Experimental Wounds: Science and Violence in Mid-Century America

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Taken from a published report on wound ballistics research during World War II, Figure 1 depicts the abdomen of a cat that has been shaved, anesthetized, marked with a grid, and shot. The individual squares are frames, the caption says, "(2880 per second) from a high speed motion picture of a cat's abdomen, showing the volume changes and movements caused by a 6/32nd inch steel sphere." We can recognize in this image the conventions of scientific inscription. The technologies are sophisticated, quantitative, impressive. The image speaks for itself. Or does it? What exactly is happening when an anesthetized cat with a shaved abdomen painted with a grid gets shot, in a laboratory, and when that event is hyper-documented in high speed photographs, and deployed in a range of texts as evidence? And what do these human creations — these highly quantified experimental wounds — tell us about the culture and practice of twentieth-century science?

In this essay, I consider several forms of laboratory work that involved experimental injury relevant to human health that was quantified, studied, controlled and recorded in mid-twentieth century science and medicine in the United States. I also look at battlefield wounds, which were medical resources commonly construed as scientifically useful by virtue of their abundance, even though they could not be experimentally produced and controlled. I construe the study and analysis of wounds and experimental injuries as an unremarkable practice of scientific and medical knowledge making. Nothing I consider here is unusual. Rather, my intention is to focus on what is usual, common, quotidian and to suggest that the commonality, the ubiquity, of the experimental wound calls us to attention and should attract our notice because of its normality. To draw on the once-very-popular ideas of the late philosopher of science Thomas Kuhn, who in his book *The Structure of Scientific Revolutions* said that most scientific research was puzzle-solving within existing theories and paradigms, I would characterize these research programs as Kuhnian normal science, not the cutting edge of knowledge production, but the everyday business of highly trained experts in industrialized nations between 1900 and 2000.[1] For someone seeking to understand any culture, the unexceptional acts might be presumed to be those most

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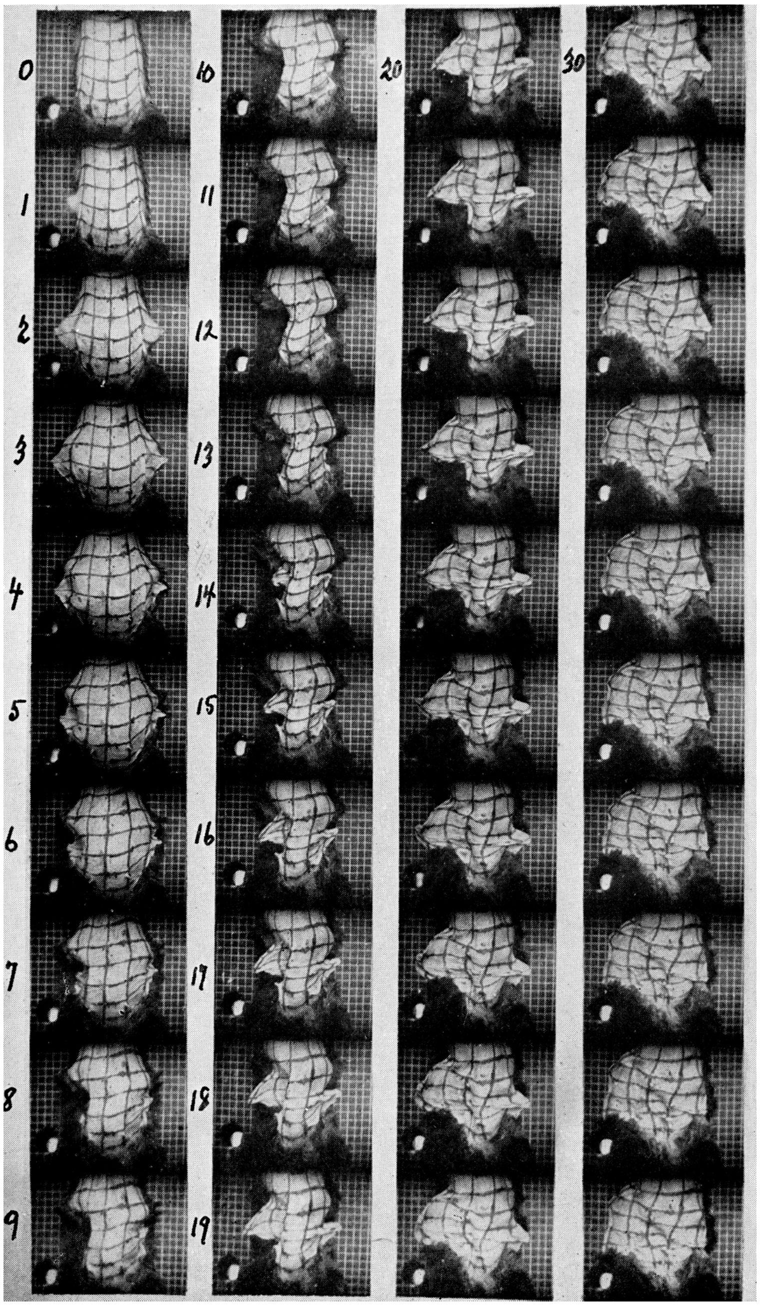
Figure 1

"From a high speed motion picture of a cat's abdomen, showing the volume changes and movements caused by a 6/32nd inch steel sphere," in E. Newton Harvey, "Studies on Wound Ballistics," in E. C. Andrus, D.W. Bronk, G.A. Carden, Jr., C. S. Keefer, J. S. Lockwood, and J.T. Wearn, eds., *Advances in Military Medicine*, vol. 1 (Boston: Little, Brown and Company, 1948): 191-205, at 202.



illustrative of social consensus. But what sort of consensus is involved in experimental violence?
I here suggest three things:

First, violence was central to twentieth-century technical knowledge systems, certainly in the United States and also (presumably, though I have studied them less thoroughly) in other industrialized and militarized nations. The relevance of medicine, engineering and science to the state's monopoly on violence shaped these forms of systematic human inquiry over the last century in many ways that we are only now beginning to notice and explore. Technical knowledge was relevant to violent conflict as far back in human history as we can see through textual and archeological records, but in the twentieth century the scale and scope of that relevance reached new and critical levels. Experts became deeply engaged with the technical production of violent injury to human beings. I am purposely using the word violence as a reference to the sociologist Max Weber's characterization of the modern state. Weber famously said in 1919 that the state holds a monopoly on socially-sanctioned violence and depends on the threat of violence for its power.[2] In the course of the twentieth century, I suggest, violence or implied violence or threatened violence became the purposive outcome of a wide range of intellectual, scientific, medical and technological labor.

