RADIOACTIVE

EDUCATIONAL RESOURCES
LESSON ONE

MARIE CURIE:
TEACHING *RADIOACTIVE* IN THE CLASSROOM

Radioactive is a biopic full length film based on the life of Marie Curie. Awarded two Nobel Prizes, the first in physics (1903) shared with Pierre Curie (her husband) and Henri Becquerel for the discovery of the phenomenon of radioactivity, and the second in chemistry (1911) for the discovery of the radioactive elements polonium and radium, Marie Curie remains one of the most formidable and accomplished scientists of our time. Her body of scientific work birthed the idea of particle physics, changed our perception of matter and the universe, and led to such monumental developments from nuclear energy to treatments for cancer.

To inform and inspire future generations of students, and to honor the scientific work of Marie Curie, Amazon Studios and Blueshift Education have developed a set of lessons for upper middle and high school educators to incorporate **clips of *Radioactive*** within the classroom. These inquiry based lessons support units on the history of science, the process of scientific discovery, as a tool for strengthening critical media literacy, and for thoughtful reflection and connection to the legacy of her work today. **Each lesson includes classroom appropriate curated short film clips, primary and secondary source material, and inquiry based activities for students to delve deep into these lesson topics.**

TEACHERS PLEASE NOTE

RATING AND CONTENT:

Radioactive is rated PG-13 for thematic elements, disturbing images, brief nudity and a scene of sensuality. However, the lessons created for the film do not include any of the more mature content. **Only curated, classroom appropriate clips are used in the resource.**

DRAMATIZATION:

Radioactive is a biopic and not a non-fiction biography. A *biopic* is a dramatization of the real-life events of a person's life. The writer, director, and actors in ***Radioactive*** use artistic license to interpret Marie Curie's story - including the timeline, events, and characterizations of people represented in the film.

LESSON ONE

MARIE CURIE: THE IMAGE AND THE REALITY

Students will learn about the early years of Marie Curie and her journey as a scientist, as a partner with Pierre Curie, and as a mother at the turn of the 20th century. Through their discovery students will apply a critical media literacy lens to ***Radioactive*** and compare this depiction with select primary and secondary source materials on Marie Curie.

LESSON TWO

MARIE CURIE'S SCIENCE: EXPERIMENTATION AND DISCOVERY

In this lesson students will learn about the power of observation and the need for creativity in sparking scientific inquiry. Students will look closely at Marie and Pierre Curie's process for discovering the phenomenon of radioactivity, their identification of radium and polonium, and develop their own scientific investigations, and models for explaining radioactivity.

LESSON THREE

THE LEGACY OF MARIE CURIE

From nuclear energy and the atomic bomb, to medical applications of radiation, students will reflect on the legacy of Marie Curie's discovery of radium and share their views in a Socratic Seminar.

LETTER TO EDUCATORS FROM THE DIRECTOR OF *RADIOACTIVE* MARJANE SATRAPI

When I read the ***Radioactive*** script, I felt that it was a very important story to tell and that I had to do it. I grew up with two role models, Marie Curie and Simone de Beauvoir. My mother wanted me to become an independent woman. It was her obsession. I did not become a philosopher or a scientist, however, I managed to become an independent woman.

It is true that everyone has, more or less, heard the name of Marie Curie but almost no one really knows the breadth and depth of her story. Not only is she the only person in the world to have received two Nobel Prizes in two separate disciplines, Physics and Chemistry, but she is also of extraordinary modernity.

I did a lot of research on this. There are quite a few biographies about her, but every biographer always has an element of subjectivity. I then read all of her correspondence and her diary. By reading her own words I tried to get close to her and understand her. There were points on which I felt close to her.

"MARIE CURIE NEVER CALLED HERSELF A FEMINIST. SHE WAS A DE FACTO FEMINIST. SHE NEVER THOUGHT THAT HER GENDER PRESENTED AN OBSTACLE TO CARRY OUT HER SCIENTIFIC WORK, AND SHE WAS RIGHT. SHE SHOWED SHE WAS EQUAL (AND EVEN SUPERIOR) TO MEN JUST BY DOING. NO SLOGANS, JUST ACTION."

- MARJANE SATRAPI

She, like me, came to France at the start of our twenties to do what we could not do in our home countries. She came from Poland where scientific studies were prohibited for women. Me, from Iran where my artistic activity was compromised by religious censorship. Because of this, she, like me, as foreigners had to do three times more to achieve what we wanted to achieve.

I found in her someone who was uncompromising and who followed at all and any costs her passion, SCIENCE. It sometimes makes her not "lovable" as we expect a woman to be, but should we always be charming when we are a woman? Did she even have time to worry about the consideration of others?

When we talk about a genius man, we can safely say that he was certainly not an easy person, but since he had a superior intelligence, he had the right to be unpleasant. For women it's another matter. They always have to be gentle and accommodating.

Marie Curie never called herself a feminist. She was a de facto feminist. She never thought that her gender presented an obstacle to carry out her scientific work, and she was right. She showed she was equal (and even superior) to men just by doing. No slogans, just action.

Unfortunately our girls don't always think they can be geniuses. Studies show that up to the age of seven, they can associate the word "genius" with themselves, but very quickly this word is only attributed to boys! This is not because of their lack of intellectual capacity but because they have no concrete role models to follow. I think ***Radioactive*** can help awaken more girls to science as a vocation. Let's teach our daughters that they don't always have to apologize, that it's okay not to please everyone.

But I don't think you should put young boys aside. The reason Marie Curie succeeds is also largely due to her collaboration with Pierre Curie. He was the Physicist, she the Chemist. He was gentle and calm, she was tornadoes and fire and their love-passion joins their passion for science and discovery. It is a couple model where the two parties are equal and where the relationship is based on respect and collaboration. There is never any question of domination. Even today the couple Marie and Pierre Curie are a couple of the future.

I think it is necessary to pass the following message to our children: There is nothing more attractive than intelligence and there is nothing more modern than the equality that concerns genders and races. And obviously this fight must be waged with men, not against them.

Finally the title of the film is ***Radioactive*** and not "Marie Curie." We are talking here about the effects of the discovery of radioactivity which changed the face of the world at the beginning of the last century. In a positive way because it made it possible to find a cure against cancer, and in a negative way because it also gave rise to the atomic bomb and the nuclear disasters.

