

International Genetic Epidemiology Society: Commentary on *Darkness in El Dorado* by Patrick Tierney

Max P. Baur¹ (President of the International Genetic Epidemiology Society) and the IGES-ELSI Committee: Partha P. Majumder² (Chair), Christopher I. Amos,^{3*} Josue I. Feingold,⁴ Terri M. King,⁵ Newton E. Morton,⁶ Michael A. Province,⁷ M. Anne Spence,⁸ and Duncan C. Thomas⁹

¹Department of Medical Biometry, Informatics and Epidemiology, University of Bonn, Bonn, Germany

²Anthropometry and Human Genetics Unit, Indian Statistical Institute, Calcutta, India

³Departments of Epidemiology and Biomathematics, The University of Texas M.D. Anderson Cancer Center, Houston, Texas

⁴INSERM Unité 155 Epidemiologie Génétique, Paris, France

⁵Department of Medicine, University of Texas, Houston Health Science Center, Houston, Texas

⁶Genetic Epidemiology Research Group, Human Genetics, University of Southampton, Southampton, England

⁷Department of Biostatistics, Washington University School of Medicine, St. Louis, Missouri

⁸Department of Pediatrics, University of California–Irvine, Orange, California

⁹Preventive Medicine, University of Southern California, Los Angeles, California

The International Genetic Epidemiology Society (IGES) has examined the charges against James V. Neel and his colleagues contained in the recently published book by Patrick Tierney entitled *Darkness in El Dorado: How Scientists and Journalists Devastated the Amazon* (W.W. Norton, 2000). The book implicates Neel in causing or promoting an epidemic of measles among the Yanomamö Indians of Venezuela in 1968 leading to “hundreds if not thousands” of deaths by using a “dinosaur” vaccine (Edmonston B) as a deliberate “experiment” to test his “eugenic” theories. Tierney also attempts to link this research, funded by the Atomic Energy Commission (AEC), with a broader tapestry of human radiation experiments. To investigate these serious charges, the IGES undertook a thorough examination of most source documents referenced in Tierney’s book, Neel’s field logs, notes, first-hand reports, contemporary writings, film sound tracks, etc., and conducted interviews with many relevant persons. The IGES finds that these allegations are false. Neel was not a eugenicist and was in fact

*Correspondence to: Christopher Amos, Department of Epidemiology, Box 189, U.T. M.D. Anderson Cancer Center, 1515 Holcombe Boulevard, Houston, TX 77030. E-mail: camos@mdanderson.org

Received 18 April 2001; Accepted 16 May 2001

highly critical of both the scientific basis of eugenics and its coercive social policies. In this regard, Tierney has grossly misrepresented Neel's views on a wide range of social implications of modern civilization for the long-term health of the gene pool. Far from causing an epidemic of measles, Neel did his utmost to protect the Yanomamö from the ravages of the impending epidemic by a vaccination program using a vaccine that was widely used at the time and administered in an appropriate manner. There was nothing experimental about the vaccination program, which in fact severely hindered the primary scientific objectives of the expedition. Although the research was funded in large part by the AEC, there was no element of radiation research and the work had no connection with the ethical abuses that have been reported from AEC-sponsored radiation research, such as studies of heavy isotopes.

Neel's seminal contributions to a broad range of topics in human genetics have been extensively chronicled elsewhere. His research on the Yanomamö in particular has provided unique insights into the evolutionary biology of our species, the role of sociocultural practices, such as kinship relationships and selective pressures in shaping the genetic diversity of primitive population isolates, as well as the general picture of health in such populations. The IGES decries the damage done to the reputation of one of its founders and its first President and the misperception this book may have caused about the conduct of research in genetic epidemiology. Ethical issues about scientific research in primitive populations deserve serious and wide discussion, but the IGES condemns the gross misrepresentation of the facts and demonization of the principal characters in this book.¹ *Genet. Epidemiol.* 21:81–104, 2001. © 2001 Wiley-Liss, Inc.

Key words: Yanomamö; bioethics; population genetics; indigenous populations; James V. Neel; eugenics

INTRODUCTION

“Neel and his eugenic disciples imbued the impersonal nature of evolution with a personal animus: natural selection became selfish, murderous, cruel, and deceitful. Doctors trained by the AEC injected the Yanomami with radioactive tracers and a vaccine that was potentially fatal for immune-compromised people. Scientists kept on filming and collecting blood in the midst of epidemics. These brave men took a long walk on the dark side, but, in the artificial brilliance of ground zero, they could see no shadows” [Tierney, 2000a, p 314–315].

So concludes the recently published book, *Darkness in El Dorado: How Scientists and Journalists Devastated the Amazon* by Patrick Tierney. Even before its publication on November 16, 2000, a storm of controversy was unleashed. Excerpts of the book appeared in the lead article in *The New Yorker* on October 9, 2000 [Tierney, 2000b]. An e-mail from Terrence Turner and Leslie Sponsel warning the President and President-Elect of the American Anthropological Association about the impending scandal was widely circulated over the Internet and received widespread media attention.² Such allegations about unethical conduct of genetic research in themselves demand careful scrutiny by the genetics community. However, when the charges concern a distinguished leader in the field—the late James V. Neel, one of the founders and first President of the International Genetic Epidemiology Society (IGES), a man in whose honor we dedicated an award in October 2000—the charges take a particular relevance to our Society.

In response, members of the IGES passed a resolution [International Genetic Epidemiology Society, 2000] at their annual meeting, stating that “With respect to the allegations made public thus far in the *New Yorker* article [Tierney, 2000b], there is sufficient evidence [Neel et al., 1970; Neel, 1994; Ridley, 2000; Zalewski, 2000²⁻⁴] to substantially refute these charges.” This report summarizes the conclusions that we have reached on the basis of further inquiry upon publication of the book. On the basis of this inquiry, we have concluded that the central charge of “science at the service of ethnocide” [Tierney, 2000a, p 11] is totally unfounded and that the author has grossly misrepresented Neel’s views on eugenics.

There are two parts to this report. In the first part, we summarize the allegations made in the book concerning the conduct of genetics research on the Yanomamö Indians of the Amazon by Neel and his colleagues and examine their validity. This section of our report includes an examination of the statements about Neel’s character and beliefs and his relationship with the U.S. Atomic Energy Commission (AEC). We also review charges that Tierney raises concerning the ethical conduct of field studies by Neel. In the second part, we summarize Neel’s contributions to the field of human genetics, the purpose and principal insights learned from the research on the Yanomamö, and his vision for the future of genetics. Some of the questions contained in Tierney’s book concerning ethical standards in the conduct of field studies are the subject of continuing discussion by the IGES’s Committee on Ethical, Legal, and Social Implications (ELSI).

We have not attempted to address many of the other charges in the book concerning anthropological research on the Yanomamö and the long history of abuses of these people at the hands of other Westerners. Likewise, we have made no attempt to examine the motives of the author in bringing these charges or others who have perpetuated them; statements on this aspect of the story can be found on the University of Michigan’s website,³ and the Southampton website.⁴ Nevertheless, as will become evident in what follows, our conclusions are that the charges by Tierney against Neel are false. Such libelous reporting causes harm in itself, both to the individuals whose reputations are slandered—particularly when they are no longer alive to defend themselves—as well as to their scientific disciplines and the organizations with which they were associated.

THE ALLEGATIONS AND THEIR FACTUAL BASIS

The book makes a number of specific charges, which we shall consider in detail. Briefly, the factual charges can be summarized as follows:

- That Neel deliberately caused an epidemic of measles among the Yanomamö by using a “deadly” and “contraindicated” vaccine (Edmonston B), resulting in “hundreds, if not thousands” of deaths; that Neel refused to provide medical care to those who were affected by the reaction to the vaccine or by the disease itself, and dissuaded members of his team from providing medical care;
- That Neel did not seek expert advice about the appropriate means of vaccination, did not obtain permission from the Venezuelan government for the vaccination program, and provided misleading information to the Venezuelan government;

- That Neel and other scientists failed to take adequate precautions to prevent diseases resulting from outside contact with an isolated population, and made no attempt to quarantine the Yanomamö who were already infected, including some of the members of his own expedition.

