



Big Science: Ernest Lawrence and the Invention that Launched the Military-Industrial Complex

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From a Pulitzer Prize winning journalist and *Los Angeles Times* contributor, the untold story of how science went big, built the bombs that helped win World War II, and became dependent on government and industry and the forgotten genius who started it all, Ernest Lawrence.

Since the 1930s, the scale of scientific endeavors has grown exponentially. Machines have become larger, ambitions bolder. The first particle accelerator cost less than one hundred dollars and could be held in its creator's palm, while its descendant, the Large Hadron Collider, cost ten billion dollars and is seventeen miles in circumference. Scientists have invented nuclear weapons, put a man on the moon, and examined nature at the subatomic scale all through Big Science, the industrial-scale research paid for by governments and corporations that have driven the great scientific projects of our time.

The birth of Big Science can be traced to Berkeley, California, nearly nine decades ago, when a resourceful young scientist with a talent for physics and an even greater talent for promotion pondered his new invention and declared, "I'm going to be famous!" Ernest Orlando Lawrence's cyclotron would revolutionize nuclear physics, but that was only the beginning of its impact. It would change our understanding of the basic building blocks of nature. It would help win World War II. Its influence would be felt in academia and international politics. It was the beginning of Big Science.

This is the incredible story of how one invention changed the world and of the man principally responsible for it all. Michael Hiltzik tells the riveting full story here for the first time.

Big Science: Ernest Lawrence and the Invention that Launched the Military-Industrial Complex Details

Date : Published July 7th 2015 by Simon Schuster

ISBN : 9781451675757

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Format : Hardcover 528 pages

Genre : History, Science, Biography, Nonfiction, Technology, Politics, Business

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From Reader Review Big Science: Ernest Lawrence and the Invention that Launched the Military-Industrial Complex for online ebook

cardulelia carduelis says

This book is, somewhat, an answer to the question of how we went from the age of a few people working on small setups in elementary physics, to the behemoth collaborations that make up the modern frontier: such as the ATLAS and CMS experiments at CERN.

But it's also a look at scientific personalities in the 40's and 50's: how a willingness to appease government counted for more than consistent, cautious criticism. How far ambition and convenient timing could go to fund the most destructive and preposterous efforts in the name of peace. Because whilst this book spends a great deal of time and effort on the advent of Big Science, its also a total character assassination of Ernest O. Lawrence.

What struck me most, when reading Big Science, was how much Lawrence was willing to give up in the name of getting ahead. He sacrificed good science and staff in his early running of the Rad. Lab, he removed himself from family life during the Manhattan Project, he deserted any hint of morality in his post-war actions, in both the push for the H-bomb and the trial-by-character of Oppenheimer, and, ultimately, he sacrificed his health and life in his drive to stay on top.

Despite that, much of his early spirit in collaborative working is still held strong in the particle physics groups I've worked in at Berkeley and Cern. In both places a good idea or suggestion can come from an individual of any rank or experience, results and data lie in the public domain for anyone to play with and all members are expected to have knowledge of the bigger picture, and not be isolated in their own research. However, the less pleasant aspects of his management style: that staff should be on hand 24 hours a day, that graduate students are expendable, have, thankfully, gone out of fashion.

Hiltzik is a master storyteller as very little of this book dragged - quite a feat given that huge swathes of it are dedicated to various committees on scientific policy making. It's a fun and entertaining read that doesn't shy from delivering in-depth explanations on the actual experiments being performed at the time, whilst also putting them in the context needed for a non-expert to appreciate their significance.

There's also a good 40 pages of chapter-by-chapter references to the material Hiltzik dredged up to put this book together, which is always appreciated.

This is an excellent read for a modern physicist trying to come to terms with how the way science was done has changed in the last 50 years but its also a cautionary tale of the role of ambition in the field and how it can be easily exploited by a trigger-happy government. A lesson which feels more relevant today than it ever did. Required reading for the modern PhD student. A++.

Geoff Habiger says

Michael Hiltzik's Big Science is a hugely interesting and fascinating look into the world of physics, and physics' interaction with government and industry, during the first half of the 20th Century. Big Science is mostly a biography about Ernest Lawrence, the inventor of the cyclotron, and also the inventor of the concept of "Big Science" - that scientific advancement needs to have patrons with deep pockets (namely the

government and industry) to fund the large scale projects necessary to advance our knowledge of the universe.