Is it the fault of science? The answer is obviously NO. Science is the expression of human curiosity trying to understand the world around it. As Marie Curie said so well: "In life, nothing is to be feared, everything is to be understood."

However, what is our responsibility as human beings in relation to these new discoveries?

Thank you.

Marjane Satrapi
DIRECTOR

LESSON ONE

MARIE CURIE: THE IMAGE AND THE REALITY

LESSON OVERVIEW

In this lesson students will learn about the trailblazing scientist Marie Curie who discovered the process and coined the term radioactivity, was the first woman to win a Nobel Prize, and to this day, remains the only person to win two Nobels in two different sciences - chemistry and physics.

Through inductive reasoning, students will learn about her early life and influences by applying a critical media literacy lens to depictions of her in select primary and secondary source materials and compare this to her portrayal in the feature length film, ***Radioactive***.

GUIDING QUESTIONS

- Who was Marie Curie?
- What is the image of Marie Curie? What was the reality?
- How did Marie Curie defy the conventions of her day?
- What do we learn about the History of Science through the life of Marie Curie and the film ***Radioactive***?

DURATION

Two, 55-minute class periods.

GRADE LEVEL

8th -12th Grade

MATERIALS

- Lesson One Packet: Can be printed or uploaded on a shared classroom drive
- Film clip and equipment to project Clip One from the film, ***Radioactive***

DAY ONE:
PLAN OF INSTRUCTION

1. INTRODUCTION: WHO WAS MARIE CURIE?

Organize students into small groups of three or four students to review a Photo Gallery of Marie Curie.

- Project, or have students view and analyze from their shared drive, photographs from The Nobel Prize Archive Project.[1]
- Begin with image 10 and view in reverse order to see the photographs in chronological order. With each image, discuss the photograph using these prompts
  - What do they see in the photograph?
  - What do they learn about Marie Curie from each image and from the captions?
  - What questions, if any, do the photographs elicit?

2. SMALL GROUP WORK - DOCUMENT ANALYSES AND DISCUSSION

Organize students into small groups of three or four students - these will be their document discussion and analyses groups. In their packet, Documents A through E.

Document A:
Vanity Fair image of Marie and Pierre Curie

Document B:
"A New Chemical Element", New York Daily Tribune, Sunday, December 17, 1899

Document C:
Nobel Prize Speech, 1911

Document D:
"Mother of Radium Returns", The Sunday Star Magazine, October 13, 1929

Document E:
"Introduction" from *Madame Curie: A Biography,* written by her daughter Eve Curie

DAY TWO:
PLAN OF INSTRUCTION

1. OPENING- DAY TWO

Introduce the film ***Radioactive*** to students. Directed by Marjane Satrapi, the 2020 film is inspired by the graphic biography of the same name, *Radioactive* by Lauren Redniss. The film tells the scientific story and romantic passions of Marie Sklodwska-Curie (Polish scientist) and Pierre Curie, and the ongoing reverberations of their discoveries.

Before showing the film clip, have students reflect on and discuss this question:

- If other films on Marie Curie already exist, what may have motivated this director to make another new film about this character?

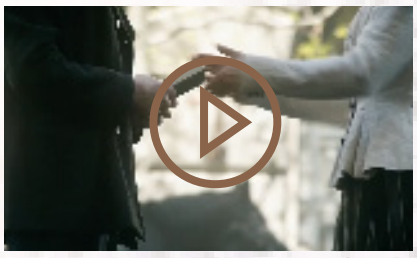
Next, share this excerpt from an interview director Marjane Satrapi did on what motivated her to make the film, ***Radioactive***.

> "THE MOST FASCINATING PART FOR HER WAS NOT ONLY THE BIOPIC OF MME. CURIE, BUT ALSO ABOUT RADIOACTIVITY - THAT IS WHAT MAKES THE FILM MODERN AND DIFFERENT THAN THE OTHERS. MME CURIE IS A ROLE MODEL BECAUSE SHE DID WHAT SHE HAD TO DO. SHE LOVED SCIENCE, SHE WANTED TO WORK ON SCIENCE, SHE WANTED TO MAKE SCIENTIFIC RESEARCH - SHE DID IT. FOR THAT, YOU HAVE TO HAVE A CERTAIN CHARACTER, YOU HAVE TO HAVE A BELIEF ABOUT YOURSELF. SOCIETY OFTEN TELLS WOMEN THAT THEY HAVE TO BE PERFECT IN EVERYTHING, THEY HAVE TO BE GREAT SPOUSES, GREAT MOTHERS, GREAT COOKS, HAVE TO BE BEAUTIFUL, SUCCEED IN THEIR WORK - IT'S IMPOSSIBLE. NOBODY CAN BE GOOD IN EVERYTHING BECAUSE WE ARE HUMAN BEINGS AND WE ARE IMPERFECT; AND THIS IMPERFECTION, WE CAN ACCEPT IT IN MEN, I HOPE THAT ONE DAY WE CAN ACCEPT THIS IMPERFECTION WITH WOMEN, THEN SOCIETY WILL CHANGE."

- Ask students for their reactions to this interview answer. Does it reinforce or conflict with what they know about Marie Curie up to this point?

2. WATCH CLIP ONE FROM *RADIOACTIVE*

Teacher Note: *The film opens with Marie Curie walking into her lab in Paris before fainting. She is then taken to a hospital where we see her wheeled on a stretcher while having a flashback to the first time she meets Pierre Curie in Paris, 1893.*



Watch Clip One: The Beginning of Their Partnership, (runtime: 10 min)

Debrief and discuss the film clip:

- What reactions do they have to the film?
- What was new or surprising?
- Hélène Langevin-Joliot, Marie Curie's grand-daughter, recalls that her grandmother wrote in a letter to her mother, Irene, that she suffered much more from the lack of resources than from the fact of being a woman. What is your reaction to this insight?

3. CLOSING: CRITICAL MEDIA LITERACY: ANALYZING THE *RADIOACTIVE* FILM POSTER.

Have students view then analyze the ***Radioactive*** film poster handout by using these questions:

- Who created this poster?
- What creative techniques were used to attract my attention?
- How might different people understand the poster differently?
- What point of view or message is this poster communicating?
- What is the purpose of this poster?