My second claim is that the battlefield over the last century became a crucial field laboratory, and this laboratory produced what we might call collateral data, analogous to the "collateral damage" that is generally seen as unavoidable in modern, high technology war. Just as battles have produced "unintended" destroyed villages or dead civilians, so too they generate information that is not the direct purpose of the battle.[3] The United States did not bomb Hiroshima and Nagasaki, for example, as a scientific test. But the two cities became a scientific resource after the fact, for studies of both the biological effects of radiation, and of the physical damage produced by nuclear weapons.[4] I wish to suggest that in the course of the twentieth century, battlefields increasingly came to be understood by scientists, engineers, physicians and even military and political leaders as open-air laboratories, and testing grounds for new technologies and new ideas — for tanks, psychological theories, healing therapies, shock treatments and so on. The claim that war is "good for" medicine refers to the experimental and experiential value of the battlefield for medical experts, but the battlefield laboratory also interested chemists, psychologists, statisticians, economists, engineers, fire control experts, entomologists, biologists and others. Indeed, one could argue that the battlefield has been one of the most important field laboratories in American science, far surpassing in resources allocated to it even the most lavishly funded academic or industrial centers.

Finally, I suggest that the experimental injuries documented in published papers, photographed, and discussed in archival records as evidence of nature are also themselves evidence of history. They enact or perform or make visible historical processes, of social expectation, and of shared, consensual belief. They were scientific evidence of natural processes for my actors, and for me, they are evidence of culture, social order, and history. As I noted before, the experimental injuring I track was not an aberration — not an abridgement of knowledge production as usual — but quintessentially normal, the product of a deep consensus that we are called upon as scholars to understand and elucidate. My primary interest is in science and what sort of activity *it* is: What kind of thing is this enterprise that has so deeply shaped our world?

So, I begin with a few laboratory projects that shed partial light on these questions.

First, I consider wound ballistics. Wound ballistics is not trauma research. Rather, it is a scientific program focused partly on how to make bullets more effective and more damaging, to maximize injury to people.[5] We might call wound ballistics the opposite of health research, or a form of public health in reverse, the term usually used for biological weapons.

Ballistics experts began shooting animals to test weapons in the 1910s (goats and cattle), but these weapons tests conducted in open fields were relatively crude and did not involve quantitative analysis of wound events. In 1943, E. Newton Harvey began shooting cats at Princeton University in order to test how bullets affected flesh. At the Biological Laboratories at Princeton University, Harvey had a team of five biologists, as well as ballistics and x-ray technicians. They were interested in producing experimental wounds in organisms about the size of soldiers, but for reasons of space and expense, settled on shooting cats and dogs. Harvey's team reduced the size of both missile and target in proportion — "A .4 gram missile moving 2,700 fps and striking a 3-kg animal represents a situation, so far as mass of missile and mass of target are concerned, analogous to those of standard army rifle ammunition and the human body."[6]

This group used high-speed cameras to take pictures at a rate of 8,000 frames per second of the "changes which occur when a high-velocity bullet enters soft tissue."[7] The wound occurs in a few thousandths of a second, but Harvey's team could make these rapid events visible, with high speed and x-ray photography. Different parts of the cat's bodies were shot and studied — heads, thighs, abdomens, femurs. Harvey's team wanted to quantify this damage and calculate the "law of force which retards the missile." They developed a retardation coefficient of living cat muscle that measured the loss of velocity which a sphere experienced in going through the thigh. In this way, wound events were carefully made into technical abstractions, which thereby enhanced their application to other problems. Their paper in 1948 proposed that it would be possible to use the equations based on their experiments to calculate "how many milligrams of TNT exploded within the body will produce a temporary cavity whose maximum volume is the same as that of a missile of a given weight striking the body with given velocity."[8]

Harvey was presumably not proposing that anyone planned to place carefully measured TNT in a human body and explode it. Rather, he was making a claim about the generality of his experimental wounds. His equations could capture the bodily effects on any type of tissue, of any form of energy. The cat was the surrogate soldier, the steel sphere the surrogate bullet, and the laws revealed in their interactions would apply everywhere. Increasing the ability of weapons to produce injury was a technical problem, and the right equation could characterize and reliably quantify the chaotic fleshly damage of the wound.

Now I want to turn to a very different kind of injury that began the same year, in 1943. Like Harvey's studies with cats, the electric shock studies with submarine crews were part of the mobilization of science under the U.S. Office of Scientific Research and Development (OSRD) and the National Defense Research Committee (NDRC). I call this study the real Milgram experiments. (Figure 2: "Electrical Circuits Used in the Reaction Time for Fusion Experiment).

The Milgram experiments were a series of social science studies carried out by Stanley Milgram at Yale University in the early 1960s. Research subjects were persuaded to believe that they were shocking other subjects as part of an experiment about learning skills and negative reinforcement. In fact, the subjects being "shocked" were pretending to be hurt, and those doing the shocking were the real focus of the research. A surprisingly high percentage of those participating were willing to inflict pain on other people when asked to do so by a white-coated male posing as a scientist. Milgram was interested in how and why so many German citizens participated in genocide, and his work did provide some insights into these questions, though it was later judged harshly as ethically dubious.[9]

Experiments involving actual electric shocks, however, were carried out during World War II at the

Figure 2

"Electrical Circuits Used in the Reaction Time for Fusion Experiment," from C. H. Graham, L. A. Riggs, N. R. Barlett, R. N. Berry, W. S. Verplanck, R. L. Solomon and C. G. Mueller, Project 44, Division 7, National Defense Research Council, "Research on the Selection of Service Personnel with Special Reference to Emotional Factors," a Report of Research on Selection Tests at the U.S. Submarine Base, New London, Contract No. OEMer-570 of the Office of Scientific Research and Development, OSRD Report No. 1770, Copy No. 25 of 150, Restricted. Declassified in 1946.

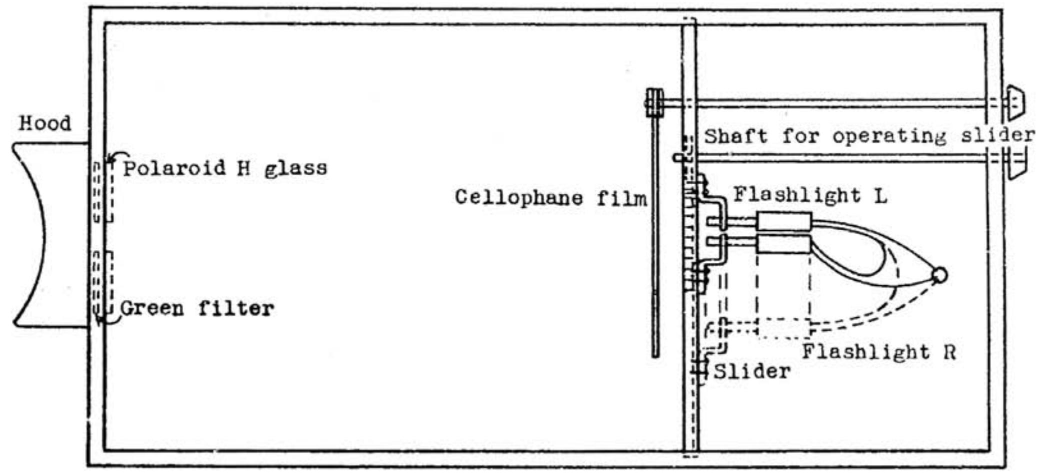


FIGURE A 1

A diagram of the visual apparatus used in the reaction time for fusion experiment.