Hiltzik does a wonderful job of weaving the story of Ernest Lawrence - who became a leading figure in high energy physics and was director of the UC Berkeley Radiation Laboratory, and the Livermore National Lab (now the Lawrence Livermore National Laboratory) - with the history of discovery around the mysteries of the atom and particle physics. We see the development of the cyclotron (the first particle accelerators) and how the cyclotron, and the research performed by Lawrence and the many physicists and chemists that he collected at the Rad Lab, led to the development of the first nuclear reactors and the atomic bomb. Hiltzik does a great job of showing Lawrence's passion for the science, and the near mania for national security and nationalism that led to the development of the hydrogen bomb after World War 2. Through it all we get a detailed view of the policies and politics (both national and personal) that shaped the world before, during, and after World War 2 and into the Cold War.

Big Science is a great read for anybody with an interest in science history, US history, and the history of World War 2 as Hiltzik weaves many separate histories and lines of inquiry to show how all of these areas coalesced in the mid-20th Century. I highly recommend this book as an in depth look into the life of Ernest Lawrence, and how his vision for "Big Science" dominated the discipline of physics for over 40 years, and still has an impact to this day.

Craig Fiebig says

While titled as a discussion of big science this book focuses most of its attention on the development of nuclear weapons. This is fine but other authors (Rhodes, et al) cover this topic sufficiently. The coverage of recent developments in big science revolve around the failures of funding stemming from an inability to articulate a clear value proposition from the advocates. Readers conversant with the Manhattan Project can probably skip this one.

Jean says

I graduated from UC Berkeley and the names of Lawrence and Sproul are on buildings on the campus. When I was in school my professors had been trained or had worked with Ernest O. Lawrence (1901-1958) and Robert Oppenheimer (1904-1967). I found the book fascinating as it provided in-depth information about people and places I saw daily and knew only general information. I was most interested in learning about the early years of one of my former professors, which was mentioned in the book, Glenn T. Seaborg.

Hiltzik follows Lawrence's career from a graduate student at Yale to winning the Nobel Prize in 1939 through his work in World War II on the Manhattan Project. Hiltzik builds a case showing how Lawrence's works created the sprawling system of Government funded research laboratories we now know as the military industrial complex. In 1961 the chemical element Lawrencium was named in his honor.

The author goes into detail about how Lawrence conceived and built his first Cyclotron, or circular particle accelerator that used enormous magnets to hurl fragments of matter at one another at superfast speed. Hiltzik tells of his building the Lawrence Livermore Radiation Laboratory and his development of the hydrogen bomb. I knew about Lawrence's work on the uranium-isotope separation for the Manhattan Project, but I was surprised to learn about his work on developing the radar tube and the Lawrence Tube used to create color television.

Hiltzik discusses how other fields became interest in Lawrence's work such as the University's Medical School for use to treat cancer. Hiltzik shows how the government's canceling of the super conducting super collider in 1993 allowed Europe to take the lead in physics research.

The book is well written and meticulously researched. I found it an absolutely fascinating read. I read this as an audiobook downloaded from Audible. Bob Saouer did an excellent job narrating the book.

Delta says

This was a really interesting book on WWII and the cold war. As much about politics as science and even more about E. Lawrence than anything else. I can't say this is for everyone, but I think Hiltzik describes the science in a graspable way.

****I received a copy of this book in exchange for an honest review.****

Ashley says

While it certainly took me long enough to get through (about three months!), this book was a wonderful read that I'd highly recommend to anyone with overlapping interests in history, politics, militarism, science, the Cold War, investigative journalism, and/or great biography. No science background is necessary, but it helps to have some historical understanding of what led to mechanization of warfare in the 20th C. It's particularly good to keep Oppenheimer in mind throughout your reading, as you'll find yourself mulling over unintended consequences, regret, and post-objective fears in the scientific community. Strong recommend.

