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Based on a True Story: Using Movies as Source Material for General Chemistry Reports

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One activity that has been used to promote deep learning is to have students write reports about the chemistry behind events reported in the news *(1–3)*. When students write reports they learn the relationship between textbook chemistry and "real-world" chemistry *(4)* in the most direct way. Nearly all facets of cognition are used when researching a topic and putting it into words for someone else to read. Having an in-class discussion is another activity that encourages students to connect real events or phenomena with their underlying chemistry. Case study analysis *(5–8)* is an excellent vehicle for preparing students for these discussions. Many case studies have been created; for a summary, visit Herreid's *(8)* or the *JCE* Web sites *(9)*.

The educational potential of the scientific principles found in certain feature films *(10–15)* has been noted. These authors report that watching entire films or showing short clips from selected films is an excellent way to provoke discussion about scientific principles.

When recent current events were used as the source material for written reports in general chemistry, Griep experienced limited success. A disappointing 59% of the students completed the required report. Therefore, a variety of approaches were considered that might improve student enthusiasm for the writing exercise. Selecting the news topic for the students would make sure that a suitably rich topic was chosen but it would also reduce the topicality of the exercise. Instead, movies were chosen as the source material because they provide a human interest angle that is lacking from the news reports. The first step was to create a list of one dozen movies that could be used. Then, two of the movies were selected and used as source material for written reports. The student response to the exercise was overwhelmingly positive; 93% of the students completed the assignment and 90% of them earned a B or better.

Movies Based on a True Chemical Story

The type of movie that is most similar to a news article is one that is based on a true story. A list of films was gathered (Table 1) that includes movies about real scientists who made important chemical discoveries or movies about the impact that real chemical compounds have had on particular people. A synopsis of each of these films can be found on the Internet movie database *(16)*. The first four films on the

Table 1. Films Based on a True Chemical Story

Film	Chemical Themes	Social Dimension
Dr. Ehrlich's Magic Bullet (1940)	Selective cell staining; development of chemo–therapy; discovery of Salvarsan	The drive to discover despite many obstacles
Edison, The Man (1940)	Discovery and development of the carbon filament light bulb	The drive to develop new technology
Madame Curie (1943)	Voltammetry to detect and quantify radioactivity in uranium ore; multiple recrystallizations to purify radium	The drive to discover despite many obstacles
The Great Moment (1944)	Development of ether anesthetics for dental and surgical use; patenting one's knowledge	Relief of human suffering; compensation for the discoverer
The Alfred Nobel Story (1951)	Scientist regrets military uses of his invention, dynamite; creates Nobel prizes	Responsibility for one's creations (dubbed in English)
1776 (1972)	Musical with a song about making gunpowder	Resourcefulness during turbulent times
Silkwood (1983)	Plutonium purification from uranium ore; ignored safety practices; americium as a plutonium decay product	The balance between observing safety practices and making a living or profit
The Serpent and The Rainbow (1988)	Tetrodotoxin is identified as the zombie molecule; pharmacological anthropology in search of new anesthetics	The drive to discover despite risk to personal health
Awakenings (1990)	L-Dopa temporarily revives patients from their decades-long comas	A practitioner's care for patients
Lorenzo's Oil (1992)	*cis*-13-Docosonoic acid (erucic acid) metabolism and chemical synthesis; nutritional cure for a neurodegenerative disease	Parental love for a child drives discovery despite obstacles
Apollo 13 (1995)	Lithium hydroxide to absorb exhaled carbon dioxide in a confined space	Survival using intellectual ingenuity
Me & Isaac Newton (1999)	6-Mercaptopurine cures childhood leukemia; development of drug metabolism	Documentary probing motivations and aspirations of seven scientists

list are biographical pictures, or biopics. The Hollywood studios produced these films during the 1930s and 1940s as prestige pictures. The studios sought to improve their image in response to the criticism that many of their movies were exploitative or violent. The biopics featured top actors directed by top directors in stories that show scientists who are single-mindedly dedicated to their work despite numerous obstacles. The only recent film that is similar to these biopics is the documentary *Me & Isaac Newton*. Its focus is on the scientist primarily and on the impact of the science secondarily. This documentary was produced to inspire viewers by examining the motivations and stories of seven diverse creative scientists.