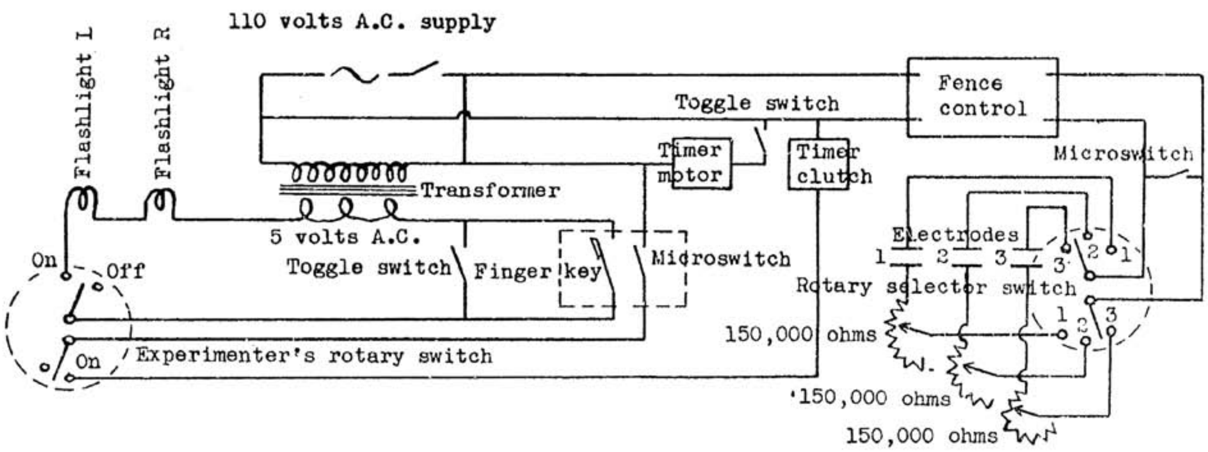


FIGURE A 2

Electrical circuits used in the reaction time for fusion experiment.

U.S. Submarine Base in New London, Connecticut, under the auspices of OSRD, Project 44, Division 7, in a "method for investigating the effects of emotional stress." Subjects were either shocked, made to believe that they would be shocked (but not shocked) or not shocked and not expecting shock. The goal was to figure out a way to assess individuals for their suitability for submarine command.[10] The apparatus required subjects to respond quickly to visual stimuli in order to avoid being shocked.[11] Seventy-five "representative Submarine School men" were tested who had already been assessed by psychiatrists as either good or bad (these were literally the terms used — good and bad). The goal was to determine whether the shock test correlated with the psychiatric evaluations — that is, could it predict as well as a psychiatric assessment whether a man were "bad" or "good."[12]

Leadership, then, looks like a mechanical circuit. Being a submarine commander is in some way equivalent to fusing two bright lights quickly; the stress of battle is like an electric shock. The layers here of metric and mechanical assumption involve a particular social performance, a drama with administrative goals: the body of the submarine crew member is cognitive, emotive and mechanical at exactly the same time; an electric shock is a good enough signal to track a quality of exquisite complexity, "leadership." What is the consensus here?

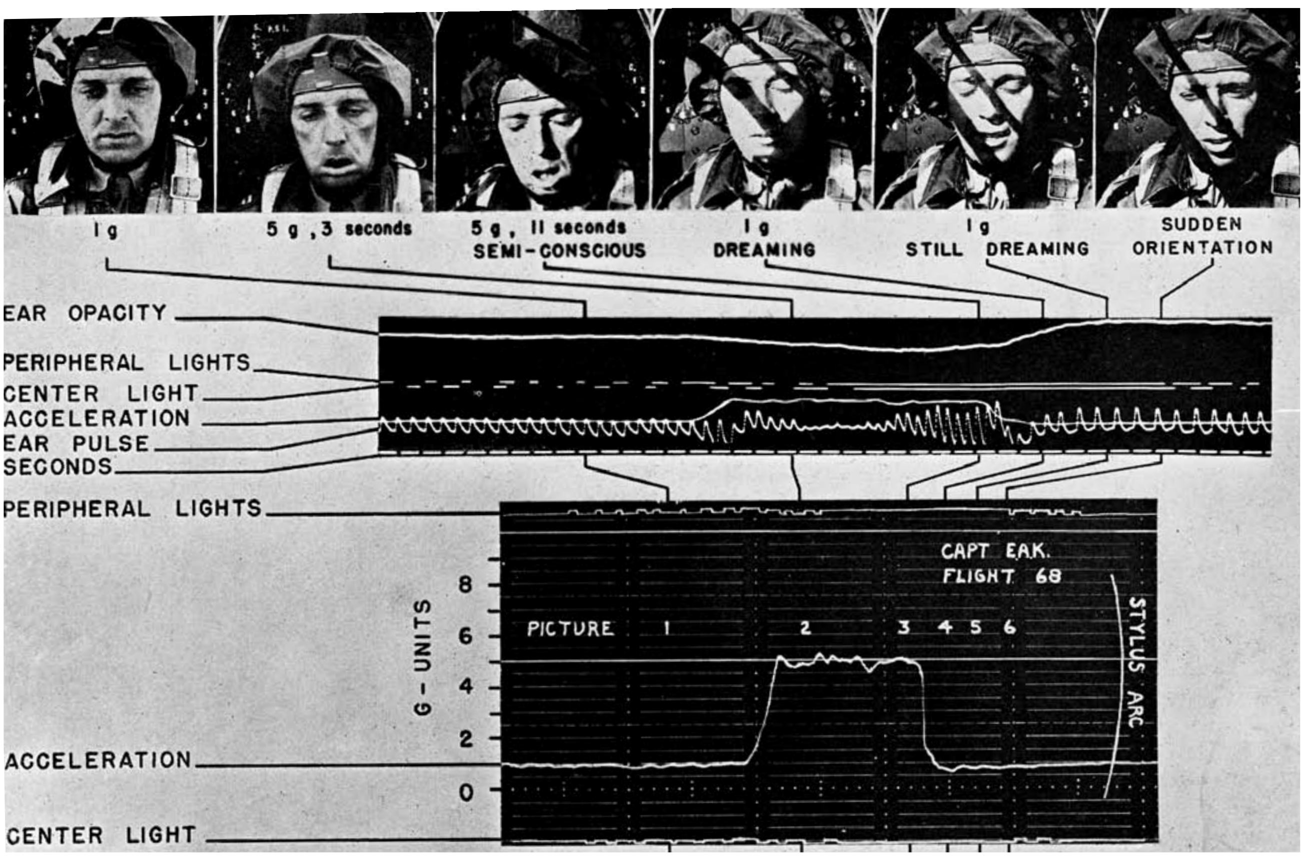
Experimental wounds in other research programs had a similar, related purpose. They were intended to identify the limits of the human body, and to decipher the differences between individuals in terms of how quickly they became nauseated, starved, unable to function due to cold or heat, or panicked as a result of stressful situations. Research programs focused on stressing the body in different environments were ubiquitous.[13]

By the late 1940s, for example, researchers in aviation medicine had a range of technologies that could mimic the nauseating, destabilizing experiences of flight, high altitude, and deceleration. They had altitude chambers, human centrifuges, and many kinds of devices that could induce motion sickness (Figure 3: The effect of +5G acceleration). The first human centrifuge in the United States was built at Wright Field in 1936, and during World War II, physician E.H. Lambert of the Mayo Aeromedical Unit developed real-time measuring devices and cameras that could record the "sagging of the loose tissues of the face, reduction of blood content of the ear, disappearance of ear pulse, blackout and semi-consciousness, followed by a period of disorientation, which persisted several seconds after return to 1G."[14] The human body's tolerance limits were thus mapped by injury to airmen.