Next, compare this poster to what you know about Marie Curie using the information you collected on your sketchnote.

- What are your initial reactions to the poster given what you know about Marie Curie?
- Is the poster an accurate representation? Why or why not?
- If you were to add a tagline to the poster, or several words on the top of the poster, what would they be?
- Return to the print viewed at the beginning of the lesson from *Vanity Fair* Magazine and compare the two representations.

Extended Learning

- Have students create a movie poster on Marie Curie from this lesson.
- What image(s) would they use?
- What medium would they choose?
- What would they want to communicate?

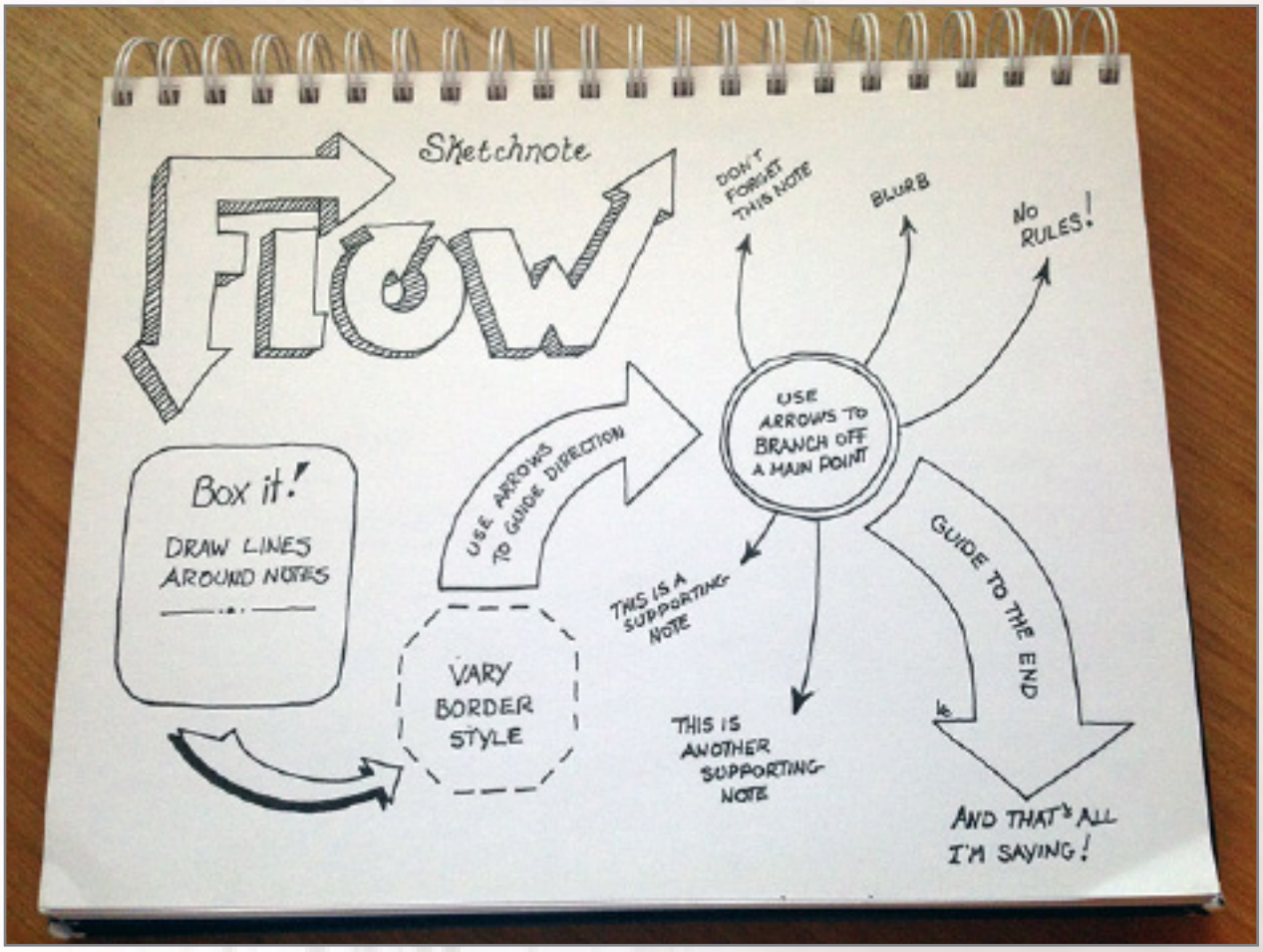
Further Learning on Marie Curie

Madame Curie: A Biography, Eve Curie
Obsessive Genius, The Inner World of Marie Curie, Barbara Goldsmith
Radioactive, Lauren Redniss

LESSON ONE PACKET:
MODEL OF SKETCHNOTE

Directions: *Create a Sketchnote of Marie Curie as you learn about her life and scientific work. Sketchnoting, also commonly referred to as visual notetaking, is the creative and graphic process to record thoughts and information with the use of illustrations, symbols, structures, and texts. For more information see:* *https://medium.com/ingeniouslysimple/free-intro-to-sketchnotes-cheatsheet-d1cf8566441b*

