MODULE 4

SCIENCE AND TECHNOLOGY IN THE MAKING:

ENTERING THE WORLD OF THE LABORATORY

Contents

Aims of the Module

Module 4 aims at giving you a precise idea of the complexities involved in the processes of building up scientific facts. You will be introduced to the way experimental research programs are set up and how they involve negotiations, translations of interests, and have political as well as cultural relevance. Because of this heterogeneous mixing of humans and non-humans, facts and artifacts, fictions and realities, we have chosen the laboratory to give unity to the lectures, seminars, and field work provided during this three week period of Module 3. In terms of knowledge to be acquired, you are expected, at the end of the three week period, to have some idea of the way laboratories actually function. This includes their internal functioning, the way they fulfil various functions in modern societies and the way they relate to other laboratories. This also includes the way they entertain multidisciplinary links with other laboratories in an industrial context.

Central Concepts, Perspectives, Issues

The scientific lab is a concrete place, located in different kinds of institutions (universities, research centers, industries, military buildings, etc.), the unity of which is usually determined by specific objects of research or specific methods. The size of labs may vary from small units to big research centers like the CERN in Geneva. The scientific laboratory is where science is practiced in collaboration between scientists, technicians, secretaries, professors, research students, engineers and so on. In some instances it is also the place where scientists are trained and from where their professional identity is acquired.

Since the origins of experimental science, the laboratory itself has been neglected by philosophers, epistemologists, and social scientists. Their analyses of science came very often through what scientists themselves had to say about it, either in the professional journals where their findings were published or in autobiographical accounts of their work. It is only in recent years that the scientific laboratory has become an object of investigation on its own. Laboratory studies have not only transformed our general views on what science is about, it has also transformed the language we use in order to speak about it. The isolated abstract terms of traditional philosophers, historians, and even sociologists, were gradually replaced or supplemented by more specific terms, linking the analysis of science to empirical data and study. The case-study is now the prominent arena of philosophical dispute. This approach is also reflected in a new sociology of scientific knowledge where scientific contents are considered as being constructed through social interactions, negotiations, translations of personal, professional, economic and political interests.

Even outside the more specifically sociological approaches it is widely realized that in order to gain insight into the workings of science, we have to understand how isolated data get transformed into scientific phenomena that eventually become the target of our high-level theories and often get translated into technological artefacts. Whatever the general outlook, most theorists of science seem to concede that what is taken as scientific reality is in fact itself the result of a scientific construction. What kind of elements actually enter this construction work is a matter of lively dispute. That is why it is legitimate to summarize the goal of this module by saying that it is intended to introduce the students to a constructivist view of science.

This constructivist image of science involves a close look at the actual way scientists work in constructing facts and artifacts. Facts are not given by nature. They are not "discovered" by scientists in any simple sense of the word. Their construction results from complex processes involving heterogeneous networks of scientists, machines, techniques, institutions, engineers, politicians, skills, information, knowledge, strategies, choices, patents, ethical conflicts, controversies, innovations, etc.

Module Structure and Organization

After the introductory module and the historical module, you are now entering the real world of science and technology, the laboratory.
Module 4 is structured along parallel lines:
- Lectures to present central perspectives
- Seminars to discuss key literature about the construction of facts and artifacts in the laboratory.

In the seminars each student has to present summaries and critical discussions of the literature. All students are required to read the literature, also when they are not scheduled for a presentation. Participation in these discussions will also influence the evaluation of your work in this module.

Skills training

Ethnographic fieldwork in a laboratory, consisting of methodological introductions and one day of actual observations in a laboratory:

Assessment

As a preparation for the seminars all students have to read the literature.
However, during every seminar two students will prepare a review of one of the texts of 20 minutes. The review should consist out of an abstract and a critical reflection on the text (formulate several questions). The latter will be considered as point of departure for plenary discussion.

The closing colloquium of the module on Wednesday, 21 Nov. and Thursday, 22 Nov. will function as module examination. You are asked to give a presentation of 15-20 minutes. Part of the presentation must be a "handout" or summary. Each presentation is followed by a discussion.