Similarly, conscientious objectors agreed to be starved — to the point at which they could not walk — in a celebrated research program during the war by University of Minnesota physiologist Ancel Keys. In his two-volume 1950 book, *The Biology of Human Starvation,* still a canonical text in this field, he described this research. The work was relevant to soldiers and their needs, but also to the anticipated

Figure 3

"The effect of +5G acceleration," from E. M. Landis, "The Effects of Acceleration and Their Amelioration" in E. C. Andrus, D.W. Bronk, G. A. Carden, Jr., C. S. Keefer, J. S. Lockwood, and J. T. Wearn, eds. ,*Advances in Military Medicine,* vol. 1 (Boston: Little, Brown and Company, 1948): 232-262, at 251.



post-war situation in Europe — there were already, in late 1944, reports of emaciated residents in European cities. In November 1944 he began work with 36 COs in the Minnesota Starvation Experiment. His subjects were members of the Quakers, Mennonites, and peace churches, and were asked to go six months in a state of semi-starvation, eating turnips, dark bread, and macaroni, such that they would lose 2.5 pounds per week.[15] Some dropped out, but most stayed, becoming progressively weaker and disabled.

Similarly, in a 1948 field study in Manitoba, Canada, soldiers were subjected to extreme cold. Thirty-two Florida recruits — many of whom had never seen snow — were flown to spend two weeks in minus-35 degree weather in a "simulated survival situation" that tested the impact of extreme cold on nutrition and metabolism.[16] The men camped in a "bivouac region…chosen to assure isolation, desolation and open exposure to the wind."[17] Their responses became part of a technical chart, "Acute Exposure to Cold — Metabolism" (Figure 4).

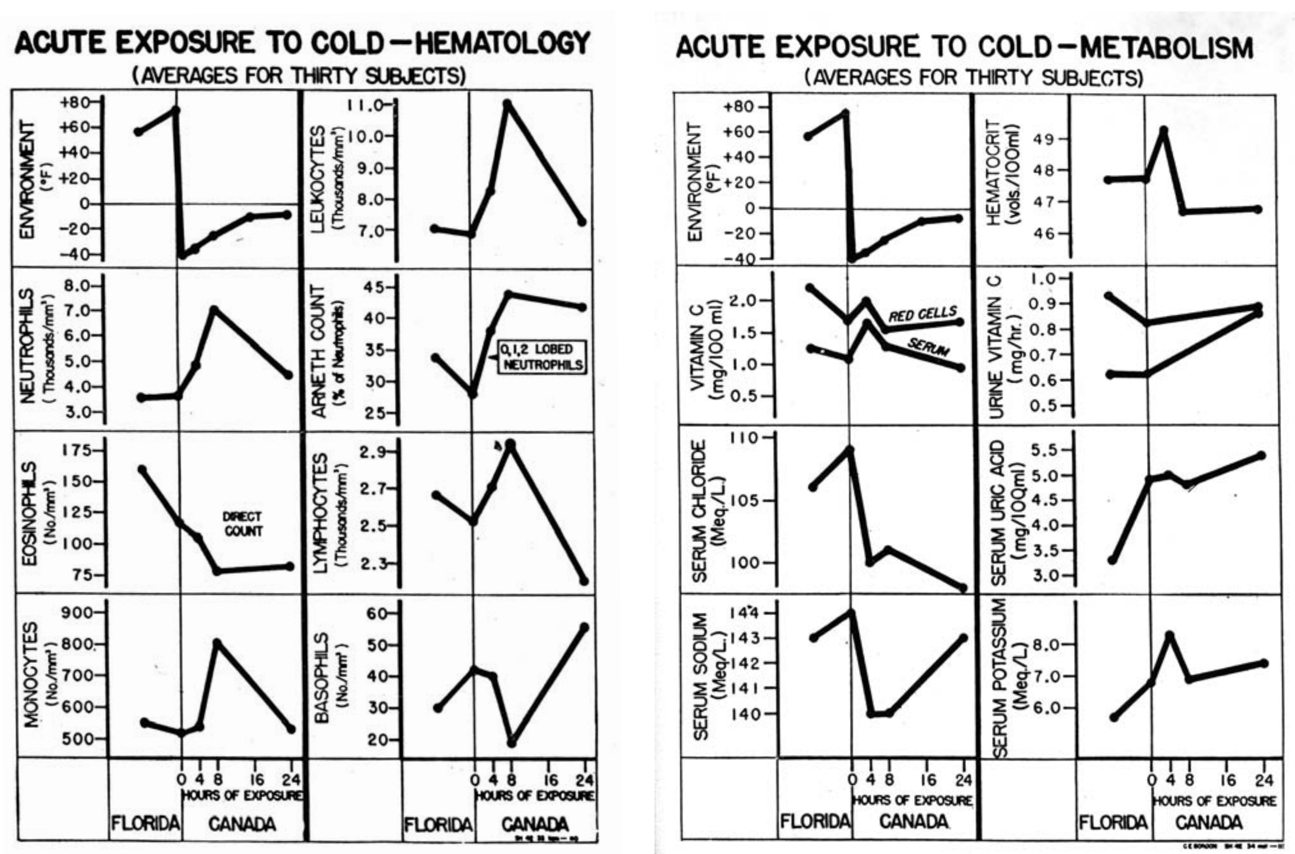
By placing subjects in conditions that mimicked real conditions of bodily risk, researchers mapped the borders of human tolerance and the limits of the human machine. They also tracked individual variations in the tolerance of such situations. Such information could provide guidance for administrative protocols for rations, cold weather gear, and G-force exposures. War was a domain of bodily extremes, and the sciences focused on wartime needs often focused on finding human limits, by producing experimental injury to human bodies construed as a technical resource.

I turn now to the experimental battlefield, where soldiers became the subject of scientific research in real time, providing collateral data, so to speak. The injuries of the battlefield were produced "naturally," and not by laboratory processes under controlled conditions, but they became statistical and mathematical resources by virtue of careful selection. Out of the abundance of grievous injury produced by modern weaponry, it was possible to cobble together something akin to a "controlled" and informative series of wounds.

In the mountains of Italy, on the Italian Front during the Second World War, the Harvard anesthesiolo-

Figure 4

"Acute Exposure to Cold — Metabolism," from Chauncey Bly et al., "Survival in the Cold," *United States Armed Forces Medical Journal* (1950)*:* 615-628, at 622-23.



gist Henry Beecher carried out a study of shock and of pain in severe wounding that drew on such field methods. Beecher was an important figure in the history of biomedicine. In the course of a long, productive career he theorized the placebo effect, wrote several papers that shaped the development of the Institutional Review Board system, and was lead author of a key report on brain death that facilitated the development of transplant surgery.[18] Beecher's ideas and views of medicine were arguably shaped by his early work studying shock in real time, with human beings who were on the brink of death.