The rationale for these activities is said to be found in Neel's "openly eugenics views," and the objectives of the AEC in funding this research. Specifically, Tierney charges that

- Neel believed that modern civilization violated natural selection, with deleterious consequences for the gene pool, whereas the violent culture of the Yanomamö led to selection in favor of genes for leadership;
- The measles vaccination program may have been a deliberate "experiment" designed to test such "eugenic" hypotheses;
- The AEC funded this research in order to estimate background mutation rates in the absence of radiation exposure, for use as a control group in the studies of the Japanese atomic bomb survivors;
- Human radiation experiments were conducted on the Yanomamö;
- A culture of violence existed at the AEC, which promoted the alleged abuses.

In addition, the book contains broader bioethical concerns that we address, namely,

- That the scientists showed lack of respect for the Yanomamö's cultural values, as exemplified by the use of indirect and sometimes deceitful ways of obtaining pedigree information;
- That proper informed consent of the individuals and assent of the community leaders were not obtained;
- That the research provided no potential benefit to the population, whose members were used simply as guinea pigs.

We now consider each of these charges under four broad headings: those relating to the measles epidemic, those relating to Neel's views on eugenics, those relating to the AEC funding and the motivation for the research, and those related to bioethical conduct of field studies. Long before the current controversy started, the IGES had constituted an ELSI committee that is discussing issues such as informed consent, family-history taking, community involvement, justice in the distribution of risks and benefits and formulating guidelines to avoid possible harm in population research. Therefore, the ELSI committee also thoroughly discussed Tierney's allegations in formulating the present commentary.

Charges Related to the Measles Epidemic

The conclusion that the vaccination program caused the epidemic is based on Tierney's interpretation of several observations, which are either factually incorrect or grossly misinterpreted. Tierney's version can be briefly summarized as follows:

In 1968, Neel brought 2,000 doses of the Edmonston B measles vaccine with him on an expedition to the Venezuelan Amazon to study the Yanomamö Indians. Although the purpose was to control an epidemic that had broken out shortly be-

fore in this previously unexposed (“virgin soil”) population, Tierney speculates that the choice of this particular vaccine may have been experimental in nature, so as to test Neel’s eugenic theories.⁵ In support of this contention, he points to the Ocamo Mission, where only half the Indians were vaccinated. At various points, Tierney describes the Edmonston B vaccine as “most primitive,” a “dinosaur vaccine,” “antiquated,” “contraindicated,” “dangerous,” or “deadly.” He argues that the newer Schwartz vaccine should have been used instead, citing various experts as having warned against its use in highly sensitive populations without adequate medical care, and claims that the reaction to the vaccine was as serious as the disease itself. Most seriously, he suggests that the epidemic could have been spread by person-to-person contact from individuals who received the vaccine but were not infected with the wild virus. He states that the vaccine was frequently administered without gamma globulin, which was required for use with this vaccine to reduce the severity of the reaction. Finally, he questions Neel’s account of the origin of the epidemic, alleges that Neel did not have appropriate government approval for the vaccination program, and interprets passages on the sound reels for the documentary film *Yanomama: A Multidisciplinary Study* as providing evidence of a cover-up.

Members of the IGES reviewed the historical record that we were able to assemble from a variety of sources, including Neel’s field notes, extensive correspondence over the period 1967–68 in the archives of the American Philosophical Society, grant applications to the AEC (1960 and 1966–74) from the archives of the University of Michigan, transcripts of the sound reels for the documentary film *Yanomama: A Multidisciplinary Study* cited by Tierney, and scientific publications by Neel. We also interviewed and corresponded with many of the key individuals, including Samuel Katz, Mark Papania, Susan Lindee, James Neel, Jr., Kenneth Weiss, and established liaisons with other professional societies and institutions that have been investigating these charges. Our reading of this historical record shows quite a different picture from that presented by Tierney.

Members of the IGES noted that several distinguished authorities and institutions have already addressed these charges, including the measles experts Samuel Katz⁶ (co-developer of the measles vaccine) and Mark Papania⁷ (Chief, Measles Elimination Activity, Centers for Disease Control [CDC]), the historian Susan Lindee,⁸ the National Academy of Sciences,⁹ the University of Michigan,¹⁰ the University of Santa Barbara (UCSB),¹¹ and the American Philosophical Society,¹² amongst others. Katz and Papania both state that they were extensively misquoted in Tierney’s book; both were interviewed by the IGES for this commentary. The 83-page UCSB report provides a particularly detailed response to the charges relating to the measles epidemic, including a careful examination of the primary sources cited by Tierney showing how they were frequently misused. In view of these various authoritative critiques, we summarize here only the highlights of what the IGES committee has learned and refer the reader to these other sources for additional details.

Preparations for the vaccination program

Even before the outbreak in the Venezuelan Amazon, Neel was concerned about the low levels of immunity, based on a serological survey he had conducted in 1966–67, the data from which were subsequently summarized in his scientific article on

the epidemic [Neel et al., 1970]. On September 19, 1967, he wrote to the missionary Daniel Shaylor expressing these concerns:

As before, we will carry with us a considerable quantity of medical supplies, and will be prepared to practice a good deal of medicine as we go. Furthermore, our special studies on the blood specimens we brought back have now shown that measles and whooping cough, not to mention small pox and tuberculosis have not yet reached these Indians to any significant extent, and we are considering whether we could do some type of inoculation which would minimize the effects of these diseases when they finally do reach the Indian.¹³

This suddenly changed from a purely preventive concern to one of epidemic control when 2 months later he learned for the first time that measles had broken out in the Brazilian Amazon:

We have just received a letter from Charles Patton, the medical missionary stationed at Boa Vista, to the effect that measles has gotten into the Toototobi and Mucujai Stations, with the usual devastating effects. Although our orientation is primarily research, we also are quite concerned with the humanitarian implications of extending proper medical services to the Indian, and would try very hard to lay a vaccination program onto our medical studies.¹⁴

A month later he wrote to Miguel Layrisse in Venezuela,

There seems to be a raging measles epidemic amongst the Yanomama. According to our information, measles was first introduced on the Brazilian side, at Toototobi when the daughter of the missionary there, Keith Wardlaw, came down with measles which she had presumably contracted when the family was in Manaus on leave. About the time, measles appeared in Mucujai. We received a letter about a month ago from Charles Patton, medical missionary in that area, concerning the severity of the disease. Now we have just had a letter from Robert Shaylor, Chief of the New Tribes Mission on the Upper Orinoco, that he has word that there is sickness amongst the Indians on the very high Orinoco, possibly due to measles.

I believe I can obtain about 2,000 immunizing doses of measles vaccine free. CAN YOU OBTAIN PERMISSION FROM THE VENEZUELAN GOVERNMENT FOR US TO VACCINATE ALL THE INDIANS WE COME IN CONTACT WITH? We know from our antibody studies that the Venezuelan Yanomama have not yet been exposed to measles.¹⁵

During the next 2 months, Neel consulted with Helen Casey, Libero Ajello, and Pente Kokko at the CDC and Francis Black of Yale University, the leading authority on virgin soil epidemics at the time, on the appropriate way to conduct a vaccination program, and he visited the CDC to meet with infectious disease specialists.

Vaccine safety, permission, potential for person-to-person spread

The Edmonston B vaccine was still widely used in the United States and elsewhere at the time, although it was gradually being phased out as the newer Schwartz

vaccine (a more attenuated live virus vaccine) gained favor. Nevertheless, at that time, the Edmonston B vaccine was licensed by the U.S. Food and Drug Administration and recommended by the World Health Organization (WHO); it was certainly not “contraindicated,” even without the use of gamma globulin. In fact, more than one million children were vaccinated in the United States in 1968 alone. The choice of the Edmonston B vaccine was driven by an offer by two manufacturers, Lederle and Parke-Davis, to donate 2,000 doses (together with gamma globulin donated by the State of Michigan) at no cost to the researchers.¹⁶ An additional 2,000 doses was provided in April 1968 by Phillips-Roxane, along with 2,000 more doses of gamma globulin from the State of Michigan. According to detailed records in Neel’s field logs, gamma globulin was given with the Edmonston B vaccine in all cases, except for the initial 40 doses administered by Marcel Roche at the beginning of the outbreak before Neel’s arrival at Ocamo.