Seminar 1

THE ORDER OF PRACTICE

The sociology of scientific knowledge (SSK) give prominence to the understanding of some of the general characteristics of scientific research, and of the knowledge it produces. But here it seems that we are immediately confronted by an insuperable difficulty. There are innumerable conflicting descriptions of scientific research and scientific knowledge. Nearly all these accounts of science are very heavily idealized, and represent the various utopias of our philosophers rather than what actually goes on in those places which we customarily call science laboratories. In contrast, there is a need for a general description which treats the beliefs and practices of scientists in a completely down-to-earth, matter-of-fact way, simple as a set of visible phenomena. The real difficulty SSK face is the daunting extent of our ignorance of the basic features of scientific activity and scientific inference, but in truth this is no greater than that routinely faced by sociologists and anthropologists when they study other forms of culture.

One example of SSK is the work of Harry Collins. He challenges the way of understanding convention. Collins identifies a group of physicists in agreement on conventional wisdom in their field, who nonetheless disagree upon its implications. In the course of attempt to replicate an experiment which had allegedly detected gravity waves, they offered diverse specifications for a gravity wave detector and diverse standards for evaluating one detector against another. They based their specifications and standards upon existing physical knowledge, but achieved a consensus upon neither. Accordingly, they were unable to agree upon what counted as a replication of the initial experiment, and unable to settle upon a single account of the phenomenon of gravitational radiation. (source: Science in Context, Barnes & Edge ed. 1982)

Readings:

Collins, H.M. 1985. *Changing order. Replication and induction in scientific practice*. London: SAGE Publications. Chapter 6 (p.129-157) + Postscript (p.158-168).

Collins, Harry, and Trevor Pinch. 1993. *The golem. What everyone should know about science*. Cambridge: Cambridge University Press. Chapter 5 (p91-107)

Additional readings:

Collins, H.M. 1985. Changing order. Replication and induction in scientific practice. London: SAGE Publications. Introduction + Chapter 1,2, 4.

Seminar 2

LABORATORY LIFE

The anthropological study of science and technology is an old and vast tradition, or a new and small one, depending how one looks at it. From one perspective, almost the entire field of archaeology, as well as ethnographically based studies of 'material culture," might be considered part of the anthropology of science and technology. Likewise, a number of anthropologists have also examined technology in the context of culture contact, colonialism, and 'development." In this sense, anthropologists began studying "science and technology" (or perhaps better, "knowledge and artifacts") long before STS emerged as an interdisciplinary field of inquiry.

In another sense, however, cultural anthropology has been a relative late-comer to the field of science and technology studies. STS emerged out of the sociology, history and philosophy of science, as well as studies by scientists concerned with the ethical and social implications of science and technology.

In the last decades, a number of factors have contributed to a new anthropological focus on science and technology. In the 1980s a number of cultural anthropologists who had previously conducted what is now thought of as "classical" anthropological field research (studying local communities in China, France and Morocco), turned their attention to the cultural dimension of "technoscience" in Europe and the United States. (source: Hess & Layne , 1992)

In *Laboratory Life* (1986), Bruno Latour and Steve Woolgar present laboratory science in a deliberately skeptical way: as an anthropological approach to the culture of the scientist. Drawing on recent work in literary criticism, they study how the social world of the laboratory produces paper and other "texts," and how the scientific vision of reality becomes that set of statements considered, for he time being, too expensive to change. The book is based on fieldwork done by Bruno Latour in Rogers Guillemin's laboratory at the Salk Institute and provides an important link between the sociology of modern sciences and laboratory studies in the history of science.

Also the work of Sharon Traweek, a cultural anthropologist, rest on the assumption that science is a human activity, one that is specific but that does not merit a change of analytical instruments. With the cultural anthropological approach she too brings into play those who carry out the experiments and prepare the samples.

Readings:

Latour, Bruno, and Steve Woolgar. 1986. *Laboratory Life: The Construction of Scientific Facts*. second ed. Princeton: Princeton University Press. Chapter1 (p.15-42)

Latour, Bruno. 1987. *Science in Action: How to Follow Scientists and Engineers Through Society*. Cambridge: Harvard University Press. Chapter 2 (p.63-100)

Shapin, Steve. 1988. Following scientists around. *Social studies of science*, P.533-550.