The field project was a direct result of Beecher's own efforts. He argued to his superiors that "many of the urgent practical problems concerned with the relationship of anesthesia to shock can only be settled on human subjects where there is an abundance of material, namely, at one of the active fronts"[19] and the "opportunity of a generation, or perhaps many generations is slipping through our fingers."[20] In the summer of 1943, Beecher's appeals were finally effective. He was commissioned in the U.S. Army, and sent to North Africa as a consultant in resuscitation and anesthesia. He spent 25 months in active service, in Africa, Italy and France, with a traveling research team of six surgeons, one chemist, two nurses, and ten clerks, drivers, technicians and other staff. This group, with its mobile laboratory and seven pyramidal tents, traveled throughout Italy, from the 19th of September 1944 until mid-May 1945, tracking "maximum military activity" — it followed the bodies, so to speak, collecting 186 seriously wounded men for study. (Figure 5: Beecher and his team).

Beecher's methods in this field research are instructive. He selected major injuries in certain categories, in a systematic, quantitatively balanced series: 50 soldiers who had penetrating wounds of the thorax, 50 with penetrating wounds of the abdomen, 50 with compound fractures of long bones, 50 extensive crushing injuries, and 25 others with different kinds of head injuries. On an active battlefield, such experimental material was readily available.[21] Beecher selected representative wounds, wounds that he presented in various publications as equivalent to those produced by auto accidents and other civilian traumas.[22]

Beecher's example was invoked as the model when the Korean War broke out. From June of 1950, when the war began, until July of 1953 when it ended with an armistice agreement that established a permanent demilitarized zone between North and South, the battlefields of the Korean War were more or less constantly functioning as field research sites. Korea became a grand, moving, surging experiment in gastric secretion, adrenal function, muscle metabolism, the natural history of wounds, the technologies of bullet-proof vests, the psychology of battle, the absorption of glucose and circulatory homeostatis after massive injury.[23] "Combat as it occurs in war affords a unique opportunity for such studies and there is a great need for development along this line...[S]elected healthy young adult males in excellent physical condition, severely injured by high-velocity missiles incurred during combat, urgently need better medical care than civil medicine can provide by its normal development."[24] Field studies included work with "control" soldiers who were not in combat — those working in non-combat areas — and calculations of standardized wound events.

Figure 5

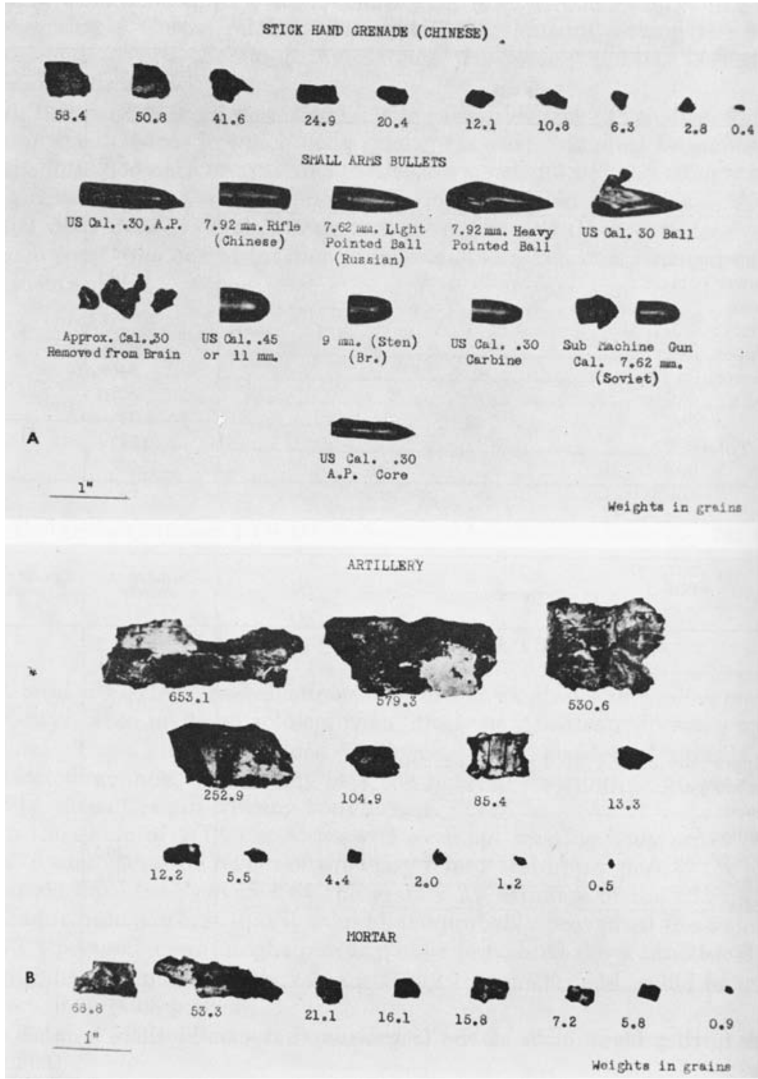
Beecher and his team in the Italian Alps, 1944-45: from Board for the Study of the Severely Wounded, *The Physiologic Effects of Wounds: Surgery in World War II* (Washington, D.C.: Office of the Surgeon General, Department of the Army, 1952). This photo is the frontispiece.

So, I return to wound ballistics. Wound ballistics studies in Korea were among hundreds that were integrated into war plans. In the charts and diagrams that made up most of their final report at the end of the war, the wound ballistics team in Korea presented data on 7,773 wounds in 4,600 persons. Through their careful analysis of historical data, front-line events and soldiers' bodies, they found that much of the ammunition on the battlefield was basically wasted. Most fragments from most bombs hit no one, and small arms killed or wounded very few soldiers. Only 7.5 percent of all casualties were caused by small arms, while 92 percent of casualties were the result of mortar and grenade fragments. Like geologists or ornithologists, they collected field objects that could be placed in relationship to each other and to their natural consequences. Fragments of bombs and grenades from killed soldiers were placed in order to compare their size and shape.[25] (Figure 6: "Typical fragments and missiles removed from casualties in Korea".)

Other wound ballistics groups in the 1960s used historical data to map the vulnerability of the body. Experts catalogued wounds and mortar fragments using the methods of natural history: They classified, compared, measured and named the fragments and wounds that formed the basis of their results.[26] The fragments collected from a World War II German shell were organized by size and laid out in sequence (Figure 7, "Fragments recovered from a German 75 mm. high explosive shell"). Bits of missiles linked only by their outcome — all had been found in persons fatally wounded by other projectiles — were clustered together for analysis (Figure 8: "Secondary missiles miscellaneous"). A human face was marked with the locations at which fragments of plexiglass had caused injuries in one chart (Figure 9, Location of 85 wounds XX). One particularly striking composite image (Figure 10: "Anatomic Location of 6,003 hits on 850 KIA due to shell fragments") shows the locations of all wounds on 850 Killed in Action (KIA) in World War II in Italy, all superimposed on a single male body. The patterns reveal where a hit is most likely to kill, providing guidance to snipers, ballistics experts developing anti-personnel weapons, and chemists and engineers responsible for the development of body armor. The map of the 850 KIA inscribed knowledge to heal and knowledge to injure, in a single image.