Josh says

Big Science by Michael Hiltzik is a book about both the man and the machine that shaped the course of history in the 20th century. But it is also much, much more. Besides following the career of Nobel Laureate Ernest Orlando Lawrence and his earth-shattering invention, the cyclotron, Michael Hiltzik pulls back the curtain on the true culture of science in the United States shedding light equally on both the good and the bad. Lawrence is the epitome of the highest tier of American Scientists, brilliant, excessively confident, impossibly demanding and indefatigable. Lawrence was the first of his peers to truly understand how to work the US grant system: make big promises, work your unpaid staff of graduate students, post-docs and visiting professors to the bone, deliver on the hardware but not on the science, and then repeat. Lawrence's legacy lives on throughout the physics community today where high priority is placed on funding the efforts of the large government labs while neglecting the smaller researchers and theorists who generate the true ideas and knowledge that moves science forward. But I digress. Big Science is a good, but not great book covering an very ambitious and historically relevant subject matter. The book is anachronistic for much of the early history of the Berkeley Radiation Lab making it difficult to make sense of Ernest's greatest successes and blunders. The book also oddly describes both Ernest Lawrence and Ernest Rutherford on a first name basis during critical junctures when there is ambiguity on which man is playing what role. Lastly, the book falls into a wikipedia mode too often in the later chapters, ignoring the people and personalities driving post-

WWII science. This being said, the book is fantastic at bringing alive the enthusiasm, passion and drive that great minds bring to bear on their inquiry of the world around them.

Amy says

Ernest Lawrence may be less known than Robert Oppenheimer, but both had equally important roles in the creation of the Atomic Bomb. In fact, after reading this book, one sees how if not for Lawrence's pre-war visions the Manhattan Project may not have succeeded.

Lawrence was a brilliant and driven scientist who established the Rad Lab at UC Berkley in the 1930s. He pioneered a device called the cyclotron, a spiral shaped particle accelerator, which set him on his path to fame. With that fame came the growth of his beloved lab and he trained many of the atomic scientists who would serve on the Manhattan Project, including Oppenheimer. Those he trained may have been his students or those he brought to Berkley as instructors or professors to further his projects. Lawrence was also the first to realize the sciences and engineering could work together to further goals, as he was not only unafraid to have non-physicists on his team, but he encouraged it. Besides the many physicists in the Rad Lab, he recruited chemists, engineers, and medical doctors to help with the experiments. Besides manpower to further his projects, Lawrence constantly sought funding from multiple sources to support the costly projects. He also became the first scientific manager as he had many of his students and staff working on his ideas and projects in addition to their own.

When Europe went to war, in the United States there were fears that the Germans had the atomic research background to create the then theoretical atomic bomb. This led to the first plans for conducting this critical research in the States, long before it was involved in the war. Lawrence not only advocated for the research, he lent his Rad Lab to the cause and helped design the facilities at Oak Ridge where the uranium was produced. It was Lawrence who suggested Oppenheimer to be in charge at Los Alamos. He worked tirelessly to further the atomic research. Also detailed in this section were the scientists' thoughts on the use of the bomb on Japan both before and after the bombs were dropped.

In the final few chapters, the development of atomic research after World War II were discussed, with a focus on Lawrence's projects. This included detailing the many commissions on the related research; the effect of the Red Scare on atomic research; post-war research, including the hydrogen bomb and nuclear missiles; his new Livermore atomic research facility and its competition with Los Alamos; and post-war research funding. Lawrence was often overworked in these years more so than before.

While the main focus of this book was on Lawrence and the Big Science he created, the many other key players were also detailed to varying extents. Included were Oppenheimer, John Lawrence (Ernest's brother and a medical doctor on the team; he pioneers radiation therapy for cancer treatment), Luis Alvarez, Milton Stanley Livingston, General Leslie Groves, Robert Serber, Don Cooksey, Edwin McMillian, Vannevar Bush, Alfred Loomis, Edward Teller, and many more. While most were scientist on his team, others were scientists elsewhere he worked with on national committees after the war. Also there was a great focus on the science involved. While it was explained well in the text, it would be helpful for readers to have a basic familiarity with physics to fully comprehend it.

Overall, I learned a great deal from *Big Science*. I never realized the full extent of Lawrence's role before now. Nor did I realize just how much the pre-war research affected the Manhattan Project or the era that followed. Too many other titles and documentaries make readers/viewers think it all began with World War II.

I was offered the opportunity to review this title by FSB Associates.