Traweek, S. (1988). *Beamtimes and lifetimes. The world of high energy physicists*. Cambridge, Massachusetts London, England: Harvard University Press. Preface + Prologue

Additional readings:

Knorr Cetina, K. (1995). Laboratory Studies: The Cultural Approach to the Study of Science. In S. Jasanoff (Ed.), *Handbook of Science and Technology Studies* (pp. 140-166). Thousand Oaks:

SAGE Publications.
Layne, Linda (1998). Introduction. In: *Science, Technology & Human Values*, vol 23 1, 4-23.
Martin, Emily (1998). Anthropology and the Cultural Study of Science. In: *Science, Technology & Human Values*, vol 23 1 (1998), 24-44.

Seminar 3

EXPLOITING SCIENCE AND TECHNOLOGY

Webster focuses on the ways in which different states have sought to exploit national knowledge bases on behalf of the 'national interest.' Webster first introduces us to the political context of decisions affecting science. He discusses different approaches taken to science policy by states characterized by advanced technology. He notes that all states consider science policy to be a national priority, with some more than others taking a centralized direction in directing technology development and dissemination.

Webster notes that, within nation states, increased emphasis has been placed on encouraging the development of "critical masses" of scientists with common research interests that also coincide with national priorities (such as the development of military weaponry).

Webster takes note of an emerging emphasis on the commercialization of public sector research and development. Public universities are being encouraged to enter into cooperative agreements with the private sector to develop and transfer technology with national and international commercial potential. He discusses three concerns that have been voiced about this trend by scientists conducting research in public universities: To what extent will commercial interests manipulate the direction and focus of scientific research? Will the conditions of work and the relationships among scholars change with increased emphasis on meeting the needs of the commercial sector? What impact will commercialization have on the free access to and exchange of information, data, materials, and findings among scientists?

The role of the state and commercial interests in setting science policy has always been a concern of scientists, even though they often benefit from national policy objectives and technology transfer to the commercial sector. These links will give you some insight into this ongoing debate between state policy and scientific autonomy:

Webster also focuses on the exploitation of science and technology by the private sector. Although still not well recognized by academic sociologists, the private sector invests large amounts of money and personnel to both "pure" and "applied" science. Private sector research labs have grown out of a need for focused research and proprietary research findings. Also, private firms competing in a global marketplace must keep abreast of technological advances to stay in business.

This growing reliance of private firms on R&D has stimulated much interest in academia on the impact of technological advancement on firm competitiveness. Although neoclassical theory would argue that the greater the capital the greater the productivity, scientists and business managers have become aware that this relationship can be mediated by many factors. Among these, access to economic and human capital, management of technology, and control over the inputs needed to use and maintain advanced technology are key components of successful technology adoption and use.

Given the strong reliance upon proper management of technology, managers have looked with much interest at alternative approaches to understanding and maximizing management, labor, and technology relationships. "Taylorist" principals of breaking large tasks into many smaller ones and maximizing the productivity of each step in a complex production system have been challenged by perspectives that emphasize labor familiarity with a broad range of production steps. In private research labs Taylorist principals can undermine the very kind of imaginative creativity that scientists are urged to exhibit.

With these basic principals in mind, Webster discusses three potential 'revolutions' that might result from applications of biotechnology. First, advances in biotechnology might create increased emphasis on multidisciplinary collaboration among natural scientists. Second, the products of biotechnology might create a new 'industrial revolution' of consumer products. Third, biotechnology might create a revolution of thought regarding the ownership of genetically engineered products. Webster might have missed mentioning the most important potential revolution resulting from advances in biotechnology: a greater integration of societal values and morals with scientific discovery and technological development.

Readings

Webster, Andrew. 1991. *Science, Technology and Society: New directions*. London: Macmillan Press LTD. Chapter1 (p.1-15) Chapter 3 (p.33-59) Chapter 4 (p.60-93) Chapter 5 (p.94-125)

Additional readings:

Links to Related Topics chapter 4:

Universities and the Private Sector:
-Iowa State University Research Park

National Research Priorities:
-The National Science Foundation;
-The National Research Initiative.
-American Association for the Advancement of Science.
-Office of Science and Technology Policy.