Figure 6

"Typical fragments and missiles removed from casualties in Korea," in J. Boyd Coates, editor in chief, *Wound Ballistics* (Washington, D.C.: Office of the Surgeon General, Department of the Army, 1962): 734.



Conclusion

I want to conclude by referencing a phrase that appears again and again in professional society codes of ethics or statements of purpose: The welfare of mankind.

The Association of Pasadena Scientists, founded late in 1945 as a response to the growing controversy over the use of atomic bombs, was intended help experts meet the "apparent responsibility of scientists in promoting *the welfare of mankind* and the achievement of a stable world peace."[27] Forty years later, in 1985, the American Society of Microbiology, after several decades of debate and contention, published a code of ethics that took an explicitly critical perspective on biological weapons research.[28] Two provisions of this code are relevant: First, it said that microbiologists "will discourage any use of microbiology contrary to the welfare of humankind" and second, microbiologists are "expected to communicate knowledge obtained in their research through discussions with their peers and through publications in the scientific literature."[29] Other societies, like the American Association for the Advancement of Science and the American Chemical Society, also adopted provisions in the 1960s and 1970s, that stated that science was intended to facilitate the welfare of mankind.

Was it necessary to have a code of ethics of a special society to promote this? That science was intended for the welfare of mankind? And that scientists, physi-

Figure 7

"Fragments recovered from a German 75 mm. high explosive shell," in J. Boyd Coates, editor in chief, *Wound Ballistics* (Washington, D.C.: Office of the Surgeon General, Department of the Army, 1962): 64.

cians and engineers should not do things that injured human beings?

Here is one of the deepest tensions: Experts trained and socialized to see their labor as benefiting humanity were often in practice committed to the systematic technical production of human injury and to the scientific study of how to maximize it. Such injury could be produced in a dizzying array of ways: Weapons were not the only issue. Increases in the effectiveness of weapons enhance their capacity to injure enemy soldiers and civilians, and therefore protect allies and allied civilian populations, and the simultaneity of these consequences matters for my story.

The same dynamic operates in a less self-evident form: Technical innovations that protected or healed some individuals were commonly intended to allow those healed to be able to continue to injure others. So for example the Philadelphia physician Malcolm Grow, who became the first Surgeon General of the U.S. Air Force, developed body armor for pilots, electrically warmed clothing for flight crews, fire resistant neck protection, and special combat rations for long flights. In other words, Grow played a critical role in enhancing the survival of pilots and crews on bombing runs, and thereby enabling them to continue to drop bombs. In healing and protecting one group (flight crews) Grow facilitated injury to another group (people on the ground in targeted areas).[30]

Many times, in many different ways, knowledge has produced both healing and injuring at the same time. Different people benefit or suffer, and this perhaps has facilitated the radical disjuncture of the two effects in

Figure 8

"Secondary Missiles Miscellaneous," in J. Boyd Coates, editor in chief, *Wound Ballistics* (Washington, D.C.: Office of the Surgeon General, Department of the Army, 1962): 592.

so many contexts. But technologies and sciences that benefit some groups and damage others may in fact be the rule rather than the exception. The impact of technical innovation is lumpy, inconsistent, and shaped by the ways we organize people into societies, social groups, professions, classes, races and nationalities. This lumpiness characterizes many industrial enterprises, which produce consumer goods, for example, that benefit some populations, and also environmental problems that injure other populations. It is present, also, in medicine, where technologies can benefit some and damage others. Nowhere is it more overt and more dramatic than in the technical empires built around war.

Economists helped guide World War II bombing runs: if you knew how economies worked, you also knew how to undermine them;[31] urban fire control experts, who knew how to prevent cities from burning, also knew how to make them burn faster; and psychiatrists who understood the critical cornerstones of psychological health planned dirty tricks, propaganda campaigns, and strategies of torture.[32] The fact that those injured, in many of these cases, would be persons identified as enemies of the United States, has no particular bearing on the point, which is merely that in modern, high-tech warfare, healing and injuring often function together, simultaneously.

The wistful ethics codes, with their invocation of the "welfare of mankind," could be an index of this state: It was not at all clear what kind of research was conducive to the welfare of mankind. Much militarized

Figure 9

"Location of 85 Wounds due to Plexiglass Fragments," in J. Boyd Coates, editor in chief, *Wound Ballistics* (Washington, D.C.: Office of the Surgeon General, Department of the Army, 1962): 592.

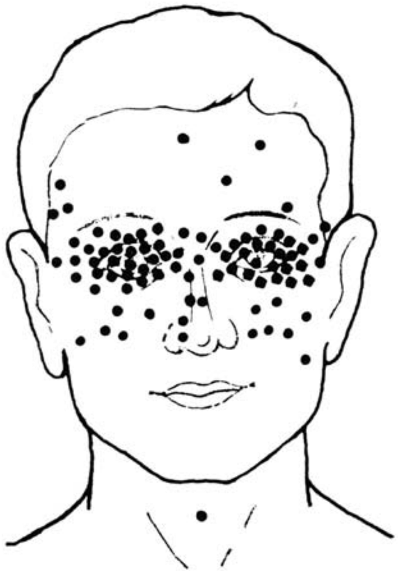
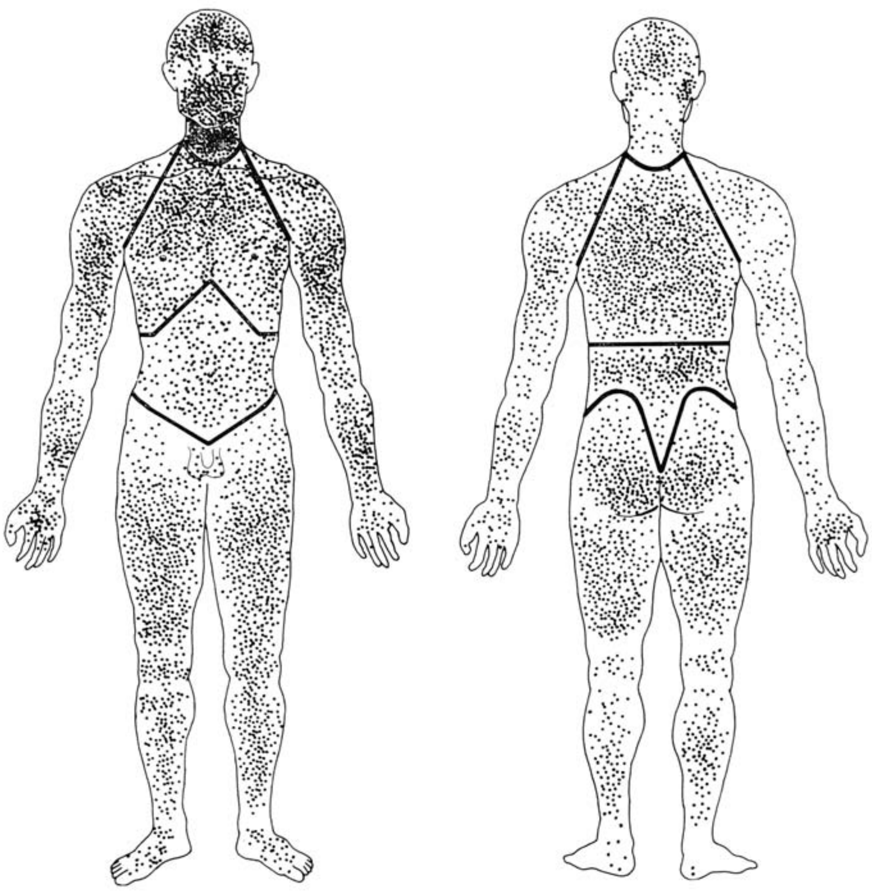