Advance permission does appear to have been obtained from the Venezuelan authorities. Neel requested governmental permission in the letter to Miguel Layrisse at the Instituto Venezolano de Investigaciones Cientificas (IVIC) quoted above. The reply from the Venezuelan public health authorities later that month has not been located, but other evidence implies that it was provided, including the obvious requirement for such authorization in order to import the vaccine through Venezuelan customs.⁸ A telegram dated April 19, 1968 has been located from Neel’s archives maintained by the American Philosophical Society,¹⁷ providing governmental permission for additional vaccines.

In more than 18 million applications of the vaccine, no case of person-to-person transmission has ever been documented and only three deaths resulted, all in severely immunocompromised individuals (one late-stage leukemia patient undergoing radiotherapy and two with immunodeficiency syndromes).^{6,7,9} In extensive experience in other isolated populations, such as in Nigeria and Zaire, no case of transmission due to the vaccine has ever been seen. Tierney proposes a biologically implausible mechanism by which an individual who received only the vaccine and not a natural infection could transmit the virus to others; this argument has been authoritatively rebutted by leading infectious disease experts, such as Katz and Papania, and the National Academy of Sciences.

Only half of the Ocamo Mission was vaccinated so as to allow sufficient numbers to care for the vaccinated during the acute phase of their reaction, as spelled out in a protocol for the vaccination program by the expedition’s pediatrician, Willard Centerwall, before departure.¹⁸ This village was also the only one that already had a substantial prevalence (20%) of antibodies from earlier exposures (identified as “Village J” in Neel’s published report) [Neel et al., 1970]. No experimental intent was involved.

Denial of medical care

Tierney relies heavily on sound reels for the film *Yanomama: A Multidisciplinary Study* for his contention that medical care was denied, citing repeatedly the statement by Neel to the filmmaker Timothy Asch: “Not the picture of the physician ministering to his flock.... You’re here to document the kind of study we’re trying to make. Anybody can walk into a village and treat people. This is *not* what we’re here to do. Now, I don’t know how I can be more definite about it” [Tierney, 2000a, p 95].

Tierney goes on to claim that “the American medical team deserted the desperately sick Yanomami, who waited for over a week until the next plane from Caracas arrived with additional doctors” [Tierney, 2000a, p 76]. According to Tierney, “Neel shocked Chagnon, telling him that, yes, the sick Yanomami were going to infect everyone they met. But they had to continue their research and filmmaking activities upriver and let the Yanomami fend for themselves until some other doctors arrived” [Tierney, 2000a, p 312].

We reviewed a transcript of these sound reels prepared by members of the American Society of Human Genetics who listened to them and do not arrive at the same interpretation as Tierney. In its proper context, the first of these quotes appears to be an instruction to Asch as to the type of material he wanted on the film, not an instruction to his medical colleagues to refuse care as Tierney interprets it. In the last passage quoted above, the expression “the sick Yanomami” was changed from “the vaccinated Yanomami” in the galleys, an important change indicating that Tierney was backing off from the contention that Neel believed the vaccine was capable of person-to-person spread. Obviously, those with natural measles would be highly contagious, but we could find no evidence in the sound reel transcripts that Tierney cites for this passage to show that Neel instructed his team not to provide medical care.

Perhaps most compelling is a passage from sound reel number 1 *not* quoted by Tierney, which follows immediately after the passage that Tierney uses to argue that “the American medical team deserted the desperately sick Yanomami.”

Neel: We have 1,000 by our estimate; we will allocate about 750, so we have about 250 left. These we want to use to get Platanal and catch it on the upper Orinoco and then the Patanowa-teri who are the principal inland village we might get to. Actually, Ocamo, we can't be sure what's going to happen next, but it would be excellent insurance to have two physicians here. Ocamo will be pretty well over in the next 3 or 4 days. We'd like to have one standing by here and one allocated to help the missionaries if the inland village comes down.

This hardly sounds like a plan to abandon the Ocamo mission! Neel's field logs show that extensive medical care was indeed provided. Susan Lindee summarizes these field logs as follows:

When the measles problem was identified as an epidemic, on or around February 16, Neel provided penicillin and terramycin not only to those affected in the villages he visited, but also to those who would be able to bring it to persons affected elsewhere. There is no evidence that he attempted to discourage anyone from providing treatment, and indeed for about two weeks he spent much of his own time administering vaccines and antibiotics.

Furthermore, Neel himself worked out a plan for controlling the epidemic, from 2 to 4 a.m. on 16 February, after he was awakened by a messenger bearing a frantic note from a colleague at the Ocamo Mission, a note which said that there was a serious outbreak of measles, and asking him to send gamma globulin. His “all Orinoco” plan included controlling movement of people in and through the five pri-

mary ports of entry to the region, liberal use of penicillin, vaccination when practical, and gamma globulin when practical.¹⁹

It is clear from his notes that the epidemic drastically disrupted his field research, making it impossible for him to collect the kinds of data he had intended to collect, and it is clear that he was at times frustrated, even angry, about this situation. A measles outbreak emphatically did not facilitate his research.²⁰

Additional evidence of an intention to provide medical care is provided by the shipping lists for the expedition, which include (in addition to 2,000 doses of vaccine and gamma globulin), 10,000 tablets of aspirin, 10,000 malaria tablets, and large quantities of penicillin, sulfa, and tetracycline—far more than the expedition needed for its own purposes.²¹ Furthermore, in his autobiography, he wrote (with respect to all his expeditions) that “we treated the sick as we traveled” [Neel, 1994, p 171] and similar passages in his correspondence, such as the letters to the Shaylor and Layrisse quoted above. Perhaps the strongest evidence of the quality of the care that was provided comes from the mortality outcomes. Contrary to Tierney’s claim that “hundreds, perhaps thousands of deaths resulted,” the case-fatality rate has been estimated at 8.8%. Although high by modern standards in civilized populations, this is far below what has typically been observed in “virgin soil” epidemics.

Cover-up claim

The allegation of a cover-up of alleged ill effects of the vaccination program is also based solely on the author’s interpretation of a brief clip from the sound record from the expedition, located in the Smithsonian’s archives. Here is the cited exchange:

“I’ve just explained to him that a few people out the vaccinated group will get a clinical case.” [Chagnon]

“Right,” Neel said.

“But he’s [Rousseau] trying to interpret all of them [the measles cases] to mean that it’s a reaction to the vaccination which I don’t think is a wise thing to do. And I think that even . . .

“Right,” another expedition doctor interjected.

“I hope that’s right,” Neel said. “But, uh, we . . .”

Neel: “The vaccination with gamma globulin gives sometimes a fever, a little runny nose but if he sees somebody with a real rash . . .

“Get him out,” Chagnon suggested.

Neel: . . .by the time he sees someone like that, that person will have contaminated the entire group. That is how contagious measles is” [Tierney, 2000a, p 73–74].

From this, the author spins an elaborate conspiracy theory with no other supporting evidence. Our reading of this passage does not support this interpretation, nor can any other evidence be found in contemporaneous field logs. Neel’s autobiography cites various reports to the Venezuelan government and papers in open literature describing this experience, [Neel, 1994, p 411; Neel, 1982], which hardly suggests any attempt to cover up the events.

Preventive measures

Tierney makes both general assertions about the responsibilities of scientists to avoid harming vulnerable populations and specific contentions about Neel's failure to quarantine the infected individuals, including some of his own assistants. With respect to the latter, he alleges that an Indian guide named Rerebawa accompanied the expedition upriver, despite being infected with measles. Unfortunately, it is difficult to verify this claim in either Neel's field notes or mission records, as Rerebawa is never mentioned by name. However, on the same date that Tierney ascribes to this event (February 18, 1968), there is a passage in Neel's field notes that reads,

“Back from Ocamo about 6:00 to find one of our Ocamo trip guides ill—presumptive measles until proven otherwise. Decided to advise “our” village to move out—but stay where they can be reached.” On the next day, there is a further notation that “in a surge of conscience, decided not to take our four exposed Pat guides with us, but to get guides at Plantanal.”