SKETCHNOTE PORTRAIT

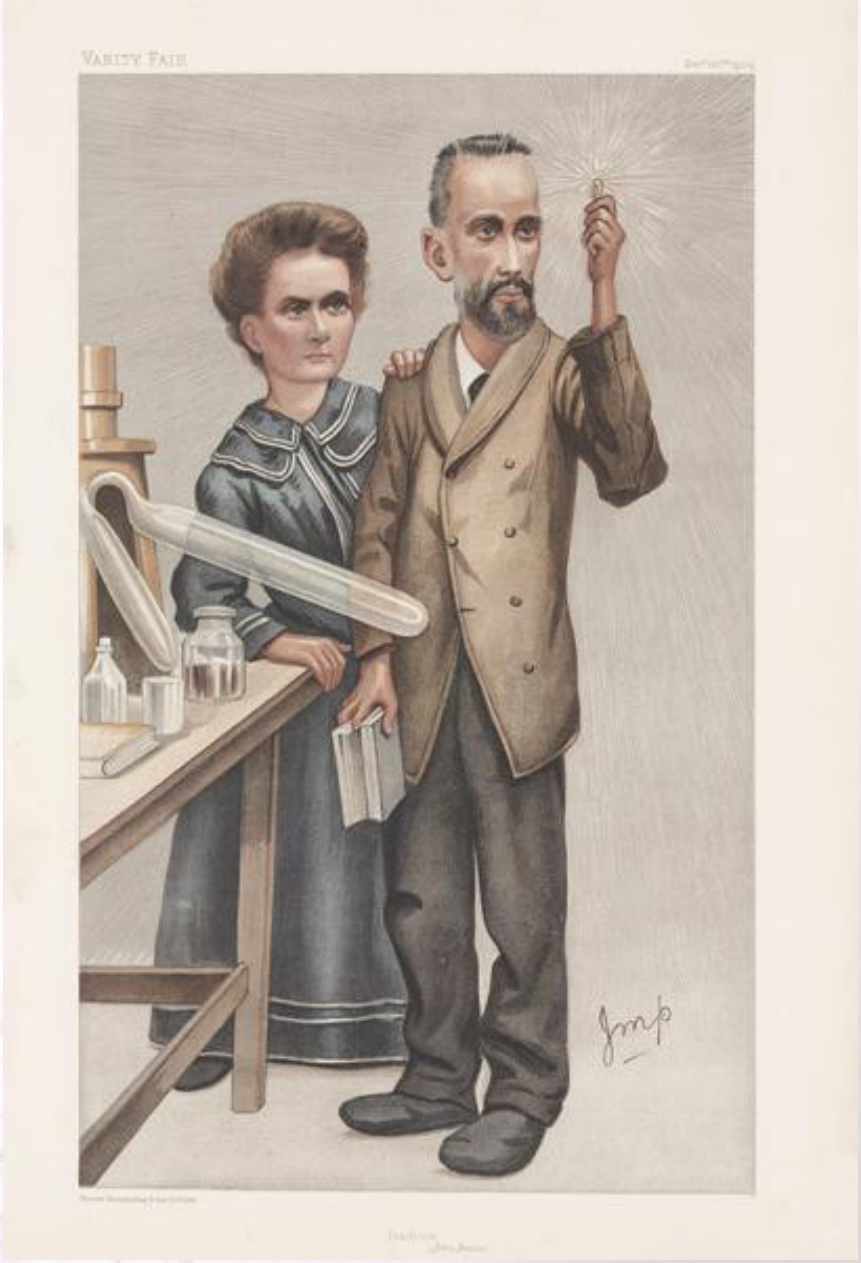


Credit: Nuggethead

DOCUMENT A: *VANITY FAIR* POSTER, DECEMBER 12, 1904

Visual Analysis Questions:

- What do they see in this print?
- Who is the intended audience?
- What message do you think the artist is trying to communicate about Marie and Pierre Curie?



Credit: Commons Wikimedia

DOCUMENT B: NEW YORK DAILY TRIBUNE, SUNDAY, DECEMBER 17, 1899

Read the transcription of the article with this question in mind:

- What do you learn about the scientific discovery of Marie and Pierre Curie from this article?

"A New Chemical Element": Transcription[1]

"Six or eight permanent additions to the list of chemical elements have been made within the last three or four years. None of them, however, possess such immediate practical importance as the discovery of radium. The find of helium in terrestrial minerals awakened a peculiar degree of interest, because it afforded fresh evidence that the earth and the sun are made of substantially the same materials. Still, no one has yet found any use for helium. It was a little startling to learn, as the world did from Ramsay's isolation of argon, that the atmosphere contained one more constituent than had previously been supposed. Yet, so far as is known, argon is as useless as helium. And so on through the list of recent discoveries, until radium is reached. Regarding this element, Professor Barker showed in Philadelphia last week than on account of the invisible radiances which it emits it is a more convenient and economical agent for surgical exploration than that which made Röntgen famous.

The investigations of M. and Mme. Curie, which resulted in the finding of radium began early in 1898, if not before, and were doubtless stimulated, in not suggested, by the Bavarian professor's brilliant achievement. Röntgen's work naturally called to mind the observations of Becquerel, that uranium and its salts exerted a very feeble photographic influence. By experimenting with pitchblende, the mineral from which uranium is obtained commercially, M. and Mme. Curie found that the former yielded the same effect much more conspicuously. This led them to suspect that they were on the track of a new element. They even went so far as to name it provisionally, although much difficult was experienced in separating it from the substances with which it was associated. Just before the close of the year, with the cooperation of M. Bemont, they obtained indications of still another new element. The first they called "polonium" and the second "radium." Polonium is believed to surpass uranium and its salts in emissive power five hundredfold, but Professor Barker estimates the efficiency of radium at one hundred thousand times that of uranium. For this reason, and because of its comparative cheapness and simplicity, the second of the Curies' discoveries seems destined to replace the costly and complicated X ray apparatus in the realm of surgery.

One important distinction is to be noted between the behavior of the Crookes tube and that trait of radium which is now for the first time being exploited in this country. The practicability of deriving one form of energy—heat, light, electricity or chemical action—from some other has long been recognized, but it is axiomatic that none of them can be produced except by that method. It is believed that the most man can do is to transform.

It is thought that he cannot, in any true sense, create. Röntgen obtained his X rays only by a conversion of force previously existing in the form of electricity. But a radiance which will penetrate opaque bodies and act upon the chemicals on a photographic plate is secured from radium without the apparent use of any known specifies of energy. The phenomenon may yet be explained. But at present it looks very much like what has long been regarded an impossibility, the spontaneous generation of force.

The fact is not altogether unique, however. Within the last few years an Englishmen, name Russell, has been calling attention to the exceedingly slow but well defined action on a photographic plate of several familiar substances, amount them printer's ink, of which he regards the varnish the potent factor. The protective covering which he placed on his plate seemingly preclude any chemical action by the ink, or any invasion of his placeholder by true light rays. And as he was able to observe the effect when he used specimens of print over a century old, it is hard to say how long this mysterious power may continue to be exerted by ink. This fact, taken with the discovery of M. and Mme. Curie, open up a fascinating, and perhaps fruitful, field of speculation as to the existence and nature of yet unrecognized physical forces."

DOCUMENT C: NOBEL PRIZE LECTURES, 1903 AND 1911

Read the excerpts of these two Nobel Prize speeches:

- What do these two lectures reveal about the culture of scientific discovery at the turn of the 20th century and the partnership between Pierre and Marie Curie?