The contemporary films in the list (Table 1) focus mostly on the impact of science and technology. In fact, someone's health is the focus of four of these films: *Silkwood, The Serpent and the Rainbow, Awakenings,* and *Lorenzo's Oil*. There is very little bench science, however, and it usually takes place off screen. For instance, a dozen or so patients in *Awakenings* are brought out their viral-induced, decades-long comas after they are given the Parkinson's drug L-dopa. The mechanism by which L-dopa achieved its effect is never explained. This movie will certainly motivate students to want to learn more, however, because the drug loses its effectiveness after a few months and all of the patients lapse back into their comas by the film's end.

Reports Based on *Dr. Ehrlich's Magic Bullet* and *Me & Isaac Newton*

Two movies were selected from this list for use during the fall 2003 general chemistry course taught by the author (MAG). *Dr. Ehrlich's Magic Bullet* and *Me & Isaac Newton* presented students with a balanced choice. The course syllabus included a one-paragraph description of each film to help the students decide which one interested them the most. Five or six students were not able to attend any of the four viewings and were required to purchase their own copies of the movies to view (again as stated in the syllabus). Before each movie viewing, the movie studio and director were named and their motivations and credentials briefly discussed. Each movie was projected twice on different afternoons and the students were allowed to choose one as the basis of their report.

The majority of students who take general chemistry course are freshman and they typically lack technical writing skills. To overcome this problem, formatting guidelines (List 1) are provided so that the students will learn how to compose a report using citations and references. In addition, the students are required to insert the chemical structure into the text electronically *(17)*. The structure is the focus of many of the reports. Each student also received a copy of the scoring sheet that is used (List 2). They were told to use it as a checklist when preparing their reports. It takes about six minutes for the instructor to score each report.

Dr. Ehrlich's Magic Bullet is about the birth of chemotherapeutic drug discovery and development. It is among the best biopics ever made *(18)*. The movie presents the ideas that caused Ehrlich to develop his theory of "differential toxicity", which says that it should be possible to find a molecule that will kill the disease-causing organism but not the person with the disease.

List 1. Formatting Guidelines for the Reports

1. Word processor: Your report must be submitted in typed form.
2. Margins: 0.75-inch margins all around.
3. Title, Name, etc.: The top of the first page should include: title of report (60 characters or less), your name, and your lab section number. You may use any font size and type.
4. Format of report: 600 ± 50 words (excluding title and citations), double-spaced, times font, size 12.
5. First paragraph of report: Summarize the movie and its narrative theme in four or five sentences.
6. Rest of report: Be sure to include the chemical structure, its scientific and common names, and the relevant chemical properties. Cite your sources in the text using numbers to signify the reference. For instance, The LD50 for griepite is 0.0003 mg/kg in mice *(1)*.
7. End of report: Include a list of references cited.
8. End of report: Include a word count of report only. To do this, highlight the report excluding the references, title, author name, etc. and then use the "word count" function in the tools menu bar. Type the word count just after your references using the format: "Word Count: xxx".
9. Number the references according to their position in the report.

   a. The proper way to cite an article in a book, newspaper, or journal is: title of article by author names (year or date) journal name vol., page numbers.

   b. The proper way to cite an entire book is: title of book by author names (year) publisher name, publisher location.

   c. The proper way to cite a Web page: title of article by author names (date page written) page host name, accessed: date page accessed (Note that if you are not able to find these items, then that Web page is probably not a good source).