These passages indicate that Neel did avoid, as well as possible, exposing new villages to measles by leaving behind his own exposed guides.

The severity of the disease and/or the reaction to the vaccine apparently terrified the Indians, who disappeared into the jungle, possibly further spreading the contagion. As alleged by Tierney, it is possible that reactions to the vaccine could have contributed to terror in the villages from the measles epidemic. However, as available documents testify, Neel took all possible steps to ameliorate the impact of the measles epidemic on the villages. It is clear from an entry dated February 17 (referring back to events on January 23) and his “all-Orinoco” plan (item 6) that quarantine measures were instituted from the beginning.

With respect to the general potential for disease spread by expeditions such as Neel's, Tierney writes:

Although the AEC protocols admirably maximized data collection, they also maximized exposure to a host of new germs. In some ways, the assembly-line blood-collecting routine was a formula for disease propagation, starting with the arrival of scientists from major cities around the world, who were ferried by speedboat to isolated Yanomami *shabonos* in the company of Yanomami guides from the missions. At no time in their films, or in any of the voluminous writings of the scientists who participated, is the question of how their own presence among barely contacted villages added to “the disease pressure” that “decimates the population” [Tierney, 2000a, p 50].

No evidence is ever offered in the book that the presence of Neel's team indeed caused or transmitted any infectious diseases [Hill and Kaplan, 1989].^{22,23} Nevertheless, these are quite legitimate concerns in working with isolated populations that have been recognized by numerous scientific and public health organizations. Neel himself acknowledged this concern in his autobiography, where he says, “We took great pains to introduce no disease” [Neel, 1994, p 171]. However, Hurtado et al.²³ indicate that, despite concerns, there are currently no guidelines to minimize the risk of spreading disease among isolated populations during the conduct of scientific or anthropological studies. Hurtado et al.²³ note: “Ironically, James Neel, a scientist

accused by Tierney of genocide among the Yanomamo, is one of the main contributors to our current understanding of disease susceptibility in these populations.” Thus, Tierney’s accusation that Neel contributed substantially to the burden of disease in the Yanomamö seems particularly reckless.

Neel’s Views on Eugenics

Tierney relies heavily on selective quotations from Neel’s own writings to paint him as a mad scientist, an adherent to long-discredited eugenics ideas [Tierney, 2000a, p 12, 38–39, 40, 49, 296–297, 314]. These are not worth responding to point by point, but two passages in Tierney’s book in particular attempt to provide a basis for his interpretation of the measles vaccination program as a deliberate “experiment” to test eugenic theories:

Because measles attacked everywhere with such predictable ferocity, geneticists expected that a measles contagion in an Amerindian tribe could allow them to measure the difference in inherited immunity between New and Old World people—a key factor in natural selection [Tierney, 2000a, p 54].

Although I can only speculate about Neel’s personal motives, opting for the Edmonston vaccine was a bold decision from a research perspective. Obviously, the Edmonston B, precisely because it was primitive, provided a model much closer to real measles than other, safer vaccines in the attempt to resolve the great genetic question of selective adaptation [Tierney, 2000a, p 59].

Unfortunately, Tierney has seriously misunderstood Neel’s ideas. Two recent reports have responded to these claims in detail.^{24,25} In this section, we attempt to summarize his views on the various topics touched on by Tierney, focusing in particular on his insights based on his Yanomamö research.

At the outset, we note that there is a great deal of confusion about the meaning of the word *eugenics* as a result of the failure to distinguish between scientific questions about the evolution of the human gene pool and the misguided and coercive social policies that some adherents advocated after about 1880, culminating in the excesses of Nazism in Germany but also reflected in compulsory sterilization programs and discriminatory immigration programs and legally supported racism in parts of the United States and elsewhere. An excellent review of the history of eugenics and the excesses of the “social Darwinists” can be found in the *Encyclopedia of Biostatistics* [Pelias, 1998]. See also an excellent discussion of the different meanings of the word eugenics and Neel’s views on the subject by Paul and Beatty.²⁴ Again, Neel’s concern with the future of the human gene pool is an important part of this scientific tradition, but he was a staunch opponent of measures to ameliorate our genetic heritage by coercive means.

Neel was in fact a critic of eugenics from his earliest days. When offered the records of the disbanded Eugenics Records Office at the Carnegie Laboratory, rather than having a “career-changing moment,” as Tierney claims, he refused to touch them:

My earlier experience at the Office had convinced me that although there were in its files a few pedigrees of genuine genetic value, most of the

material was worthless; there was little in the way of a legacy from the past to be realized there [Neel, 1994, p 25].

His textbook *Human Heredity* [Neel and Schull, 1954, Chapter 20] provides a carefully argued critique of any attempts to modify the gene pool by coercive restrictions on reproduction. This argument is summarized in his autobiography:

Here the contemporary human geneticist differs from the eugenicist of the 1920s and 1930s, who, without today's understanding of the principles of population genetics, believed deterioration could occur very rapidly. Genetic deterioration has a relatively long fuse, in a world whose attention seems riveted on tomorrow [Neel, 1994, p 312].

His autobiography also takes pains to distinguish eugenics from what he called *euphenics*, the goals of which are “to ensure that each individual maximizes his genetic potentialities” [Neel, 1994, p 353].

Neel wrote extensively on the social implications of population genetics. The concluding chapters of his autobiography and several articles elaborate the specifics of his opinions. Neel was profoundly concerned with the dangers of overpopulation:

I submit that not only do geneticists lack the knowledge to recommend a comprehensive eugenic program in the classical sense but such a program would be socially unacceptable. Rather, each couple the world over should be encouraged by all means available to limit itself to two children. . . . This is not a eugenic program. It simply seeks for the foreseeable future to stabilize the human gene pool in all its wondrous diversity as it now is . . . I can only suggest that even greater social injustice may overtake various ethnic groups without this effort at stabilization [Neel, 1993, p 331–340].

He was also concerned with the changes that modern “civilization” had brought to our environment and the ability of the human species to adapt to these changes. His seminal paper on the “thrifty genotype” hypothesis [Neel, 1962]—suggesting that susceptibility to diseases such as diabetes in modern society might be a deleterious consequence of genotypes that had formerly been advantageous in human ancestral environments—has been called “arguably one of the most influential hypotheses in genetic epidemiology” [Weiss and Ward, 2000]. But perhaps the most relevant information comes from his 1980 article “On Being Headman,” which Tierney has very selectively quoted. Neel begins with a thoughtful analysis of the three major forces of evolution—chance, mutation, and selection—in the context of the Yanomamö, in which he considers the role of microdifferentiation of population structure and mating patterns, estimates of mutation rates obtained from the electrophoretic variants, and the reproductive advantage of headmen and their possible genetic superiority. All this would be considered mainstream ideas in population genetics. He concludes with a section entitled “Are There Tenable Countermeasures to the Loss of Our Primitive Population Structure?,” which is worth quoting more extensively than Tierney does:

The population explosion of the past several thousand years, plus the consolidation of large numbers of people of diverse origins in urban complexes and the ease of travel between these complexes, should introduce a

great deal of inertia into the larger and much less isolated gene pools into which our species is currently subdivided, rendering it more unlikely that favorable accumulations of genetic traits can be wiped out by chance. A further stabilizing factor will be introduced by the increasing availability of contraceptive measures, which will decrease the variance in mean family size the world over. Otherwise stated, the scope for stochastic factors in the disruption of the evolutionary process should be substantially dampened, albeit by no means eliminated. On the other hand, the loss of headmanship as a feature of our culture, as well as the weakening of other vehicles of natural selection, is clearly a minus. Finally, erosion by mutation will continue, and if the concerns of some are correct, with increasing environmental pollution will even increase . . .