National Funding Priorities:
-The International Space Station.
-The Future of the Superconducting Super Collider.
-Arguments in Favor of the Strategic Missile Defense System ("Star Wars").
-Arguments in Opposition to the Strategic Missile Defense System ("Star Wars").
-The B-2 Stealth Bomber.
-Arguments in Opposition to Increased Funding for the B-2 Bomber.

Links to Related Topics chapter 4:
-John Chrystal: Rural America's Future: Capital--Not Land--Will Be King.
-Robert Wolf: "Iowa: Living in the Third World."

Skills Training

ENTERING THE LABORATORY YOURSELF

No single textbook focuses on the different ways of "doing research in science and technology". This deficiency may be due to a specific view on methods within STS. In his *Coming to Age in STS: Some Methodological Musings*, Bowden makes clear that in the field of STS, methods refer to "various strategies for data collection and analysis" and "the method of explanation for data that have been collected." Examples of the latter are general and prescriptive rules such as the four characteristics of Bloor's Strong Program and Latour's seven rule of method (Bowden 1995; quoted in Jasanoff 1995, 65). With respect to the former meaning of method (i.e., strategies for data collection and analysis), Bowden stresses that within STS, traditional disciplinary approaches are dominant, such as participant observation, ethnomethodological research, analysis of historical documents, and textual analysis. Most of the research is topic focused and multidisciplinary, which means that a "researcher uses the methods and techniques of his or her particular academic discipline to study some aspect of science or technology." (source: Bijsterveld, 1999)

Each one of you will spend one day in a laboratory concentrating on one particular aspect. For instance, replication of an experiment, the importance of inscription devices, the hierarchical structure of the lab, the technological infrastructure of the lab, the role of skills and tacit knowledge, the disputes, the arts of storing and retrieving information, the national or international collaborations of the lab, the involvement of the lab in expertise, the financial support of the lab.

To gather information about these topics you need to observe, taking notes and interview people within the context of its own practice.

Readings:

Collins H.M. (1984). Researching Spoonbending: Concepts and Practice of Participatory Fieldwork. In: C. Bell & H. Roberts (eds.), *Social Researching: Politics, Problems, Practice*. Routledge & Kegan Paul, p. 54-69.
Hammersley M., Atkinson P. (1983). *Ethnography, Principles and Practice*. Routledge, London, chapter 5.
Seale, Clive (ed.) (1998). *Researching Society and Culture*. Sage Publications, chapter 16

Additional Readings:

Alasuutari, P. (1995). *Researching culture. Qualitative method and cultural studies*. London: Thousand Oaks.
Mol, Annemarie & Jessica Mesman (1996) Neonatal Food and the Politics of Theory: Some

Questions of Method. In*: Social Studies of Science*, vol 26 2, 419-444
Seale, Clive (ed.) (1998). *Researching Society and Culture*. Sage Publications, chapter 17

Seminar 4

BIG SCIENCE

Big science has brought research an unprecedented strength and vulnerability. After the development of radar and nuclear weapons in World War II, science occupied an unparalleled position of prestige and power. Other coordinated efforts built on those accomplishments, capitalizing on a broad public and political support : weapons projects like the hydrogen bomb and guided missiles: huge particle accelerator centers that ushered in a new understanding of matter: space programs of moon missions and unmanned interplanetary craft; massive efforts in controlled fusion; and a plethora of large-scale scientific-industrial projects in new materials, electronics, computing, and pharmaceuticals.

In the years since, the blurred domain between science and technology has demanded – and received – more than popular attention; it has required ever larger fractions of national budgets. Perhaps inevitably, the rising scale of science collided with economic constraints. Even without the catastrophic explosion of the space shuttle *Challenger* and the near meltdown of Chernobyl, big science was in for questioning. With such events, reflection on the nature and wisdom of large-scale science has been rife – from the pages of scientific journals to the halls of government. Scientists, scholars, and the public, willingly or not, must now confront basic issues about research priorities, and where scientific effort is best put.

Readings:

AA1994. How Big can be Beautiful. *The Economist* (October 8th):100-104.

Adams, J.B. 1973. Some Problems of a Big Science. *Daedalus* 102 (2):111-124.

