of wildlife, or control of toxic chemical pollution, that are the mainstays of our work. Scientists' support for this work has remained strong.

Marshall suggests that employees of groups like EDF proceed without oversight or responsibility to a larger organization. This is not the case. Organizational oversight of EDF involvement has been the same, if not more intense, for work on recombinant DNA as it has been for other controversial issues. As Marshall states, our Executive Committee has systematically reviewed and approved our position on recombinant DNA. It is true that our members are not involved in approving each position taken by EDF's staff. Instead, like the majority of membership organizations, EDF staff actions are judged by members on a regular, more general basis—when it comes time to renew membership and by letters. A recent poll conducted by Resources for the Future indicated that 61 percent of EDF's members felt it was important for environmental organizations to become involved in the recombinant DNA debate. According to the same poll, a majority of EDF's members, 52 percent, supported an immediate moratorium on DNA research pending public discussion. (I wonder whether our scientist friends would want us to accept that democratic input into our decision-making process.)

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The situation reported by Eliot Marshall reflects a far larger syndrome. The conservation-environmentalist movement owes its origins primarily to laymen, not to professional biologists; we have been slow in joining it, and that is our fault. Against this, however, must be balanced the fact that environmentalists lacking biological credentials and expertise have often zealously guarded their

bailiwicks and studiously ignored—even deprecated—the biologists who have attempted to cooperate and further the cause.

Top-heavy with amateur naturalists and professional altruists, environmental organizations are apt to strongly resist input from biologists who tell them things they do not want to hear. For example, hard facts about demography—plant, animal, or human—are unpalatable compared to soft soap on organic gardening or returnable bottles.

It is exceedingly frustrating to be the sole, "token" biologist employed by a major conservation agency and bounce repeatedly off a solid wall of bureaucratic ignorance. When the ultimate decision-makers sport baccalaureates in business administration, economics, or "environmental affairs," perceptive, responsible positions on biological issues are most unlikely.

What we need to do is "biologize" the whole environmental movement. I see signs for hope in the young, aware professionals moving up in the ranks of biologists. But I fear they may be too few and reach positions of influence too late.

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Fusion: Neutral Beam Technology

We strongly disagree with the statement by William D. Metz (Letters, 27 Oct. 1978, p. 370) that "it is generally acknowledged that the neutral beam technology used at Princeton (based on positive ions) cannot be extrapolated to a reactor-level plasma because the already modest efficiency plummets when the beam energy is raised." In fact, we believe it is likely that very high energy beams will not be needed for tokamak reactors. Early assessments (*1*) of neutral beam energy requirements indeed led to Metz's conclusion. However, these were typically made for circular, cross-section plasmas with neutral beams injected tangent to the inside edge of the plasma and with some combination of large plasma size, high density, or both. Conservative assumptions were also made about the required depth of penetration for the neutral beams. The resulting rules of thumb for injection requirements are not borne out in current conceptual designs for tokamak plasmas heated to ignition.

Because of increased understanding of tokamak plasmas, recent reassessments of beam energy requirements have led to a relaxation of some of the conservative assumptions. Smaller, elongated plasmas with nearly perpendicular injection will provide for a large decrease in beam energy requirements. These energy requirements are further reduced by low plasma density ($\bar{n}$) during the injection heating phase ($\bar{n} < 10^{14}$ ions per cubic centimeter), outward shift of the magnetic axis as the plasma pressure increases, heating of the core of the plasma by alpha particles produced in fusion reactions, and the possibility of expanding the plasma radius during the approach to ignition.

These considerations have been incorporated into new assessments (*2*) of the required neutral beam energies for a noncircular tokamak reactor plasma with a minor radius of 1.25 meters. Beam energies in the range of 100 to 150 kiloelectron volts (keV) (deuterium) are calculated to provide adequate penetration for heating to ignition. Lowering the beam energy requires increasing power input to the plasma, but the higher neutralization efficiency of lower energy positive ion beams leads to roughly constant power supply requirements over the range of energies considered (100 to 150 keV deuterium). Direct conversion of the unneutralized positive ion beams has already been demonstrated (*3*) and, when perfected, will make neutral beams based on positive ion sources an efficient heating mechanism.