My principal thesis in this presentation is that although we were all to some extent aware of a relaxation of natural selection, now we can see that the selection may have been both more rigorous and more necessary to the maintenance of human attributes than we have realized. The rate of the genetic deterioration of our species which we are led to predict by the foregoing considerations is indeterminate but, on the time scale on which man usually thinks, slow. Given the array of problems which the civilized world must solve during the next 100 years, even if we all saw the implications of the loss of headmanship as I have presented them, it would be difficult for geneticists to command real attention for such distant problems. But, should we get that attention, what can we offer at this time?

Since there is little prospect society will ask us to remake it with these or other extensive eugenic measures, there really are available only two practical (i.e., socially acceptable) courses of eugenic action for the immediate future. The first is an increasing concern with the provision of genetic services designed to decrease the transmission of genes causing disease, especially genetic counseling coupled where indicated with prenatal diagnosis and early abortion. The second eugenic measure which geneticists can facilitate is a concern with measures which influence human mutation rates. We are all very aware of the need to minimize human exposure to environmental mutagens and the necessity of careful cost-benefit analyses insofar as these are possible when some exposure seems inevitable in our industrialized society. . . . Beyond this, however, it is now becoming apparent that there may be a more active role for the geneticist than simple protection of the public against unjustifiable exposures to mutagens. One of the very significant developments of the past decade has been the realization of the extent of the cellular potentiality for the editing and repair of lesions in DNA, but a variety of mechanisms. . . . To what extent the quantity and functioning of the enzymes involved in these repair mechanisms is in man subject to manipulation is extremely unclear and certainly a subject worthy of much more attention than it is presently receiving. Given the maximum feasible reduction of environmental mutagens, then the protection and favorable manipulation of these repair systems might prove to be the next chief eugenic avenue open to us [Neel, 1980].

Despite Neel's frequent references to the word eugenics in the passages we have quoted and elsewhere in his writings, the sentiments expressed here are very much ones most human geneticists would be in sympathy with. They are based on solid scientific principles and do not contain the element of coercion that made the eugenics movement of earlier days ethically unacceptable. In particular, in his last publication [Neel, 2000], he takes pains to distinguish what he calls "soft eugenics" characterized by individual free choice in the exercise of reproductive freedoms to affect the genetic makeup of a couple's offspring from the coercive forms of eugenics of the past.

The AEC Motivation for Funding the Yanomamö Research, Human Radiation Experiments, and the "Culture of Violence"

Neel's research of the Yanomamö was indeed partially funded by the AEC, which was at the time one of the major funding sources for research on population genetics because of its interest in mutation rates, both natural and radiation induced. Additional funding was provided by the National Institutes of Health, the Population Council, the International Biology Program of the International Council of Scientific Unions, and the Pan American Health Organization. However, his autobiography indicates that the expeditions had a very broad range of scientific objectives, ranging from studies of the microdifferentiation in the gene pool in primitive populations and its relationship to population structure and breeding patterns to the profile of disease pressures in a (virtually) uncontacted population, and the evolutionary basis of these phenomena. In part, then, an objective of the expeditions would naturally have been to estimate spontaneous mutation rates, had this been possible at the time, but this could not be accomplished by direct observation given the extreme rarity of germline mutations. On the other hand, the "indirect" method of estimating mutation rates based on fitting population genetics models to the distribution of allele frequencies in present-day samples was not available until its scientific basis was introduced by Kimura and Ohta in 1969 [Kimura and Ohta, 1969]. In Neel's words:

At the outset, in 1962, there had been a variety of justifications for the Indian studies, but the study of mutation was not one of them. In discussing the Indian studies, I have mentioned the extent to which we employed electrophoresis to detect genetic variants of some of the serum proteins and erythrocyte enzymes, with a view to characterizing the nature of the genetic differences between tribes. It must have been sometime in 1970, after reading a paper by the Japanese geneticists M. Kimura and T. Ohta, that I realized that we could employ our data on electrophoretic variants among Amerindians to generate estimates of mutation rates, but now the approach would be indirect rather than the direct approach discussed thus far [Neel, 1994, p 218].

In any event, the use of the term *control group* for the atomic bomb survivor studies would be inappropriate to describe the Yanomamö studies as there are numerous reasons why human populations are likely to differ in their estimated baseline mutation rates, including genetic heterogeneity, unmeasured environmental factors, and methodological artifacts. In addition, the Kimura-Ohta theorem only applies to

genetic loci that are not under selective pressure, an assumption that would not hold when comparing such highly different populations as the Yanomamö and Japanese. Neel was highly cognizant of these issues and never proposed to use the Yanomamö data as a control. Indeed, we examined all Neel's research grants to the AEC for the period 1966–1974 and did not find any indication that this research was motivated by a desire to use these data as a control for the atomic bomb survivors. The first mention of mutation rates appears in the continuation application for the period 11/1/71 to 10/31/72, where it is stated: "It involves an examination of blood specimens from a large series of children born to the irradiated survivors of Hiroshima and Nagasaki, and from a suitable series of controls, for evidences of mutation at the biochemical level."

Earlier, Neel had discarded the non-irradiated city of Kure as a suitable control, since its social conditions were not comparable to Hiroshima. He was too good a scientist to contemplate using the Yanomamö as a better control. Although this application does not clarify the source of controls, recent correspondence with William J. Schull explains that all comparisons were internal to the atomic bomb survivor cohort in relation to dose.

Only in the analysis of the biochemical data has a dichotomy been used, proximal versus distal parental exposure, but I would emphasize that the comparison is internal and not dependent on some "control" from Michigan or South America. The notion of a control as Tierney apparently uses this word simply never occurred to us. It was too stupid to entertain even briefly. There were too many differences between the Japanese and Michiganers or South Americans to consider using anything other than internal comparisons. As it was, even when comparing one group of Japanese with another, there were numerous sources of extraneous variability that could create spurious differences or obscure real ones. Our focus was always to minimize, if not wholly mitigate these latter possibilities.²⁶

Of course, it is possible that the AEC rationalized support of this research on this basis, as suggested by the information obtained by Tierney from the AEC under the Freedom of Information Act. Although we have not seen the specific document to which Tierney refers, the following press release, dated February 16, 1976, is similar enough to give a flavor of the possible interpretation:

Past research by Neel and his associates, supported by the Atomic Energy Commission (which was absorbed by ERDA last year) and the National Science Foundation, dealt primarily with establishing long-range genetic trends in the relatively primitive Yanomama Indians of South America, a civilization unexposed to modern-day pollutants, and the Japanese survivors of the Hiroshima and Nagasaki bombings. These on-going projects will provide a basis of comparison for data developed on mutation rates in the United States.²⁷

However, it is important to note that this document was written 7 years after the Kimura and Ohta paper and did not refer to earlier studies. Estimation of natural human mutation rates is of considerable scientific importance in population genetics and essential for providing a comparison with the available experimental animal data.

The thyroid uptake study using tracer doses of radioiodine conducted among the Yanomamö by Marcel Roche of Venezuela was neither a “genetic study,” as characterized by Tierney, nor was it related to Neel’s research in any way. In any case, it is extremely unlikely that this study caused any harm to the Yanomamö. The use of very low doses of radioiodine is a widely used diagnostic tool to assess thyroid function, even today.

The final chapter of Tierney’s book reviews the history of the human radiation experiments conducted by the AEC [Faden, 1996] and attempts to link Neel’s research by means of association with several participants, by his involvement with the Atomic Bomb Casualty Commission (ABCC) and by the AEC funding of his Yanomamö studies. Specifically, Tierney points to Neel’s presence at the Strong Memorial Hospital in Rochester, NY, around the time when the plutonium injections were carried out there. Neel received his medical degree from Rochester and, therefore, his presence in the Strong Memorial Hospital was natural. Tierney also makes connections with Stafford Warren, the chief of the Rochester Manhattan Project Medical Section, who was responsible for Neel’s posting to ABCC, and with several other figures, including Shields Warren, Joseph Howard, Avery Brues, Walter Libby, Paul Henshaw, Paul Aebersold, and Marcel Roche. None of these individuals, with the exception of Marcel Roche, was involved in any way with the Yanomamö studies, and no credible connection with Neel’s research has been established. Tierney alleges that Stafford Warren asked William Valentine (who had previously been Neel’s collaborator in his thalassemia research in 1942–45) to perform plutonium injections. Valentine denies having used any radioactive substance at Rochester or knowing of the top-secret work being done by Stafford’s group until it became public in the 1990s.²⁸ Furthermore, this section is filled with numerous factual errors, which have been addressed extensively by Bruce Alberts on behalf of the National Academy of Sciences,²⁹ and need not be repeated here.