List 2. Report Scoring Sheet (85 Points Possible)

1. Formatting (20 points possible)
   a. Word count is listed and is between 550 and 650
   b. Double-spaced, times font, size 12, 0.75-inch margins
   c. Top of first page includes title, name, lab section
   d. First paragraph summarizes the movie
2. Chemical Content & Scientific Accuracy (25 points)
   a. Structure included
   b. Names and pertinent chemical info included
   c. Content and accuracy
3. Quality of Writing (25 points)
   a. Quality
   b. Grammar
   c. Spelling
4. References (15 points)
   a. At least one reference from print-based medium
   b. Citation for structure
   c. References numbered according to their position in the report
   d. High-quality sources used

The movie begins in the 1890s when Ehrlich was working as a physician at a hospital. He is frustrated that he has to prescribe a cure for syphilis that he knows does not work. He spends his evenings in the lab developing stains that are able to differentiate cell types. Dr. Robert Koch learns of his work and challenges him to develop a specific tubercle stain. Ehrlich achieves this aim but contracts tuberculosis. While recuperating in Egypt, he treats a father and son who have been bitten by a snake. The father is not affected because he survived three previous bites. This sparks Ehrlich to develop his "side chain", or immune response theory, which earned him the 1908 Nobel Prize in Medicine. Soon thereafter, the organism that causes syphilis was isolated and his team of researchers used rats to discover a chemical cure for syphilis. Throughout the movie, he perseveres despite opposition from colleagues, supervisors, funding committees, and racism against his Japanese research assistant.

The actual name of the antibiotic is not given in the movie. It is first referred to as "an arsenic compound". About three-quarters into the movie, there is a wonderful research crosscut montage that summarizes the 606 trials it took to discover the right formula and dose. After that, the molecule is named "Compound 606". In anticipation that some students would equate the element arsenic with the molecule Compound 606, it was announced in handouts and during lecture that it was an organic compound that included arsenic. In reality, Ehrlich named his compound Salvarsan, which means "saved by arsenic". It was later renamed Arsphenamine.

Me & Isaac Newton is the modern equivalent of *Dr. Ehrlich's Magic Bullet*. It is an inspiring documentary by a gifted director in which scientists from seven diverse fields explain their motivations for doing what they do. Gertrude Elion represents pharmaceutical chemists and their industry. Briefly, the other scientists and engineers are: Ashok Gadgil, water purification; Michio Kaku, string theory; Maja Mataric, robotics; Steven Pinker, language disorders; Karol Sikora, gene therapy; and Patricia Wright, lemur preserve.

In the movie, each of the seven scientists gives their response to a particular question before proceeding to the next question. During the part of the movie wherein Elion describes how she became interested in science, she gives a matter-of-fact description of the serious obstacles she faced as a woman seeking education and employment as a chemist in the 1950s. She is quick to follow by saying that she has enjoyed the rewarding hard work ever since the day she was hired by Burroughs Wellcome. She is clearly humble about having won the 1988 Nobel Prize in Medicine and other prizes since she was just doing work that she hoped would benefit people. She is touched far more deeply by the thanks from grateful parents whose children have been cured with the drug she helped develop. She died in 1999 while the documentary was being completed and it is dedicated to her.

Elion does not name the antileukemic drug that she developed and it becomes the student's task to identify its name and structure in the report. Since Elion is responsible for several drugs and the process by which she discovered their effects (from nucleoside metabolism studies), the students were assured during lecture that the name and structure of any molecule that Elion was associated with was acceptable but that the one that cures childhood leukemia was preferable. The antileukemic is 6-mercaptopurine but she is also responsible for the antiviral acycloguanosine, or acyclovir, among many others.

Conclusion

The students were enthusiastic about this project because the two movies are very engaging and create chemical mysteries by not naming their famous compounds. Both Ehrlich and Elion faced numerous scientific and social obstacles and both were motivated by humanitarian goals. They each won a Nobel Prize in Medicine and, because of this, there is excellent material about their research on the Internet and in reference books. After a little digging, the students are able to find the corresponding molecular names, structures, and properties, and the real-life stories demonstrate the societal impact of those molecules.

The movies in Table 1 present the instructor with a range of possibilities to select one or more movies with just the right flavor and subject emphasis. Using movies in the chemical classroom helps an instructor move the subject of chemistry from abstract, general themes to the personal and subjective arena of human interactions.

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