Charles H Berlemann Jr says

I had gone into this book based on some wonderful reviews from a friend. However, instead of talking all about Ernest Lawrence or even the evolution of science from the lone person playing with test tubes in a home brewed lab like the 1930s era trope and progressing over to industrialized science of large firms and universities leading the way. In the middle of this story is the story of the leader of this evolution of science s Ernest Lawrence. The man who helped to develop a cyclotron that helped to advance nuclear physics and make the bomb possible. However, buried in all of this is extra fluff about other scientists that cross Lawrence path and the later development of the bomb. Some of this information is retread material if you have read *The Making of the Atomic Bomb* the whole development of Oak Ridge and Lawrence's involvement in solving the problems there are covered in this book. In the middle of this story about the nuclear weapons development program, we lose Lawrence and his Berkley RadLab, the cyclotron development and the idea of where we got modern day big science? The later third of the book loses Lawrence, his family, his relationships into the larger post war super power problems and nuclear spying and such. That I was getting bored, since again this is material that was almost constantly retread in a number of other books about the post war nuclear weapons programs in the US. There were some bright spots such as how Lawrence worked to develop Livermore into a big research center. That Lawrence was almost instrumental in development of the tech that would lead to color TVs. That material would have been interesting and probably still tied in well with the attempted thesis of this book where science went after nuclear physics came alone in hunting for donor dollars and big returns on making nuclear physics do stuff from present color images on a TV screen to help threaten the world many times over. I would recommend this book if only for the first half since it presents an interesting view of a man who was willful, successful in breaking a mold, and developed a really interesting bit technology that helped us solve physics problems that even now are being found answers towards.

I just wish the author had chosen to either talk about Lawrence, or Lawrence and his Cyclotrons or the role of Lawrence in procurement of large government and industrial contracts to finance his science. All of that would have been better and rounded out the book better than the rehash of the development, arguments and science debates about the Atomic and later Thermonuclear weapons developments, all of which were hashed out well by other writers.

Joel says

(Note: I received a free copy of this book through Goodreads First Reads.)

Primarily a biography of Ernest Lawrence; a Nobel-laureate physicist who invented the cyclotron and was a key figure in America's development of atomic bombs during World War 2. While Hiltzik does provide some information on the science behind Lawrence's work, his primary focus is on Lawrence's skills as an organizer and fund-raiser. His thesis is that, before Lawrence, scientific research consisted mostly of a lone scientist, perhaps supported by an assistant or two, working on a modest budget in a modest laboratory with small-scale equipment. Lawrence's career placed him at the forefront of a shift in that model, where he founded the first research lab (the "Rad Lab" in Berkeley) with a massive staff, supported by massive government checks, using large equipment costing millions of dollars.

It's an interesting story; most accounts I've seen of the development of the atomic bomb focus on the research facility in Los Alamos, New Mexico, so this account presents an interesting alternate viewpoint. I have to

say that I found it impossible to be entirely sympathetic towards Lawrence. After the war, while many of his physicist colleagues became strong advocates for reining in the advance of nuclear weaponry, Lawrence was a gung-ho advocate of building bigger and bigger bombs (not to mention smaller bombs, for use as submarine missile warheads). He was also entirely too willing to play along with the red-baiting of the time period, and fired some of his subordinates at his lab for "leftist sympathies".

I can't really recommend this book to readers who don't have a particular interest in the history of science (particularly the history of scientific institutions). It's a bit dry, and even I- who am interested in the subject matter- found the book tedious at times (most especially when Hiltzik goes into the details of how Lawrence went about cajoling various organizations and eccentric millionaires for funding). But, if you do have an interest in the subject, it's worth your while.

Jim Angstadt says

Big Science

Ernest Lawrence and the Invention That Launched the Military-Industrial Complex
by Michael Hiltzik

Informative, interesting, sometimes provocative, sometimes mildly annoying.

There are two stories here: Ernest Lawrence and big science. The stories overlap. For most of the book I thought it should have been titled "Ernest". Toward the end, it veered "off track", back to its real name. Annoying, but nothing to stop a real reader.

One century ago, one man, and many others, created a revolution in how physics and science was done. Big science means big money, big staffing, big government, and a great scientist/manager/salesman/visionary, or two. Before that, science was done in a lab on a bench top. That morphed into Los Alamos, Lawrence Livermore Labs, and a lot more. That activity helped us win WWII. But it led almost immediately to an arms race, nuclear weapons, and an uncertain future.