Ethical Conduct of Field Studies

Collection of pedigree data

Tierney attacks the mode of conduct of field work relating to the Yanomamö project. It should be noted that Tierney’s allegations are not directly against Neel, but his field workers. However, even these allegations are biased and therefore lack credibility.³⁰ Chagnon and other field workers typically did not directly request information about family relationships from close relatives of deceased individuals. The motivation for an indirect method of collecting pedigree information actually reflected the cultural taboo against naming both living and deceased individuals in the Yanomamö villages. Chagnon indicates that initially he had used some methods for collecting pedigree information that he later abandoned when he learned that the methods did not conform to the cultural values of the population. It is known that there has been a temporal change in cultural values of the Yanomamö through their contact with governments and missionaries. For example, Tierney refers to many Yanomamö by name despite the previous taboo against naming individuals. Therefore, it is virtually impossible to retrospectively evaluate the degree of seriousness of the conflict between cultural and scientific values during the conduct of the Yanomamö studies.

The consent process

The consent process for research studies has changed dramatically during the 30 years since the studies by Neel. Therefore, current guidelines for obtaining informed consent cannot be applied to Neel's studies in the Yanomamö. Indeed, no records have yet been located documenting the consent process for the Yanomamö studies. It is unclear whether documentation of the consent process was requested by the University of Michigan or by any other relevant agency. On the face page of Neel's grant applications, the box adjacent to the question "Does the proposed study involve human subjects?" is marked "No" with the annotation "(Not in the usual sense)." This box, however, appears on the face page of the grant applications beginning only in 1967. It is pertinent to mention that Neel was himself the Chair of a WHO International Scientific Group that made recommendations on conduct of Research on Human Population Genetics including "Relations of the Research Team with the Population Studied." [WHO, 1962, 1968], and also that when the Yanomamö studies were conducted, these WHO guidelines were the only available guidelines that specifically pertained to the conduct of genetic research on populations. Additionally, Peter Smouse, one of Neel's later co-investigators on the Yanomamö study writes

All of our studies involved a "human use" protocol, appropriately filed with the university. There were always questions about "informed consent" on the forms, and that was always a tough one. We always had informed consent, after a fashion, but you have to understand the field context. We were communicating through a 3rd party, Chagnon or a missionary, or someone else who spoke Yanomama. These were people living in the 1500s (culturally), and their understanding of what we were doing was imperfect, at best. There is only so much one can accomplish with linguistic translation; we all did our best, but to say they were "informed", in the sense you and I would expect it in a modern clinic, would be false. We explained all this to the Human Use Committee, and they understood and approved the protocols. We never drew blood from someone who was unwilling, and there were definitely those who were unwilling. In general, something of value to them was offered in return. What that was depended on whom we were dealing with (and what they really valued), which tended to depend on the local trade network, more than anything else. They seemed pleased with the exchange, at the time; it is their normal way of doing business. Today, with changing attitudes, a lot more information, and a change in the commodity values of the offerings, there are those who would pass on the opportunity of venipuncture (I'm not fond of it myself), but for the time and place, we played it straight and in good faith. We followed the protocols.³¹

Venipuncture was necessary for the research studies that Neel conducted regarding the public health and population structure of the Yanomamö and later for the indirect studies of mutation rates.

Benefits of contact

Neel always felt that his research was directed at "critical health needs" of the population. This is perhaps most clearly spelled out in a letter to Mr. and Mrs. Keith

Wardlaw, missionaries at the Toototohi Station, dated March 13, 1967 (before the measles expedition):

During this period there is perhaps the opportunity to initiate certain measures which will protect them when the inevitable contacts with a wider world occur. For the purposes of this discussion, we can divide the types of disease from which they suffer into three categories, namely, traumatic, infectious, and nutritional.

He then provides another two pages of specific recommendations for addressing each of these concerns. In his autobiography, he also confronts this question:

As we examined the Indians and collected our samples, all this the basis for learned papers that would ultimately contribute to our professional reputations, were we only the latest of the exploiters, now for scientific reasons? Students have on several occasions raised this point when I have lectured on these studies.

We took great pains to introduce no disease. We treated the sick as we traveled. At the end of each period in the field, we submitted detailed reports and recommendations to the appropriate authorities of Brazil and Venezuela and wrote general accounts of our findings. In 1968, I arranged a Symposium—subsequently published—for the Pan American Health Organization, entitled “Biomedical Challenges presented by the American Indian,” at which a variety of health issues were discussed. I have no illusions about how effective any of this was in the long-range sense. . . . Did we ameliorate the situation, even if by ever so little, and simultaneously collect data of some scientific value [Neel, 1994, p 171]?

Thus, even if the scientific research on population genetics had no direct benefit to the Yanomamö, Neel and his team did their best to provide them medical care (not as part of their research) and by calling attention of various individuals and agencies to their more immediate needs.

Members of the IGES, therefore, do not find any evidence in support of the charge that Neel and his team had abused the then existing ethical guidelines during their conduct of research on the Yanomamö. Concern for the impact that members of Western societies, including scientists, can have on primitive cultures reinforces the need for development of internationally accepted guidelines for the collection of genetic information from populations. The IGES has already initiated discussion on ethical issues pertaining to the conduct of genetic epidemiological research (long before the current controversy stemming from the publication of Tierney’s book) through its ELSI Committee. It is unfortunate that Tierney has seriously distorted facts and has demonized James V. Neel without clarifying any of the ethical issues, which the IGES membership condemns unequivocally.

NEEL’S CONTRIBUTIONS TO GENETIC EPIDEMIOLOGY IN GENERAL AND PURPOSE AND LESSONS FROM THE YANOMAMÖ RESEARCH IN PARTICULAR

No review of *Darkness in El Dorado* would be complete without an examination of Tierney’s characterization of Neel’s views as “quixotic” and similar disparag-

ing terms, nor of his distortions of the purpose of the research and what was learned from it. It would be impossible to do justice to the breadth of Neel's career in a few paragraphs in this report, focused as it is on the major ethics charges that have been leveled against him. Fortunately, however, there have been a number of eloquent tributes written to him, both during his life [Schull, 1986] and upon his death [Schull, 2000; Weiss and Ward, 2000], which will help to compensate for the inadequacies of our following brief restatement of his contributions. In addition to his vision of our field, which led to the creation of the IGES and his service to the IGES as its first President, his role in founding the world's first Department of Human Genetics at the University of Michigan, the large number of individuals he has inspired and trained, and his leadership in many other organizations (President of the American Society of Human Genetics, first Director of the ABCC, member of the National Academy of Sciences, and the list goes on and on), Neel has left behind a monumental body of important research findings. His early work spanned such topics as thalassemia and sickle cell anemia, the thrifty genotype hypothesis for diabetes [Neel, 1962] and other diseases of modern civilization, and the role of homeostasis in congenital anomalies. For more than 50 years, he was involved in the most comprehensive effort ever undertaken to study the mutagenic effect of ionizing radiation in humans—the study of the atomic bomb survivors. His efforts beginning in 1972 to estimate the radiation-induced mutation rate by direct observation, entailing more than a million genotypes, was a model for “big science” in biology in its day, particularly considering the primitive state of the genotyping technology then available. As characterized in Schull's eulogy [2000],

But if there is a single thread that connects his scientific career, it is his preoccupation with the phenomenon of mutation. . . . His interest focused not merely on the frequency of mutation, whether spontaneously occurring or induced, but on the biochemistry of the process, the manifestation of mutations when present in single dose, and the factors that govern the persistence or loss of new mutations at the population level.