Figure 10

"Anatomic Location of 6,003 hits on 850 KIA due to Shell Fragments," in J. Boyd Coates, editor in chief, *Wound Ballistics* (Washington, D.C.: Office of the Surgeon General, Department of the Army, 1962): 849.



research produced both healing and injuring at the same time.

I proposed in my introduction that violence was central to twentieth-century knowledge systems, that the battlefield became a crucial field laboratory in this period, and that the wounds I consider, the experimental injuries documented in formal texts, are both evidence of nature and evidence of history. The early twentieth-century biologist and philosopher Ludwik Fleck suggested that those things seen to be neutral or rational — those things understood to be outside of the realm of emotion — are precisely the things around which crucial values and assumptions are expressed. Fleck, in his shrewd psycho-social analysis of knowledge and emotion, proposed that emotion is everywhere, in every act, and if and when emotion seems to disappear, then that point of disappearance is a point of critical consensus. It is as though neutrality and rationality were cultural blindspots in Fleck's eyes.[33] They were notions around which the consensus was so thick that emotion could seem to be absent. But what was the nature of the consensus that made shooting cats or starving soldiers or making pilots vomit emotionally flat, or neutral? What were participants agreeing about exactly? And how does the body look in this militarized logic? When the Yale physiologist John Fulton was helping to plan a wound ballistics program, he described the brain to a colleague as "a semi-fluid substance, suspended by fairly inelastic attachments in the cerebro-spinal fluid in a rigid box." This was a way of seeing the brain as a target for a bullet: Fulton selected those properties of the brain relevant to its demolition by firearms. How does the body look in this militarized logic?[34]

The intersection of violence and truth over the last century have produced phenomena that should puzzle us, give us pause, and lead us to wonder how the ideals of natural knowledge and intellectual neutrality became central to the state's monopoly on violence, how this shaped individual careers and trajectories, what it meant for scientists and what it has meant for us. The experimental wounds that I consider are evidence of a system of making sense of human relations and human knowledge. They make manifest what is possible, what is obvious, and what is unremarkable in a particular context.

References

1. T. S. Kuhn, *The Structure of Scientific Revolutions* (Chicago: University of Chicago Press, 1996).
2. Max Weber made this argument in his lecture "Politics as a Vocation," in 1918. The lecture was published in German immediately, and then subsequently in translations in 1919. It is readily available in complete form on the web, *available at* <http://blogs.law.harvard.edu/guorui/files/2007/11/weber.pdf> (last visited December 16, 2010).
3. I use the term "collateral damage" advisedly, and am sympathetic to the critiques of Elaine Scarry and others that the term is automatically suspect. See E. Scarry, *The Body in Pain: The Making and Unmaking of the World* (Oxford: Oxford University Press, 1985).
4. My own study of the Atomic Bomb Casualty Commission is S. Lindee, *Suffering Made Real: American Science and the Survivors at Hiroshima* (Chicago: University of Chicago Press, 1994).
5. See also Larry Owens' evocative discussion of this research in L. Owens, "The Cat and the Bullet: A Ballistic Fable for the Modern World," *The Massachusetts Review* 45, no. 1 (2004): 178-190. Also see Eric Prokosch's fascinating and often overlooked study of the development of anti-personnel weapons, E. Prokosch, *The Technology of Killing* (London: Zed Books, 1995).
6. H. E. Newton, J. H. McMillen, E. G. Butler, and W. O. Puckett, "Mechanism of Wounding" *Wound Ballistics*, J. Boyd Coates Jr., J. C. Beyer, and L. D. Heaton, eds. (Washington, D.C.: Office of the Surgeon General, Department of the Army): 143-235, at 147.
7. *Id*, at 143.
8. E. Newton Harvery, "Studies on Wound Ballistics" *Advances in Military Medicine,* volume 1, E.C. Andrus, D. W. Bronk, G. A. Carden, Jr., C. S. Keefer, J. S. Lockwood and J. T. Wearn, eds. (Boston: Little, Brown and Company, 1948): 191-205, at 197.
9. See T. Blass, *The Man who Shocked the World: The Life and Legacy of Stanley Milgram* (New York: Basic Books. 2004).
10. See C. H. Graham, L. A. Riggs, N. R. Barlett, R. N. Berry, W. S. Verplanck, R. L. Solomon, and C. G. Mueller, Project 44, Division 7, National Defense Research Council, "Research on the Selection of Service Personnel with Special Reference to Emotional Factors," *A Report of Research on Selection Tests at the U.S. Submarine Base*, New London, Contract No. OEMer-570 of the Office of Scientific Research and Development, OSRD Report No. 1770, Copy No. 25 of 150, Restricted. Declassified in 1946. There is a microfilm copy of this report at the University of Pennsylvania. Penn's microfilm copy was made from a copy at Brown University, but the Brown library no longer lists it.
11. In the protocol, the subject looked into a darkened interior of a portable box where he would see two spots of green light, one to stimulate the left eye and one the right. He was asked to purposively "fuse the two spots to a single spot as rapidly as possible after the two-spot stimuli flash." In the "apprehension" trials, the threat of shock was presented, but subjects were not in fact shocked. They had, however, been shocked in advance when the "intensity of the shock" to be used with each individual was calibrated – it had to be enough to produce a vigorous contraction of leg muscles. When this intensity of stimulation had been determined, the subject was reseated at his place in front of the apparatus and the electrodes were replaced. The subject was told, basically, that the shock could come at any time, either before the lights appeared or after, in random sequence. "The warning interval employed is four seconds...." *Id.*, at A7.
12. *Id.*, at A8.
13. The historian of medicine Sarah W. Tracy, Director of the Medical Humanities Program in the Honors College at the University of Oklahoma, has been developing a scholarly examination of Ancel Keys, his starvation studies, his role in developing the K Ration, and his larger story, of a 70-year career in the evolving context of the human and biomedical sciences. Tracy's work is not yet published but it promises to be an important scholarly account of these studies. See also T. Tucker, *The Great Starvation Experiment: Ancel Keys and the Men Who Starved for Science* (Minneapolis: University of Minnesota Press, 2008).
14. E. M. Landis, "The Effects of Acceleration and Their Amelioration," *Advances in Military Medicine,* volume 1, E. C. Andrus, D. W. Bronk, G. A. Carden, Jr., C. S. Keefer, J. S. Lockwood,

and J. T. Wearn, eds. (Boston: Little, Brown and Company, 1948): at 232-262.