Was that a good thing?

Peter Mcloughlin says

Biography of Ernest Lawrence and the Rad Lab at Berkeley and the origins of big science. Lawrence was a physicist and experimentalist who pioneered work in early cyclotrons the forerunner of our modern particle accelerators like the LHC. He was an excellent scientist but also had the social and managerial skills to run huge projects and developed early contacts with government and business to forge what would be the model of big science which would be a way of doing things for the rest of the 20th and our part of the 21st century. Definitely an interesting character and major figure in 20th century science.

Rosemary Standeven says

When I was a teenager I was fascinated by nuclear physics and read everything I could find on the subject.

My dream was to work in the Cavendish laboratory like my fellow New Zealand countryman, Ernest Rutherford. Then I met 6th form school physics, and hated it. End of dream. I have read very little about nuclear physics over the last 40 years, and was very keen to read this book and rekindle my interest. The book is primarily a biography of Ernest Lawrence, Nobel Prize laureate and inventor of the cyclotron. I could not remember having ever heard of him before, but surely I must have, as he was linked to just about everything to do with nuclear physics from the 1930s onwards including the Manhattan project and the creation of the atomic bombs.

The book begins with the contrast between the old-style physics exemplified by the Cavendish laboratory, where each physicist worked on his own projects with the minimum of equipment and very little money, to the new physics of Lawrence in Berkley with “teamwork that combined the disparate knowledge and skills of physicists, chemists, biologists, physicians, and engineers into a new paradigm of science”, and where the equipment started to become an end in itself. Little Science versus Big Science, elegance and frugality versus monumental machines and seemingly limitless funding.

The book is very well written and flows as an absorbing story about a remarkable man, as well as being a history of nuclear physics and the way that the modern world of Big Science came into being. You do not need a science background to understand what is happening, although a little knowledge about the origins of nuclear physics and some of the scientists involved would certainly enhance your reading.

Lawrence wasn't just a world-class scientist, he was an adept fundraiser, an inspiring leader of people and involved in political decisions at the highest level – even though he claimed to have no interest in politics, and actively dissuaded his co-workers from such. Lawrence worked with, and was admired by, many of the most prominent physicists in the world. He believed passionately in sharing his knowledge, and encouraged research across the globe.

He invented tools and procedures that changed science forever, but he also had his faults. As soon as he got funding for the development of one project, he was already thinking about, and campaigning for, the next bigger, more costly project. This continual change of focus, and the reluctance of any of his devoted co-workers to challenge him, meant that many ground-breaking discoveries that should have been made in the “Rad Lab” went unnoticed, and relied on other, more systematic physicists, for detection.

Lawrence did not deal well with those who disagreed with him. As time passed he became increasingly right wing and intolerant, to the dismay of his former friends and colleagues. His never-ending pursuit of financial support caused him to adopt the opinions of his sponsors: “The government's immense financial sway over research funding gave its interests—including its political interests—immense weight. Thus did the economics of Big Science create a double-edged sword. Under the circumstances, scientists' fealty to military and political orthodoxy trumped their honest scientific judgment.”

It was not just science that changed in the 20th century, but also the way in which scientists approached their work. With the atomic bomb came a new moral dimension to scientific invention. The interaction between Lawrence and Oppenheimer shows this very clearly.

August 6th – next week as I write this– is the 70th anniversary of the bomb being dropped on Hiroshima. This book goes into a lot of detail about how the bomb came about, and its military, political and human consequences, which I found really fascinating. We all know what happened – this story tells you how. And it was nowhere near as straightforward as I thought.

I would have loved to have read this book when I was younger, but it is no less engaging reading it today. I am really pleased to have learnt about Ernest Lawrence, and my interest in nuclear physics is definitely rekindled. I can recommend this book wholeheartedly to anyone interested in history, science and/or the human condition.