Radioactive Substances, especially radium, Pierre Curie, 1905*[2]

**Because of illness, Pierre and Marie Curie did not travel to Stockholm, Sweden to accept their Nobel Prize in Physics in 1903. Two years later, Pierre Curie presented this lecture on Jume 6, 1905.*

"Allow me, first of all, to tell you that I am happy to speak today before the Academy of Sciences which has conferred on Mme. Curie and myself the very great honour of awarding us a Nobel Prize. We must also tender you our apologies for being so tardy in visiting you in Stockholm, for reasons quite outside our control.

I have to speak to you today on the properties of the radioactive substances, and in particular of those of radium. I shall not be able to mention exclusively our own investigations. At the beginning of our studies on this subject in 1898 we were the only ones, together with Becquerel, interested in this question; but since then much more work has been done and today it is no longer possible to speak of radioactivity without quoting the results of investigations by a large number of physicists such as Rutherford, Debierne, Elster and Geitel, Giesel, Kauffmann, Crookes, Ramsay and Soddy, to mention only a few of those who have made important progress in our knowledge of radioactive properties.

Becquerel discovered in 1896 the special radiating properties of uranium and its compounds. Uranium emits very weak rays which leave an impression on photographic plates. These rays pass through black paper and metals; they make air electrically conductive. The radiation does not vary with time, and the cause of its production is unknown. Mme. Curie in France and Schmidt in Germany have shown that thorium and its compounds possess the same properties. Mme. Curie also showed in 1898 that of all the chemical substances prepared or used in the laboratory, only those containing uranium or thorium were capable of emitting a substantial amount of the Becquerel rays. We have called such substances radioactive.

Mme. Curie has studied the minerals containing uranium or thorium, and in accordance with the views just stated, these minerals are all radioactive. But in making the measurements, she found that certain of these were more active than they should have been according to the content of uranium or thorium. Mme. Curie then made the assumption that these substances contained radioactive chemical elements which were as

yet unknown. We, Mme. Curie and I, have sought to find these new hypothetical substances in a uranium ore, pitchblende. By carrying out the chemical analysis of this mineral and assaying the radioactivity of each batch separated in the treatment, we have, first of all, found a highly radioactive substance with chemical properties close to bismuth which we have called polonium, and then (in collaboration with Bémont) a second highly radioactive substance close to barium which we called radium. Finally, Debierne has since separated a third radioactive substance belonging to the group of the rare earths, actinium. These substances exist in pitchblende only in the form of traces, but they have an enormous radioactivity of an order of magnitude 2 million times greater than that of uranium. After treating an enormous amount of material, we succeeded in obtaining a sufficient quantity of radiferous barium salt to be able to extract from it radium in the form of a pure salt by a method of fractionation. Radium is the higher homologue of barium in the series of the alkaline earth metals. Its atomic weight as determined by Mme. Curie is 225. Radium is characterized by a distinct spectrum which was first discovered and studied by Demarçay, and then by Crookes and Runge and Precht, Exner, and Haschek.

Finally, in the biological sciences the rays of radium and its emanation produce interesting effects which are being studied at present. Radium rays have been used in the treatment of certain diseases (lupus, cancer, nervous diseases). In certain cases their action may become dangerous. If one leaves a wooden or cardboard box containing a small glass ampulla with several centigrams of a radium salt in one's pocket for a few hours, one will feel absolutely nothing. But 15 days afterwards a redness will appear on the epidermis, and then a sore which will be very difficult to heal. A more prolonged action could lead to paralysis and death. Radium must be transported in a thick box of lead.

It can even be thought that radium could become very dangerous in criminal hands, and here the question can be raised whether mankind benefits from knowing the secrets of Nature, whether it is ready to profit from it or whether this knowledge will not be harmful for it. The example of the discoveries of Nobel is characteristic, as powerful explosives have enabled man to do wonderful work. They are also a terrible means of destruction in the hands of great criminals who are leading the peoples towards war. I am one of those who believe with Nobel that mankind will derive more good than harm from the new discoveries.

[Important Note: On April 19, 1906 Pierre Curie was killed in a street accident in Paris.]

Radium and the New Concepts in Chemistry, Marie Curie, 1911[3]
"Some 15 years ago the radiation of uranium was discovered by Henri Becquerel, and two years later the study of this phenomenon was extended to other substances, first by me, and then by Pierre Curie and myself. This study rapidly led us to the discovery of new elements, the radiation of which, while being analogous with that of uranium, was far more intense. All the elements emitting such radiation I have termed radioactive, and the new property of matter revealed in this emission has thus received the name *radioactivity*. Thanks to this discovery of new, very powerful radioactive substances, particularly radium, the study of radioactivity progressed with marvellous rapidity: Discoveries followed each other in rapid succession, and it was obvious that a new science was in course of development. The Swedish Academy of Sciences was kind enough to celebrate the birth of this science by awarding the Nobel Prize for Physics to the first workers in the field, Henri Becquerel, Pierre Curie and Marie Curie (1903).

It is therefore my task to present to you radium in particular as a new chemical element, and to leave aside the description of the many radioactive phenomena which have already been described in the Nobel Lectures of H. Becquerel, P. Curie and E. Rutherford.

Before broaching the subject of this lecture, I should like to recall that the discoveries of radium and of polonium were made by Pierre Curie in collaboration with me. We are also indebted to Pierre Curie for basic research in the field of radioactivity, which has been carried out either alone, in collaboration with his pupils.

The chemical work aimed at isolating radium in the state of the pure salt, and at characterizing it as a new element, was carried out specially by me, but it is intimately connected with our common work. I thus feel that I interpret correctly the intention of the Academy of Sciences in assuming that the award of this high distinction to me is motivated by this common work and thus pays homage to the memory of Pierre Curie."

DOCUMENT D: THE SUNDAY STAR MAGAZINE, OCTOBER 13, 1929

Read the transcription of the article with these questions in mind:

- What new information do you learn about Marie and Pierre Curie?
- From the article, what is opinion and what is fact?