This leads us thus to the population studies among the Yanomamö. Contrary to the characterization by Tierney as a test of “eugenic theories,” this research program was highly multidisciplinary with a broad range of objectives. These are laid out clearly in his AEC grant applications, his correspondence, the numerous scientific publications that resulted, and his autobiography. His 1965 grant application lays out the purpose as follows:

The specific objective of these teams is to gain as comprehensive a picture as possible of the circumstances under which man evolved. . . . In the field, the following items represent the information to be obtained:

- (a) Secure as complete a pedigree of the village under study as possible, including the reproductive performance of all living individuals, with the viewpoint of determining the breeding structure and vital statistics of the group.
- (b) Obtain physical examinations and anthropometric measurements on as many individuals as possible, in order to characterize the health and development of the group.

(c) Collect blood, saliva, urine and stool specimens on as many persons as possible, to determine genetic structure and disease experience.

Firstly, the concept of the population structure under which human evolution occurred which is beginning to emerge from these studies differs from any of the formal models thus far proposed. Briefly stated, the “fission-fusion” model which we are developing, with fissions occurring along biological lines, would tend to maximize the “founding effect” but, within a tribe, tend to minimize the importance of drift. Secondly, we are at the point ready to challenge the concept that primitive man is innately extremely susceptible to such diseases of civilization as smallpox, measles, and tuberculosis, feeling that the true reasons for the devastation produced by these diseases is as apt to be found in the epidemiological characteristics of these groups and attitudes towards death. This has important implications for the kind of selection thought to have accompanied the process of civilization. Other hypotheses, regarding the changing significance of differential fertility and the manner of acquisition of disease immunities and how this leads to genetic selection, are also presenting themselves.³²

Perhaps the most wide-ranging summary of what was learned from this research is contained in a *Science* article Neel published in 1970 [Neel, 1970]. In this article, he summarizes the findings on four topics: “(i) microdifferentiation and the strategy of evolution, (ii) population control and population size, (iii) polygyny and the genetic significance of differential fertility, and (iv) the balance with disease.” After reviewing the data on each of these points, he concludes with four principles that he suggests are relevant to the problems of highly civilized communities: “stabilize the gene pool numerically . . . ; protect the gene against damage . . . ; improve the quality of life through parental choice based on genetic counseling and prenatal diagnosis . . . ; [and] improve the phenotypic expression of the individual genotype.” He concludes with a passionate plea to live in harmony with the biosphere that anticipates the ecological concerns of later decades. Chapters 8 through 12 of his autobiography provide a much more detailed discussion, in layman’s language, of the insights that were learned from this experience on such topics as the spectrum of disease, tribal demography, genetic differentiation between villages and its implications for evolution, and the rates of spontaneous mutation.

Reflecting back on Neel’s accomplishments, Weiss and Ward [2000] wrote

Over a 20-year period his work in a large number of Yanomama villages and in at least 20 other tribes in South and Central America generated a formidable set of data providing unparalleled and perhaps unrepeatable insight into the evolutionary biology of our species.... These data revealed a wholly unexpected magnitude of genetic variation in human populations, just when the merits of Kimura’s neutral theory were being hotly debated. The many analyses of these data have been influential in shaping our perception of human genetic diversity, highlighting in particular the role that sociocultural practices such as culturally defined kinship relationships within and among local villages have in the shaping of human genetic diversity at the micro scale. The continued existence of 15,000 or so samples collected 30 or more years ago ensures that this scientific legacy will be profitably

mined for many years to come. . . . There can be little doubt that the selective pressures 10,000 years ago were substantially different from those of the recent past, a concept that has implications for how we design studies of the genetic contribution to common disease.

Beyond his purely scientific accomplishments, Neel may be remembered best for his vision of the future of genetics and its policy implications for the future of humanity. Many of these ideas have already been discussed above, but the reader is particularly encouraged to study the final six chapters of his autobiography, where his thoughts on such issues as overpopulation, evolutionary biology, increasing exposure to mutagens, the emergence of a gerontocracy, radiation risks, eugenics, genetic counseling, prenatal diagnosis, gene therapy, and aging are discussed.

CONCLUSIONS

The publication of *Darkness in El Dorado* has ignited a firestorm of controversy in both the scientific community and the popular press. As laid out above, the central charges against James V. Neel are all false. Neel was not a eugenicist. He did not cause a deadly epidemic of measles among the Yanomamö. On the contrary, even though it was not a part of his scientific research, he took all efforts within his means to contain the epidemic and to vaccinate the population, which undoubtedly reduced its impact. He did provide medical care to the infected population, despite the obvious disruption of his research program. No aspect of the vaccination program was in any sense an experiment to test “eugenic views.” There is no indication that Neel violated the then existing ethical guidelines for genetic research on populations. The harm done to Neel and his associates by the slanderous allegations made by Patrick Tierney deserves to be set right and forcefully condemned.

ACKNOWLEDGMENTS

We thank Nancy Wang, Dr. Carol Etzel, and Cynthia Thomas for technical and secretarial assistance in preparing this document and Rebecca Pentz for thoughtful comments.

REFERENCES

- Faden R, editor. 1996. Final report of the Advisory Committee on Human Radiation Experiments. Oxford: Oxford University Press.
- International Genetic Epidemiology Society. 2000. Resolution concerning recent allegations against James V. Neel. *Genet Epidemiol* 19:i-ii.
- Hill K, Kaplan H. 1989. Population and dry-season subsistence strategies of the recently contacted Yora of Peru. *Natl Geog Res* 5:317-34.
- Kimura M, Ohta T. 1969. The average number of generations until extinction of an individual mutant gene in a finite population. *Genetics* 63:701-9.
- Neel JV. 1962. Diabetes mellitus: a “thrifty” genotype rendered detrimental by “progress”? *Am J Hum Genet* 14:353-62.
- Neel JV. 1970. Lessons from a “primitive” people. *Science* 170:815-22.
- Neel JV, Centerwall WR, Chagnon NA, Casey HL. 1970. Notes on the effect of measles and measles vaccine in a virgin-soil population of South American Indians. *Am J Epidemiol* 91:418-29 (Tables 1 and 2).
- Neel JV. 1980. On being headman. *Perspect Biol Med* 23:277-94.

- Neel JV. 1982. Infectious disease among Amerindians. *Med Anthropol* 6:47–54.
- Neel JV. 1993. How would Haldane have viewed the societal implications of today's genetic knowledge? In Majumder PP, editor. *Human population genetics*. New York: Plenum Press. p 331–40.
- Neel JV. 1994. *Physician to the gene pool*. New York: John Wiley & Sons.
- Neel JV. 2000. Some ethical issues at the population level raised by 'soft' eugenics, euphenics, and isogenics. *Hum Hered* 50:14–21.
- Neel JV, Schull J. 1954. *Human heredity*. Chicago: University of Chicago Press.
- Pelias MZ. 1998. Eugenics. In: Armitage P, Colton T, editors. *Encyclopedia of biostatistics*. Chichester: John Wiley & Sons.
- Ridley M. 2000 Oct 17. Acid test. *The Daily Telegraph*; 45206 (also <http://www.dailytelegraph.co.uk/00/10/17/do03.html>).
- Schull WJ. 1986. Scientist, journalist, orchidist—will the real James V. Neel please stand up. In: Rucknagel DL, Tashian RE, editors. *Evolutionary perspectives and the new genetics, progress in clinical and biological research*. New York: Alan R. Liss. p 1–9.
- Schull WJ. 2000. James Van Gundia Neel. *Genet Epidemiol* 18:289–91.
- Tierney P. 2000a. Darkness in El Dorado: how scientists and journalists devastated the Amazon. New York: W.W. Norton.
- Tierney P. 2000b Oct 9. The fierce anthropologist. *The New Yorker*:50–61.
- Weiss K, Ward RK. 2000. James V. Neel, M.D., Ph.D. (March 22, 1915 – January 31, 2000): founder effect. *Am J Hum Genet* 66:775–60.
- WHO Scientific Group on Research in Population Genetics of Primitive Groups. 1962. Research in population genetics of primitive groups report of a WHO Scientific Group (meeting held in Geneva from 27 November to 3 December 1962). World Health Organization Technical Report Series No. 279.
- WHO Scientific Group on Research on Human Population Genetics. 1968. Research on human population genetics report of a WHO scientific group (meeting held in Geneva from 3 to 7 July 1967). World Health Organization Technical Report Series No. 387.
- Zalewski D. 2000 Oct 8. Anthropology enters the age of cannibalism. *The New York Times* (see also <http://www.nytimes.com/2000/10/08/weekinreview/08ZALE.html>).