I received this copy from the publisher via NetGalley in exchange for an honest review

Mal Warwick says

Throughout the twentieth century, the city of Berkeley has been a breeding ground of invention. Even before World War I, there was August Vollmer, who served as police chief from 1909 to 1931 and was widely regarded for transforming police work from thuggery to a modern profession. Over the years since then, the city has been host to an outsized number of notable people who have made world-class contributions to science, industry, journalism, the arts, the military, and innumerable other fields. But none achieved impact as great as Ernest O. Lawrence, the Nobel Prize-winning physicist who invented the cyclotron — the centerpiece of his scientific work and the building-block of Berkeley physics — and played a critical (albeit questionable) role in developing the atomic and thermonuclear bombs.

Today, Lawrence is best remembered locally because three institutions bear his name: Lawrence Berkeley Lab, Lawrence Livermore Lab, and the Lawrence Hall of Science. As a long-time resident of the city, I wondered idly from time to time why any individual would be memorialized so extravagantly. Now, having read Michael Hiltzik's eye-opening biography of Lawrence, *Big Science*, I fully understand.

Lawrence was much, much more than a brilliant physicist who won the first Nobel Prize in the history of the University of California, Berkeley. He was a science administrator whose invention of the cyclotron and towering managerial talents shaped virtually single-handedly what today we know as Big Science — the collaborative work of often enormous teams of scientists, frequently across national borders, to pave new paths in understanding our lives and the universe we live in. Working in close collaboration with Robert Gordon Sproul (President of the University of California from 1930 to 1958), Lawrence helped build UC Berkeley into a world-renowned center of learning through his drive, charisma, towering scientific reputation, and prodigious fundraising skills. (Funding for Lawrence's laboratory often exceeded the combined total of the funds received for all other research at UC Berkeley.) It was also Lawrence who proposed his colleague and then-friend, J. Robert Oppenheimer, to manage what became known as Los Alamos, where the bombs that devastated Hiroshima and Nagasaki were designed and built. He also drove the development of the facility in Tennessee that produced the U-235 fueling the Hiroshima bomb. And, more than anyone else, we have Ernest Lawrence, Edward Teller, and Lewis Strauss to thank for the H-bomb (known in their day as the "super").

Hiltzik concludes that Lawrence "presided over a transformation of American science as profound as any change inspired purely by scientific discovery: the launch of peacetime government patronage." However, before the Manhattan Project began to pour millions into Berkeley, Lawrence succeeded in fundraising in a broader context, assembling consortia of donors from the foundation world and academia as well as government. It's difficult not to think of Lawrence as one of the greatest fundraisers ever.

In a real sense, the stature of UC Berkeley today can be traced back to the collaboration of Ernest Lawrence and Gordon Sproul. More than eight decades after the two men began their careers on campus, "Berkeley" is routinely ranked as the world's greatest public university and is in contention with a handful of others — notably, Harvard, Oxford, and Stanford — for top honors among all institutions of higher learning.

For all his accomplishments, Lawrence is remembered today as an equivocal figure with a decidedly dark side. Though his seminal role in creating the atomic bomb might be excused as a response to the threat of Adolf Hitler and the military and scientific juggernaut he commanded, Lawrence's ferocious, no-holds-barred advocacy of the H-bomb is more difficult to understand in the twenty-first century. So are his aggressive enforcement of the University of California loyalty oath and his partnership with Atomic Energy Commission chairman Lewis Strauss in vilifying Robert Oppenheimer. Though Lawrence began his career at UC Berkeley as a New Deal Democrat (though doggedly apolitical), his views in his later years veered sharply rightward, apparently influenced by his mentors, Alfred Loomis (a wealthy businessman who played a pivotal role in physics research) and UC Regent John Francis Neylan, both virulent anti-Communists. Viewed in the light of later events, when we came to understand how dramatically the Communist threat was exaggerated, I find it difficult to understand Lawrence's shift so far to the Right. Sadly, he was hardly alone in falling prey to knee-jerk anti-Communism. He was a man of his times, after all.

Sean O'Hara says

The book never quite decides what it wants to be -- a biography of Ernest Lawrence, a history of the cyclotron/particle accelerators, a history of UC Berkeley's laboratories, or even the nuclear bomb. The last is most frustrating since that's a subject that's been covered in detail elsewhere, and in order to cover it in any detail the book has to branch off from all the other subjects. Likewise the coverage of the post-war debate on nuclear weapons doesn't add a lot to what you can find elsewhere apart from focusing on Lawrence's part in the debate (though again, it has to cover the rest of the debate, which means getting off the subject).