The Sunday Star

Mother of Radium Returns

"Mother of Radium Returns" (Transcription)[4]

When Mme. Marie Curie This Month Pays Her Second Visit to America, Her Many Friends and Admirers Here Will Present to Her Another Gram of the Precious Materials She Discovered, to be Used in the Fight Against Disease in Poland.
By Dr. Francis Carter Wood
Professor and Director of Cancer Research at Columbia University

"One of the great scientists of the present century will make her second visit to America this month. Marie Curie comes to dedicate the new Hepburn Laboratory of Chemistry at St. Lawrence University, to attend a dinner given in honor of Thomas Alva Edison and to meet the friends she made on her previous trip in 1921.

This previous trip was arranged by a group of women who admired one who is perhaps the greatest woman scientist of all time and who not only wished to do her honor, but to give her a long needed vacation from the arduous labors of her research laboratory; for the continuous handling of radium in large quantities is dangerous and her health had been seriously undermined not only by such exposure to the radium rays, but by her long devotion to her laboratory. Her only vacations have been occasional visits to her native country to see her relatives, a few short trips which she made to give lectures on the discovery of radium, and the traveling which she did during the development of radiological services during the war. In this she played a most important part, for she created out of nothing a group of portable radiological laboratories which traveled to the spot where they were most needed for the diagnosis of bone injuries or the location of bullets or shell particles which needed extraction.

(The President) presented Mme. Curie with the key to a box in which radium —at that time in safe storage in the vaults of the Bureau of Standards—was afterward transported to France. With the true scientific spirit Mme. Curie refused to accept the radium as a personal gift, but insisted that the deed should be so made that the radium would become the property of the laboratory named in honor of her husband—the Curie Laboratory—and the surplus money, for the momentum of the subscription had carried the fund quite a distance beyond the amount necessary to pay for the radium, was trusted and the Income offered to Mme. Curie to conduct further work.

Now she has come again, and her friends have subscribed $50,000 to give her what she most desires—another gram of radium to be used in the service of humanity in her own country, Poland, which at present has no radium. By her efforts and the generosity of the French government and private individuals, the Paris Institute of Radium, in which she is interested, has a sufficient supply for its purposes...To these two Institutes must go all those who are interested either in the scientific investigation of the nature of radium and the rays which it gives off, or in the application of these rays to relieve human suffering from cancer.

Few people know the details of the dramatic discovery which Mme. Curie and her husband made. Like so many other discoveries in science, it was not wholly independent, for it was preceded by the discovery by Roentgen of the X-rays in 1895.

Prof. Henri Becquerel thought that perhaps rays similar to X-rays might be emitted from fluorescent uranium. By accident he selected some crystals of a uranium compound which he had prepared some 15 years before. If he had used a fresh preparation, radium might not have been discovered. He placed these crystals upon a photographic plate enclosed in black paper and promptly found that the plate was blackened after development. Prof. Becquerel then discovered that this blackening was not due to the fluorescence of the uranium salt, for it was obtained when that salt had not been exposed to light for several months. It must, therefore, be due to some rays coming from the Uranium itself said he.

Mme. Curie's profound knowledge of chemistry was known to Prof. Becquerel, and he asked her to take up the question and find out why the uranium gave off a kind of light which would pass through black paper. It was shortly found that the uranium had also the capacity to discharge electricity from bodies near it. It happened that Mme. Curie's husband had been interested in devising a very sensitive instrument for detecting, such minute electrical currents as pass through air influenced by uranium, so he joined with his wife in testing the radioactivity of a large number of substances.

Certain minerals were found to be highly radioactive, but only those containing uranium or thorium. Mme. Curie then suggested the Hypothesis that there must be in these ores some substance which was much more radioactive than either uranium or thorium Itself. This meant, of course, separating chemically these new substances from uranium ores. The separation was based entirely on the tested radioactivity of each substance separated. The ore contained a large number of elements, each one of which had to be collected by the most careful chemical analysis and tested. The new radioactive substance did not amount to a millionth of 1 percent of the original ore. Nevertheless, polonium, named after Mme. Curie's native country was discovered in July. 1898, and radium in December of the same year.

In order to obtain more than a few specks of either of these substances it was necessary to work with large quantities of ore, and Mme. Curie gave her entire time to isolating more radium and polonium in order that they might determine the nature of these substances. This work had to be carried out in an abandoned storeroom, which was merely a wooden shed with an asphalt floor, a roof which did not keep out the rain and without any fittings. The only objects which this magnificent laboratory contained were some old pine tables, a cast iron stove and a blackboard. There was no ventilator to carry off the poisonous gases given off in the chemical analysis, so that in good weather they worked outside of the building in a courtyard, and when the weather was unfavorable they worked inside, with the windows left open. This in a Paris Winter. In her published account of the life of her husband she says, "We were at this time entirely absorbed in the new field that opened before us, thanks to the discovery so little expected. And we were very happy, in spite of the difficult conditions under which we worked. We passed our days at the laboratory, often eating a simple student's lunch there. A great tranquillity reigned in our poor, shabby hangar; occasionally, while observing an operation we would walk up and down, talking of our work, present and future. When we were cold a cup of hot tea, drunk beside the stove, cheered us. We lived in a preoccupation as complete as that of a dream.

So wretched were the conditions under which these two devoted persons worked that they even had to pay out of their own meager in comes for some of the chemicals which they used, and their combined incomes were at that time about one-fifth of what an able-bodied bricklayer could make in the city of New York—not in 1929, but in 1900.

The effect of the discovery on these two was a crushing blow. Pierre Curie...was over whelmed with demands for speeches, public lectures, portraits, autographs—the thousand things which an unthinking and selfish public inflict upon someone who has achieved a great discovery...in spite of the French appreciation of Intellectual achievement, these two persons, who have given more fame to France than almost anyone else except Pasteur, continued to work in poverty and great physical discomfort owing to the lack of ordinary laboratory conveniences.

When I took Mme. Curie into the great physics laboratory of Columbia University and showed her some of the experimental equipment with which that great institute is provided her astonishment was such that she could scarcely speak. In a single room the students and investigators in that Institution had more apparatus than she had ever possessed in her entire lifetime, or, as a matter of fact, would ever possess, though she now holds her husband's position of professor in the university.

They were told that they should patent their processes for extracting radium and that they would thus become rich, but they both felt that their work was entirely for humanity and that any patenting of these processes would inevitably result in high prices, and that if any practical value resided in their discovery it should be turned over to the people who needed it.