OTHER SOURCES

- ¹This document and supporting information is posted on the IGES website (www.genepi.org).
- ²<http://www.anth.uconn.edu/gradstudents/dhume/darkness.htm>
- ³<http://www.umich.edu/~urel/darkness.html>; http://cedar.genetics.soton.ac.uk/public_html/needstat.html
- ⁴http://cedar.genetics.soton.ac.uk/public_html/needstat.html
- ⁵In post-publication interviews, Tierney has partially retracted this claim but continues not to accept evidence from experts about non-virulence of the vaccine. In an interview for *Newsweek/MSNBC* with Sharon Begley and Nadine Joseph on November 27, 2000, Tierney said “I don't think their intentions were malicious at all...I do not claim that it was done deliberately and I don't reach a clear conclusion about whether or not their vaccination was responsible for the spread of the disease. What I do show is there was reckless behavior. There was widespread distribution of trade goods and filming activities during the epidemic that certainly contributed to its spread beyond its original point. And some people who were vaccinated died, which is a terrible thing.”
- ⁶<http://listserv.acsu.buffalo.edu/cgi-bin/wa?A2=ind0009&L=anthro-l&F=&S=&P=21046>
- ⁷Letter to Patrick Tierney, dated October 25, 2000, provided to the IGES by Papania.
- ⁸<http://www.tamu.edu/anthropology/Lindee.html> and <http://www.anth.uconn.edu/gradstudents/dhume/Dark/darkness/0178.htm>
- ⁹<http://www4.nationalacademies.org/nas/nashome.nsf/b57ef1bf2404952b852566dd00671bfd/57065f16ff258371852569920052d283?OpenDocument>
- ¹⁰<http://www.umich.edu/~urel/darkness.html>
- ¹¹<http://www.anth.ucsb.edu/chagnon.html>
- ¹²Cox R. Salting slugs in the intellectual garden: James V. Neel and scientific controversy in the information age. <http://www.amphilsoc.org/library/mendel>
- ¹³Letter from James Neel to Daniel Shaylor, Sept. 19, 1967.
- ¹⁴Letter from James Neel to Robert Shaylor, Nov. 21, 1967.

¹⁵Letter from James Neel to Miguel Layrisse, Dec. 11, 1967 (emphasis in original).

¹⁶E-mail from Robert Cox of the American Philosophical Society, November 10, 2000, summarizing correspondence from Martins da Silva of the Pan American Health Organization to RR Widman of Cyanamid International (Lederle Labs) December 19, 1967; from J.V. Neel to S.J. Musser of Philips Roxane on April 26, 1968; and from J.V. Neel to Marcel Roche of IVIC on April 22, 1968.

¹⁷The telegram dated 1968 April 19 from VENEZGOVT=ETAT to NEEL DEPARTAMENT HUMAN GENETICS MICHIGAN UNIVERSITY ANN-ARBOR reads: "DONATION ACCEPTABLE OUR GOVERNMENT = MARCEL ROCHE IVICSAS."

¹⁸Protocol for vaccination program included in a memo by Willard R. Centerwall to Black dated January 9, 1968:

"In brief, it should be realized that the Edmonston strain of the vaccine, though immunologically effective is known to cause significantly high fevers and reactions in some persons. This is perhaps even more likely among measles-free peoples. The concomitant use of gamma globulin would help modify the reactions but in the absence of gamma globulin, measles vaccination is still considered very much worth the risks providing certain precautions are taken, i.e.:

1. avoid vaccinating infants especially under 1 year of age, tuberculosis patients, acutely ill people, and persons who are old and/or infirm.

2. *vaccinate only half the able-bodied village population at one time so the unvaccinated individuals will be able to care for the needs of the vaccinated ones* [italics added]

3. vaccinate populations which can be observed during the resting period (8–12 days post vaccination) so that any high fevers can be treated with aspirin and fluids and any bacterial complications treated with antibiotics or sulfa drugs.

4. alert the people being vaccinated that they may feel a bit ill from the vaccination but not as badly as the disease from which they are being protected.

The vaccination causes what is essentially a mild case of measles which is not contagious from one person to another."

¹⁹The entry reads as follows:

1. Gamma globulin is effective in modifying the clinical course of measles only before the rash appears.

2. Accordingly, give gamma globulin only to those Indians at Ocamo who were not vaccinated and who are not sick with measles. By our calculation this should be ± 20 people. We are sending 60cc of gamma globulin to them, to administer as .1cc per kilogram.

3. We believe it wise to give Depo Penicillin to the Indians who are most ill. Send 20 doses of Bicillin, all we can spare if we anticipate troubles at Mavaca. In this ___?___ the current epidemic of "grippe" could interact deleteriously with the measles.

4. There are five chief portals of entry on the Orinoco: Padamo, Ocamo, Mavaca, LeChosa, and Platanal. Since we sent vaccine with Cecil to Padamo two days ago, since Bill is about finished vaccinating at Mavaca, and with the Ocamo situation, the first three are now covered. We will send the two Makiritare S.A.S. people at Mavaca to vaccinate LeChose (a village on the river between Ocamo and Mavaca, and also at Yabrobatedi, first village up Ocamo. Will try to arrange for vaccination at Platanal.

5. Suggest the Ocamo mission request 200 doses of Depo Penicillin for use along Orinoco.

6. Isolate and vaccinate all visitors coming to any place there is vaccine. Send 20 doses to Ocamo for this purpose.

²⁰Open e-mail from Susan Lindee, historian at the University of Pennsylvania, dated Sept. 21, 2000, posted at <http://www.tamu.edu/anthropology/Lindee.html>

²¹Equipment for I.V.I.C.—University of Michigan study of Venezuelan Indians, stamped by U.S. Customs Jan 11, 1968, 7 pp.

²²Hill K. The ethics of anthropological fieldwork. <http://www.unm.edu/~kimhill/tierney/ethics.htm>

²³Hurtado AM, Hill K, Kaplan H, Lancaster J. The epidemiology of infectious diseases in South American Indians: a call for ethical research guidelines. <http://www.unm.edu/~kimhill/tierney/health.htm>

²⁴Paul D, Beatty J. James Neel, "Darkness in El Dorado and eugenics: the missing connection." Society for Latin American Anthropology e-Newsletter, number 17-18, Nov 1, 2000. <http://www.aaanet.org/slaa/newsletter.htm>

²⁵University of California at Santa Barbara, Preliminary report on the Neel/Chagnon allegations. Dec. 9, 2000. <http://www.anth.ucsb.edu/chagnon.html>, pp 19–30.

²⁶Schull W.J. E-mail to Duncan Thomas, Nov. 29, 2000.

²⁷Garon PA. ERDA (Energy Research and Development Agency) to fund mutation monitoring program (press release). Washington, DC: ERDA, Feb. 16, 1976 (http://search.dis.anl.gov/plweb-cgi/mhrexpage.pl?0703038+1+2+_free_user_+1%2bminute+60+0+unix+12502+table+mhrex-user+query+doe:dod:hhs:cia:va:nrc:+neel).

²⁸Letter from W.N. Valentine to Newton Morton, Nov. 20, 2000.

²⁹<http://www4.nationalacademies.org/nas/nashome.nsf/b57ef1bf2404952b852566dd00671bfd/57065f16ff258371852569920052d283?OpenDocument>

³⁰The UCSB report <http://www.anth.ucsb.edu/discus/html/messages/62/103.html?976418030>, Chapter 3, The Napoleonic Wars.

³¹Smouse P. E-mail to Duncan Thomas, Nov. 28, 2000.

³²Neel JV, Schull WJ. Area program in population genetics. University of Michigan application to the U.S. AEC for 11/1/65–10/31/66, Proposal number ORA-65-840-F1, pp 8–9.