Galison, Peter, and Bruce Hevly, eds. 1992. *Big Science: The growth of Large-Scale Research*. Stanford: Stanford University Press. Introduction (p.1-17) + Afterword (p.355-363)

Krige, John. 1994. Megaprojects, megateams and motivation. *Physics World* 7 (5):17-18.
Galison, Peter & Bruce Hevly (1992). *Big Science. The growth of large-scale research*. Stanford University Press, Introduction + Afterword.

Latour B.,(1987) *Science in Action: How to follow scientists and engineers through society*. Cambridge, MA: Harvard University Press, chapter 6

Additional Readings:

Latour B. (1983). Give me a laboratory and I will raise the world. In: Knorr-Cetina & Mulkay (eds.), *Science Observed. Perspectives on the social study of science*. Sage Publications, London, p. 141-170.

Grattan-Guinness. 1994. Review: Big Science: the growth of large-scale research. *Annals of Science* 51 (4):441-443.

Seminar 5

THE CONSTRUCTION OF WHAT?

If one is not doing the sociology of science or knowledge, or working in the interdisciplinary field of science studies, Hacking's *The Social Construction of What?* is probably not going to be a priority on a reading list. Perhaps, however, it should be, and it certainly deserves a thorough look by anyone interested in the philosophy of knowledge. The work is of course shaped by the ongoing skirmishes of 'the science wars,' although Hacking warns us that the metaphor of war for an academic debate does disservice to both the debate and its intractability, and to the messy ugliness of real war. It does not provide an analysis of the science debate, such as the one suggested by T. Gieryn's (1999) *Cultural Boundaries of Science* (Chicago), but nor does it add to the polemics,

What Hacking does do, in this collection of lectures and essays, is provide clarification. He discusses three "sticking points" in the debates on the epistemic authority of science: contingency, nominalism, and stability. Contingency addresses the question of whether things might be otherwise, for example, whether there might be a 'non-quarky' physics. For most physicists, physics as we now understand it is simply not contingent, being the inevitable outcome of the research trajectory and its revelations of nature as-it-is. The constructivist view argues,
variously, the "opposite," the strongest position being that 'things could be otherwise.' To Hacking, contingency in science is to be found in the framing of the questions, but once questions are framed, the answers, the "contents" of a science, are noncontingent.

Hacking identifies nominalism as the second "sticking point" in debates about scientific knowledge. Nominalism debates question the relationship between our names and categories as referents to the world-as-it-is. 'Realists' posit a correspondence, while nominalists posit a disjuncture. Hacking's argument overall is weakest here, because, as he notes, realism is not treated as the opposite of nominalism anymore, but he does not review the alternatives. Finally, the problem of the stability of knowledge is at issue in 'the science wars.' Is the stability of knowledge the result of 'getting it right,' of the correspondence between scientists' fact statements and the world out there, or it the stability of knowledge the result of 'external' factors, such as its institutionalization, social networks, and so on.

Given this multidimensional discussion of positions on correspondence, representation, and truth, Hacking's discussion of the politics of science studies is not particularly enlightening. He illustrates what is apparently a continuum from a quasi-conservative historicist position in science studies, to debunking methodologies and revolutionary anti-authoritarian positions. However, based on his typology, one would expect something other than a rather linear continuum. Even a two-by-two table does better at describing the authoritarian/antiauthoritarian and Constructivist/essentialist dimensions of the debate. However weak his particular argument in this area, it did make me think. Is constructivism either necessary or sufficient for progressive social agendas? Under what conditions does the 'space' opened up by asking how things might be otherwise have liberatory potential? At one point Hacking asserts that understanding anorexia does not help those who are suffering from it. A better question, rather than this assertion, would be to inquire as to if, or under what conditions, an understanding of something as constructed is going to make positive social change possible?

Hacking also revists his prior work in chapters on child abuse, weapons research, rocks (dolomite, sedimentology and nanobacteriology), Captain Cook's voyage, and mental illness. In an interesting section in the chapter on mental illness he attempts to transcend the nature/society divide, with an interesting discussion of feedback loops among and between mental and social activities and biological states. For example, behavioral therapies can change serotonin levels in people with depression, and so on. However, he reinvents the nature/social divide in his discussion of indifferent and interactive kinds. Thus one would expect 'natural' things to be indifferent to our classifications of them, but interactive things to respond in some way to our classifications. Based on his stated positions on nominalism, one might see this distinction as somewhat contradictory to the positions articulated earlier in the book.