It is a shabby story and yet a wonderful one, because, as the work went on, they were aided by brilliant chemists and physicists working in other departments of the university, who helped them for the pure love of discovery and who, without claiming any reward or even without desire to share in the glory at the new."

DOCUMENT E: EXCERPT FROM *MADAME CURIE: A BIOGRAPHY*, BY EVE CURIE. PUBLISHED 1937

Directions: *With the previous documents in mind, discuss in your small group how this introduction to Madame Curie's biography written by her daughter inform your understanding of the image and the reality of Marie Curie?*

Introduction

THE LIFE OF MARIE CURIE *contains prodigies in such number that one would like to tell her story like a legend.*

She was a woman; she belonged to an oppressed nation; she was poor; she was beautiful. A powerful vocation summoned her from her motherland, Poland, to study in Paris, where she lived through years of poverty and solitude. There she met a man whose genius was akin to hers. She married him; their happiness was unique. By the most desperate and arid effort they discovered a magic element, radium. This discovery not only gave birth to a new science and a new philosophy: it provided mankind with the means of treating a dreadful disease.

At the moment when the fame of the two scientists and benefactors was spreading through the world, grief overtook Marie: her husband, her wonderful companion, was taken from her by death in an instant. But in spite of distress and physical illness, she continued alone the work that had been begun with him and brilliantly developed the science they had created together.

The rest of her life resolves itself into a kind of perpetual giving. To the war wounded she gave her devotion and her health. Later on she gave her advice, her wisdom and all the hours of her time to her pupils, to future scientists who came to her from all parts of the world.

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When her mission was accomplished she died exhausted, having refused wealth and endured her honors with indifference.

It would have been a crime to add the slightest ornament to this story, so like a myth. I have not related a single anecdote of which I am not sure. I have not deformed a single essential phrase or so much as invented the color of a dress. The facts are as stated; the quoted words were actually pronounced.

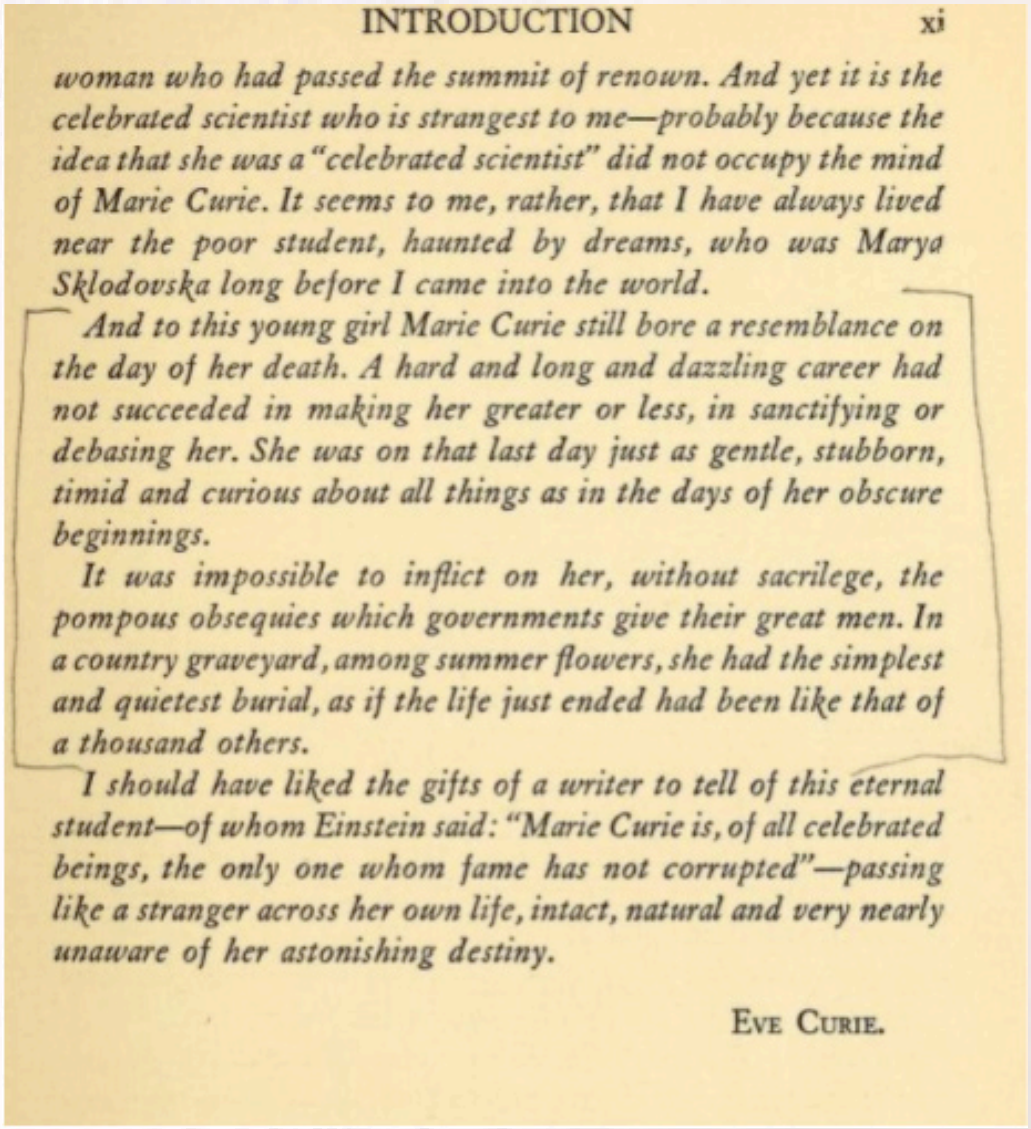
I am indebted to my Polish family, charming and cultivated, and above all to my mother's eldest sister, Mme Dluska, who was her dearest friend, for precious letters and direct evidence on the youth of the scientist. From the personal papers and short biographical notes left by Marie Curie, from innumerable official documents, the narratives and letters of French and Polish friends whom I cannot thank enough, and from the recollections of my sister Irène Joliot-Curie, of my brother-in-law, Frederic Joliot, and my own, I have been able to evoke her more recent years.

I hope that the reader may constantly feel, across the ephemeral movement of one existence, what in Marie Curie was even more rare than her work or her life: the immovable structure of a character; the stubborn effort of an intelligence; the free immolation of a being that could give all and take nothing, could even receive nothing; and above all the quality of a soul in which neither fame nor adversity could change the exceptional purity.