If the presently estimated sizes for conceptual reactor plasmas prove to be correct, positive ion deuterium beams below 200 keV can be efficiently used to heat tokamaks to ignition, at least through the first demonstration reactor. The Princeton Large Torus results have certainly helped increase our confidence both in neutral beam heating and in scaling to reactor plasmas.

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4. Oak Ridge National Laboratory is operated by Union Carbide Corporation under contract W-7405-eng-26 with the Department of Energy.

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Risk: A Pragmatic De Minimis Approach

Society is becoming increasingly well informed and anxiety-prone about technology-associated risks, which leads to desire for their elimination. The logical and traditional approach is first to estimate the risk, a scientific task. Then comes the issue of risk acceptance, a most difficult step—moving from the world of facts to the world of values. Ideally, judgments involving risk acceptance should be made on society's behalf by a constitutionally appropriate body. But no such public decision-making process exists. We make do with disparate efforts of individuals, special-interest groups, self-appointed public interest groups, and legislative, judicial, and regulatory systems. However, if at least very large and very small risks were dealt with on the factual basis of effects, the individual and social value systems could be accommodated to some degree and much confusion avoided.

It is human nature to be concerned primarily with effects on our own person and family and secondarily with effects on the population at large. Unfortunately, although we can predict statistical effects on populations, there is no way to predict effects on individuals. This is why fortune-tellers never become as rich as insurance companies. We need then to define actuarially the existing state of well-being and calculate effects on it.

Each person has a probability of dying in any particular year, the value depending mainly on age. The existing probabilities are well known for the United States. For example, in 1975, 1.89 million died out of a population of 213 million, giving an overall probability of 1 in 113. For some specific age groups the values were: 1 to 4 years, 1 in 1425; 5 to 14 years, 1 in 2849; 25 to 34 years, 1 in 692; 55 to 64 years, 1 in 67. We can now answer the question, What does changing a risk do to a person's existing probability of dying? For instance, if a young child were exposed to an additional risk of 1 in 100,000 (0.014 in 1425) in 1975, his overall risk for that year would be 1 in 1425 plus 0.014 in 1425, or 1.014 in 1425.

For the purpose of discussion some guidelines, which may depend somewhat on age, can now be stated in terms of numerical risk:

1) Eliminate any risk that carries no benefit or is easily avoided.

2) Eliminate any large risk (about 1 in 10,000 per year or greater) that does not carry clearly overriding benefits.

3) Ignore for the time being any small risk (about 1 in 100,000 per year or less) that does not fall into category 1.

4) Actively study risks falling between these limits, with the view that the risk of taking any proposed action should be weighed against the risk of not taking that action.

Clearly, these suggested guidelines are a gross oversimplification. The unfortunate, overtaken by a one-in-a-million catastrophe, have a 100 percent chance of harm. The hard fact is that attempts to eliminate risks for the unfortunate few tend to markedly increase them for the rest of a large population. This idea is most difficult to defend politically, especially when the unfortunate few are known and the unfortunate many are nameless. In addition, it is necessary to take into account such matters as validity and uncertainty in risk estimates, nonlethal and esthetic effects, voluntary versus involuntary risks, societal abhorrences, and the strange versus the familiar.

Nevertheless, other than depriving the news media of a ready source of attention-grabbing items, the pragmatic de minimis approach should serve to promote understanding about how to deal with risk in the real world; encourage identifiers of risk to provide risk estimates; focus attention on actions that can effectively improve health and welfare and at the same time avoid squandering resources in attempts to reduce small risks while leaving larger ones unattended; and prevent anxiety, apathy, or derision as a response to the increasing recognition that we apparently live in a sea of carcinogens (the "today" risk).—Cyril L. Comar, *Professor Emeritus, Cornell University, and Director, Environmental Assessment Department, Electric Power Research Institute, Palo Alto, California 94303*