Hacking differentiates himself from social constructivists, particularly on the basis of his analysis of contingency, although I am not so convinced by his demarcation efforts. He also identifies elsewhere (81) as a philosophical purist, which leads me to place this book into the realm of boundary work (as discussed by Gieryn). For sociologists, his dismissal of the 'social' of social construction theses as redundant should give pause. In that regard, while Hacking's work of philosophical clarification is timely and important, it provides little methodological help for people who want to do serious sociologically informed work on knowledge. Perhaps not Hacking's best work, in the sense of originality or power, it is not, as one on-line reviewer elsewhere dismisses, "tripe." Those taking strong positions in the 'science wars' might argue that it is 'immoderately moderate.' Nonetheless, it is a very useful work of clarification, and the dimensions and implications of this work may be disputed and further clarified, which is what the positive model of academic debate and discourse should be about. (Source: Jennifer L. CroissantProgram on Culture, Science, Technology & Society University of Arizona)

Readings:

Hacking, Ian. 1999. *The construction of what?* Cambridge, MA: Harvard University Press. Chapter 3 (p.63-99) + Chapter 6 (p.163-185)

Additional reading:

Crease, Robert. 1999. The Manhattan Project: an enduring legacy. *Physics World* (December):59-63.

Seminar 6

FAT MAN AND LITTLE BOY

The Manhattan Project was started after Albert Einstein wrote President Roosevelt that it was possible to make a tremendously powerful bomb from atomic energy. General Leslie Groves, who had just finished building the Pentagon, was placed in charge of the project. He enlisted some of the greatest scientists of the era: J. Robert Oppenheimer, Enrico Fermi and Harold Urey.

J. Robert Oppenheimer (1904 - 1967) was a brilliant professor of physics. He built large schools for the study of theoretical physics at the University of California at Berkeley and at the California Institute of Technology. He personally made major contributions to quantum theory, the theory of relativity, and to our understanding of cosmic rays, positrons, and neutron stars. He took a leave of absence from 1943 - 1945 and served as director of the Manhattan Project. He was awarded the Presidential Medal of Merit for his efforts.

In 1947 Oppenheimer became director of the Institute for Advanced Studies in Princeton, New Jersey and served there until he retired. He also served as chairman of the General Advisory Committee of the Atomic Energy Commission from 1947 to 1952. Oppenheimer opposed the development of the hydrogen bomb. In the red scares of the 1950's his past association with communists and so called "fellow travelers" was used by those opposed to his views to obtain a revocation of his security clearance. His good name was finally restored and in 1963 he received the Enrico Fermi Award, the highest award offered by the Atomic Energy Commission.

General Groves was obsessed with security. This brought him into conflict with the scientists because the scientific method requires the free exchange of ideas to obtain the best results. But despite all the security precautions, secret information was smuggled to the Soviet Union by Los Alamos employees Klaus Fuchs and David Greenglass. Using this information the Soviets built their first atomic bomb in 1949.

Winston Churchill was told by Truman of the tremendous power unleashed by the first test of an atomic bomb at the July 1945 Potsdam Conference. Churchill observed that: "This is the Second Coming, in wrath."

The first atomic bomb was dropped without warning on Hiroshima on August 6, 1945 killing 129,558 people, maiming countless others and completely destroying four square miles of the city's center. Still, the Japanese government did not capitulate. Only after a second Japanese city, Nagasaki, was bombed on August 9, killing another 66,000 people, did the Japanese surrender.

In 1945 some in the scientific community opposed the use of the atomic bomb. Other people, including certain officers in the Navy and the Army, favored putting Japan on notice, perhaps by exploding one of the devices in a demonstration on an uninhabited island or a lightly settled area of Japan. These views, however, were not endorsed by any of the major decision makers, including Oppenheimer. The film exaggerates Oppenheimer's concerns about the morality of using the bomb in order to have a major character express the opinions of those who objected to dropping the bomb on a city without a prior demonstration of its power. There is some poetic justification for using Oppenheimer as the voice of the dissenters, because, years later Oppenheimer vocally opposed the development of the much more powerful H-bomb.