15. See *supra* note 13.
16. The 32 heat-acclimatized men were transported by air from MacDill Air Force base in Florida to Camp Shilo, Manitoba, Canada, in January 1948. The goal was to understand the effects of severe cold on metabolism, dietary requirements, and the adrenal system. The men were exposed to severe cold and limited caloric intake for 12 days in minus 35 degree weather. "The bivouac region was chosen to assure isolation, desolation and open exposure to the wind." Their urine and blood were monitored. They stayed in tents, had standard cold weather soldiers gear, and were divided into four groups of 8, with each group on a different ration. "As a psychologic strategy to insure the continuity and reliability of the last days' observation, the subjects and staff were led to believe that they would be 'rescued' on the fourteenth day at the earliest." They were suddenly rescued on the evening of the twelfth day, when they were quickly transported to a warm building in Camp Shilo. All from C. Bly et al., "Survival in the Cold," *United States Armed Forces Medical Journal* (1950): 615-628. (please provide issue number.)
17. *Id.*, at 620.
18. Considering his important role in twentieth-century American medicine, it is odd that Beecher has been the focus of relatively little historical, scholarly research. Jonathan Moreno discusses some of Beecher's work in his 2000 book J. Moreno, *Undue Risk: Secret State Experiments on Humans* (New York: Routledge, 2000). See also V. Kopp, "Henry K. Beecher, M.D.: Contrarian (1904-1976)," *American Society of Anesthesiologists Newsletter* 63, no. 9 (1999), *available at* <http://www.asahq.org/Newsletters/1999/09_99/beecher0999.html>, which at least raises some key issues. Kopp proposes that "Henry Knowles Beecher, M.D., is one of the most influential personalities in the history of anesthesiology and medicine. The list of his achievements, honors and publications is as impressive as the role of medical leaders he mentored. Yet Beecher remains a hidden presence behind the visible facade of modern medicine. To those who knew him, he was gregarious, imposing and energetically committed to controversy. To those who opposed him, he was a genteel but persistent adversary. It is impossible to conceive of modern medicine without his contributions, all of which derive from his contrarian views on a wide range of important issues. His legacy is the influence that his views and work have had on medical science, academic anesthesiology, medical ethics and society's standards regarding patients' rights and the definition of death." The historian of medicine Lara Freidenfelds won the 2001 Shryock Medal from the American Association for the History of Medicine, for a paper about Beecher's campaign, entitled "Recruiting Allies for Reform: Henry Knowles Beecher's 'Ethics and Clinical Research'" but I cannot find a record of the publication of this paper as of July 2010.
19. Letter, H. Beecher to A. N. Richards, October 16, 1942, in Folder 10, Papers of Walter B. Cannon, Countway Medical Library, Boston, MA.
20. *Id.*
21. Patients were selected who were clear mentally and who were not in shock when they were questioned. Selection also involved some judgment about which wounds were primary: Beecher noted "Men wounded in battle usually have multiple wounds. The categories listed [used to choose subjects] refer to the chief wound." H. Beecher, "The Control of Pain in Men Wounded in Battle," *Surgery in World War II, General Surgery,* vol. II, J. B. Coates, ed., (Washington, D.C.: Medical Department of the United States Army, 1955): 41-52.
22. Beecher, *id.*, at, 43.
23. J. M. Howard, ed., *Battle Casualties in Korea: Studies of the Surgical Research Team* (Washington, D.C.: Army Medical Service Graduate School, Walter Reed Army Medical Center, 1955).
24. W. Stone foreword in Howard, *id.*, at iii.
25. J. Boyd Coates, ed., *Wound Ballistics* (Washington, D.C.: Office of the Surgeon General, Department of the Army, 1962). See particularly 734-737 and Appendix H, 843-853.
26. From November 1950 until May of 1951, Carl M. Herget, an Army PhD who had been working for several years on body armor, Captain George Coe, a member of the chemical corps, and physician Major James Beyer of the Medical Corps worked together in Korea. They were the Wound Ballistics Survey of the Medical Research and Development Board of the Surgeon General's Office of the Department of Army. Their survey included studies of wound events produced on the battlefield, and of body armor and its protective qualities. A very detailed history of their work is available digitally, *available at* <http://history.amedd.army.mil/booksdocs/wwii/woundblstcs/chapter12.2.htm> (last visited December 16, 2010).
27. The collected papers of the Association of Pasadena Scientists are held at the University of Chicago archives and the phrase "welfare of mankind" appears quoted in the guide to the collections: "The Association of Pasadena Scientists was founded late in 1945 as a response to the growing controversy over the use of atomic energy. Membership in the organization was open to scientists, graduate students, and technicians in the Pasadena area. The main purpose of the group was "to meet the increasingly apparent responsibility of scientists in promoting the welfare of mankind and the achievement of a stable world peace." The records of the Association of Pasadena Scientists cover the period 1945 to 1946 and include press releases, statements and correspondence of members of the Association. *Available at* <http://ead.lib.uchicago.edu> (last visited December 16, 2010).
28. G. H. Cassell, L. A. Miller, and R. Rest, "Biological Warfare: Role of Scientific Societies," in R. A. Zilinskas, ed., *The Microbiologist and Biological Defense Research: Ethics, Politics and National Security*, in the *Annals of the New York Academy of Sciences*, vol. 666 (New York: New York Academy of Sciences, 1992): 230-238.
29. *Id.*
30. Grow, 1887-1960, was the first Surgeon General of the U.S. Air Force, and the author of an autobiographical account of his time at the Russian front in World War I, *Surgeon Grow: An American in the Russian Fighting* (New York: Frederick A. Stokes, 1918). He was deeply involved in interwar biomedical research relating to aviation and in 1941 published H. G. Armstrong and Grow, *Fit to Fly; A Medical Handbook for Fliers* (New York: D. Appleton-Century, 1941).
31. There is a fascinating discussion of this in L. Eden, *Whole World on Fire: Organizations, Knowledge and Nuclear Weapons devastation* (Ithaca: Cornell University Press, 2004). See also, for a somewhat different use of economic knowledge as an aid to government policy, J. Perkins, *Confessions of an Economic Hit Man* (San Francisco: Berrett Koehler Publishers, 2004).
32. On psychological warfare, see A. B. Gilmore, *You Can't Fight Tanks with Bayonets: Psychological Warfare Against the Japanese Army in the Southwest Pacific* (Lincoln and London: University of Nebraska Press. 1998).
33. Fleck's work is now widely used, but the first English translation of his most influential book, published originally in German in 1935, appeared from the University of Chicago Press in 1979, edited by T. J. Trenn and Robert Merton, and with a forward by Thomas Kuhn as X. Fleck, *The Genesis and Development of a Scientific Fact* (Chicago: University of Chicago Press, 1979). Virtually ignored during his own lifetime, it is now a staple in history of science programs.
34. J. F. Fulton to E. N. Harvey, September 29,1943. Papers of E.N. Harvey, American Philosophical Society, Philadelphia, PA.