**CANCER: THE EMPEROR OF ALL MALADIES**

**SCIENTIFIC METHOD: LESSON PLAN**

**THEME OF LESSON:**
The history of cancer research has shown how scientists have used the basic steps of the scientific method to make new discoveries and advances in the understanding of cancer, cancer treatment and cancer cures. For each of these three scientists, identify and discuss the steps they took to make their discoveries. What was the problem they were trying to solve? What evidence did they have? What kind of experiments did they conduct? What conclusions did they draw from their experiments? Were they able to replicate their experiments?

For more detailed stories on the scientists refer to the chapters cited from *The Emperor of All Maladies: A Biography of Cancer*, by Siddhartha Mukherjee.

**Dr. Sidney Farber – Childhood leukemia**
Childhood leukemia was once considered a death sentence, but thanks to the research by Sydney Farber, today childhood leukemia is 90% curable. Sydney Farber was trained in pathology and this motivated him to look to chemistry for a solution to childhood leukemia. His experimentation with the drug aminopterin and the success he had in putting cancers into remission introduced the idea that drugs could be used to treat cancer. He is considered the father of modern chemotherapy.

**CLIPS:**
**CLIP 1** - Dr. Sidney Farber
EP1 01:07:17- 01:14:54
Dr. Sidney Farber, an oncologist at Children's Hospital in Boston, strives to find a cure for Leukemia.

**CLIP 2** - Robert Sandler
EP1 01:24:10 – 01:26:05
In 1947 Robert Sandler received his first injection of controversial amnipterin

**Discussion questions:**
How did Sidney Farber approach the treatment of cancer differently than other doctors at that time?

How did Sidney Farber's experiment change the course of cancer research?

Why were Sydney Farber's trials considered progress in cancer treatment even though the children did not survive?

**Further Reading:**
The Emperor of All Maladies, Siddhartha Mukherjee, pgs. 32-36 “Farber's Gauntlet”

**Dr. Bernard Fisher – Breast cancer and the radical mastectomy**
In the 1970s, surgeon Bernard Fischer questioned the accepted assumption that radical mastectomies were the best treatment for breast cancer. He went on to prove this through his
clinical trials, where he found that in early-stage breast cancers a “lumpectomy” combined with chemotherapy and/or radiation was just as effective as a radical mastectomy. His research led to the abandonment of the radical mastectomy and uncovered the systemic nature of cancer cells.

**CLIP 3- Dr. Bernard Fisher**
EP2 01:04:41 – 01:15:02
Dr. Fisher believed in lumpectomy rather than mastectomy in treating Breast Cancer.

**Discussion questions:**
What does Dr. Bernard Fisher mean when he states that the radical mastectomy became a dogma?
What is the difference between a localized and a systemic disease?
How did the women’s movement in the 1970s contribute to Bernard Fisher’s research?

**Further Reading:**
The Emperor of All Maladies, Siddhartha Mukherjee, pgs. 193-201 “In God we trust. All others [must] have data”

**Robert Weinberg, PhD – Discovery of the human oncogene**
In the early 1980s, Robert Weinberg developed experiments to identify the first human oncogene – the *Ras* oncogene. An oncogene is a gene that can change a healthy cell into a cancer cell. In his experiments, he transferred the DNA of a cancerous cell to a normal cell and turned the normal cell malignant. This discovery changed the way scientists understood the cancer cell and led to the development of targeted cancer therapies.

**CLIP 4- Dr. Robert Weinberg**
EP2 01:52:52 – 01:58:01
Dr. Weinberg developed experiments to identify the first human oncogene- the Ras Oncogene.

**Discussion questions:**
Why was the discovery of the human oncogene so important?
In the clip, Siddhartha Mukherjee mentions the blind men and the elephant. Research this folktale and describe how it relates to cancer research.

**Further Reading:**
The Emperor of All Maladies, Siddhartha Mukherjee, pgs. 370-383

**ADDITIONAL RESOURCES:**
Celebrating Oncology Luminaries, American Society of Clinical Oncology – profile of important researchers in the treatment of cancer.
http://cancerprogress.net/celebrating-oncology-luminaries

Dana-Farber Cancer Institute, Boston, Massachusetts.
http://www.dana-farber.org
Cancer Milestones, Nature - highlights of important discoveries in the field of cancer over the past century. 
http://www.nature.com/milestones/milecancer/index.html

Weinberg Laboratory of Cancer Biology, MIT, Boston Massachusetts
http://weinberglab.wi.mit.edu

EDUCATIONAL STANDARDS:
Benchmarks for Science Literacy
1A/H3bc* In science, the testing, revising, and occasional discarding of theories, new and old, never ends. This ongoing process leads to a better understanding of how things work in the world but not to absolute truth.

1B/H7 New ideas in science are limited by the context in which they are conceived; are often rejected by the scientific establishment; sometimes spring from unexpected findings; and usually grow slowly, through contributions from many investigators.

3A/H1 (Grades: 9-12): Technological problems and advances often create a demand for new scientific knowledge, and new technologies make it possible for scientists to extend their research in new ways or to undertake entirely new lines of research. The very availability of new technology itself often sparks scientific advances.

12A/H5 (Grades: 9-12): Curiosity motivates scientists to ask questions about the world around them and seek answers to those questions. Being open to new ideas motivates scientists to consider ideas that they had not previously considered. Skepticism motivates scientists to question and test their own ideas and those that others propose.

Next Generation Science Standards
Disciplinary Core Idea:
Environmental factors also affect expression of traits, and hence affect the probability of occurrences of traits in a population. Thus the variation and distribution of traits observed depends on both genetic and environmental factors. (HS-LS3-2),(HS-LS3-3)

Crosscutting Concepts:
Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-LS3-1),(HS-LS3-2)

Science and Engineering Practices:
Asking questions and defining problems, planning and carrying out investigations, analyzing and interpreting data, engaging in argument from evidence.

Scientific inquiry is characterized by a common set of values that include: logical thinking, precision, open-mindedness, objectivity, skepticism, replicability of results, and honest and ethical reporting of findings (HS-LS1-3).