There is still debate concerning whether the U.S. should have used atomic weapons on Japan. The atomic bomb was originally built to be used on Germany. The Manhattan Project was rushed ahead out of fear that the Germans would get the bomb first and use it on the allies. After Germany was defeated with conventional weapons, the focus turned to Japan.

It is probable that without the use of the bomb an invasion of Japan would have been required to end the war. Estimates were that this invasion would cost more than a million casualties among the Allied soldiers. The invasion would also have undoubtedly caused the deaths of several million Japanese defenders. There would also have been millions of deaths among the Japanese civilian population from fighting, famine and disease.

The United States had been, for almost four years, involved in a brutal war with savage and fanatic opponents. There was a feeling that these opponents did not merit much consideration and that the war should be ended as easily as possible.

The strongest arguments against using the bomb are that almost two hundred thousand people, mostly civilian, children as well as adults, were killed in an instant. Tens of thousands more died later of exposure and radiation sickness. In addition, some elements in the Japanese government were, although they denied it at the time, looking for a way to surrender without losing face. However, the fanatic military clique that had started the war was still in power and there is no assurance that those seeking peace would have prevailed. In fact, even after the Japanese Emperor had ordered the surrender, there was an attempted coup by military extremists opposed to peace.

There is also some evidence that efforts to restrain Russian influence played a role in the determination of whether or not to bomb Japan. At the request of the United States, Russia had committed itself to attack Japan after the war with Germany was won. This attack had just begun. The more ground that the Soviet Union conquered in Asia, the more the U.S. would have to share power in the occupation. Given what was already happening in Europe, the U.S. didn't want to share a postwar occupation of Japan with the Russians. A quick and easy victory over Japan using
the atomic bomb would limit Soviet influence in the region. Moreover, in the post war tests of strength and resolve that were already occurring in Europe, the U.S. would gain substantial strategic advantages if the Russians knew that the U.S. had an atomic bomb and the will to use it. These reasons it is argued, are not sufficient to kill 200,000 human beings and establish a precedent to use atomic energy in anger.

The subplot in which a scientist dies of radiation exposure is based on an actual event that happened nine months after the first bomb was dropped. Canadian physicist Louis Slotkin was "tickling the dragon's tail," performing an experiment in which two globes of fissionable plutonium were separated only by a screwdriver. On the fatal occasion the globes touched, starting a small chain reaction that filled the lab with radiation. Slotkin lunged forward and pushed the globes apart stopping the reaction and saving many lives. But he subjected himself to a lethal dose of radiation. Slotkin had the others who were in the lab mark their places with chalk and calculated on a blackboard that they would live and that he would die. He died, gruesomely, within a week.

The scene which describes the sudden discovery of the implosion method of making the bomb is fictional. The theory was developed slowly and not taken seriously at first. Most scientific discoveries are the process of slow and painstaking research. Often the theory that is ultimately accepted was dismissed at first.

Discussion Questions:
1. Possible new Words and phrases: atomic bomb, nuclear bomb, fission, fusion, chain reaction, radioactive, rad, "tickling the dragon's tail."
2. In August of 1945 the U.S. had enough enriched uranium for only two bombs. It would have taken several months to manufacture enough uranium for a third bomb. Should the U.S. have dropped one of its two bombs on an uninhabited island in
front of an invited Japanese delegation rather than killing 129,558 people with the first bomb? What are the arguments for and against this approach?
3.Should the U.S. have simply refrained from using weapon as terrible as an atomic bomb and invaded Japan using conventional weapons?
4. Why did the scientists chafe at General Grove's security restrictions? How does secrecy affect the work of a scientist?
5. Some historians say that the deciding factor in the decision to use the bomb in early August 1945 was to prevent the Soviet Union from playing a significant part in the war against Japan and to show Stalin that we were willing to use the bomb. Truman and Churchill wanted to minimize Soviet influence in the Far East and to impress upon the Russians, in the maneuvering over the fate of Europe, that the U.S. had the bomb and would use it. Do you think that these reasons justified the quick use of the atomic bomb on Japan?

Bibliography: Past Imperfect, Mark C. Carnes, Ed., Henry Holt and Company, New York, 1995.