Because she had that soul, without the slightest sacrifice Marie Curie rejected money, comfort and the thousand advantages that genuinely great men may obtain from immense fame. She suffered from the part the world wished her to play; her nature was so susceptible and exacting that among all the attitudes suggested by fame she could choose none: neither familiarity nor mechanical friendliness, deliberate austerity nor showy modesty.

She did not know how to be famous.

My mother was thirty-seven years old when I was born. When I was big enough to know her well, she was already an aging



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woman who had passed the summit of renown. And yet it is the celebrated scientist who is strangest to me—probably because the idea that she was a "celebrated scientist" did not occupy the mind of Marie Curie. It seems to me, rather, that I have always lived near the poor student, haunted by dreams, who was Marya Sklodovska long before I came into the world.

And to this young girl Marie Curie still bore a resemblance on the day of her death. A hard and long and dazzling career had not succeeded in making her greater or less, in sanctifying or debasing her. She was on that last day just as gentle, stubborn, timid and curious about all things as in the days of her obscure beginnings.

It was impossible to inflict on her, without sacrilege, the pompous obsequies which governments give their great men. In a country graveyard, among summer flowers, she had the simplest and quietest burial, as if the life just ended had been like that of a thousand others.

I should have liked the gifts of a writer to tell of this eternal student—of whom Einstein said: "Marie Curie is, of all celebrated beings, the only one whom fame has not corrupted"—passing like a stranger across her own life, intact, natural and very nearly unaware of her astonishing destiny.

EVE CURIE.

Credit: https://archive.org/stream/madamecuriebiogr00evec_0#page/n13/mode/2up

FILM POSTER, *RADIOACTIVE* (2020)

As a class, or in small groups, have students engage in a critical media exercise of the poster using these steps:

- Who created this poster?
- What creative techniques were used to attract my attention?
- How might different people understand the poster differently?
- What point of view or message is this poster communicating?
- What is the purpose of this poster?

Next, compare this poster to what you know about Marie Curie using the information you collected on your sketchnote.

- What are your initial reactions to the poster given what you know about Marie Curie?
- Is the poster an accurate representation? Why or why not?
- Do you agree with the terms used - "Pioneer. Genius. Rebel."? What other terms would you use to describe Marie Curie for a movie poster?
- Return to the print viewed at the beginning of the lesson from *Vanity Fair* Magazine and compare the two representations.

STANDARDS

NGSS

MS-PS1-1. Develop models to describe the atomic composition of simple molecules and extended structures
https://www.nextgenscience.org/sites/default/files/evidence_statement/black_white/MS%20PS%20Evidence%20Statements%20June%202015%20asterisks.pdf

HS-PS1-2. Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties.
https://www.nextgenscience.org/pe/hs-ps1-2-matter-and-its-interactions

HS-PS1-8. Develop models to illustrate the changes in the composition of the nucleus of the atom and the energy released during the processes of fission, fusion, and radioactive decay.
https://www.nextgenscience.org/pe/hs-ps1-8-matter-and-its-interactions

Common Core State Standards Connections:

ELA/Literacy

ELA-LITERACY.RI.9-10.1: Cite strong and thorough textual evidence to support analysis of what the text says explicitly as well as inferences drawn from the text.

ELA-LITERACY.RI.9-10.2: Determine a central idea of a text and analyze its development over the course of the text, including how it emerges and is shaped and refined by specific details; provide an objective summary of the text.

ELA-LITERACY.RI.9-10.3: Analyze how the author unfolds an analysis or series of ideas or events, including the order in which the points are made, how they are introduced and developed, and the connections that are drawn between them.

ELA-LITERACY.RI.9-10.7: Analyze various accounts of a subject told in different mediums (e.g., a person's life story in both print and multimedia), determining which details are emphasized in each account

ELA-LITERACY.RH.9-10.1: Cite specific textual evidence to support analysis of primary and secondary sources, attending to such features as the date and origin of the information.

ELA-LITERACY.RH.9-10.2: Determine the central ideas or information of a primary or secondary source; provide an accurate summary of how key events or ideas develop over the course of the text.

WHST.9-12.2
Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (HS-PS1-2)

WHST.9-12.5
Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience. (HS-PS1-2)

SOURCE

1 https://www.nobelprize.org/prizes/chemistry/1911/marie-curie/photo-gallery/
2 https://chroniclingamerica.loc.gov/lccn/sn83030214/1899-12-17/ed-1/seq-8/#date1=1898&index=1&rows=20&searchType=advanced&language=&sequence=0&words=Curie+radium&proxdistance=10&date2=1900&ortext=&proxtext=curie+radium&phrasetext=&andtext=&dateFilterType=yearRange&page=1
3 https://www.nobelprize.org/uploads/2018/06/pierre-curie-lecture.pdf
4 https://chroniclingamerica.loc.gov/lccn/sn83045462/
5 https://www.nobelprize.org/prizes/chemistry/1911/marie-curie/lecture/
6 Marie Curie, quoted on p 20, Obsessive Genius, by Barbara Goldsmith, Atlas Books, New York, New York, 2005.
7 A glimpse of the solution. NobelPrize.org. Nobel Media AB 2020. Tue. 12 May 2020. https://www.nobelprize.org/prizes/themes/a-glimpse-of-the-solution
8 Interview with Blueshift Education and Marjane Satrapi, May 19, 2020.
9 The organizers are from TheWonderofScience.org, which also includes videos and teacher resources to support student use.
10 The “grape fermentation model” was written for the film, there is no evidence of Marie Curie using it to describe radioactivity.
11 Eve Curie, *Madame Curie: A Biography* (New York: Doubleday, 1937), p. 341.
12 https://www.nobelprize.org/uploads/2018/06/pierre-curie-lecture.pdf
13 Barbara Goldsmith, *Obsessive Genius: The Inner World of Marie Curie* (New York: W.W. Norton, 2005) p. 229.
14 Ibid, p. 229.
15 Ibid., p. 229.
16 Ibid., p. 226.
17 Lauren Redniss, *Radioactive* (New York: Harper Collins, 2011), p. 183.

THE EDUCATIONAL CONTENT FOR RADIOACTIVE WAS DEVELOPED BY Blueshift Education

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