Critical thinking, in the realm of science, is essentially analogous to logical reasoning. Max Black of Cornell University explains the analogy in this way: "LOGIC can be briefly defined as the study of reasoning. The study of any subject calls for thought, and every student is, or ought to be, a thinker; but he is not a student of logic unless he thinks about reasoning" (Black, 1952).

One of the objectives in the teaching of biology, or the sciences in general, is to develop within the student the ability to reason, to effectively use the element of abstraction in the solution of problems. The involvement of inductive thinking in the derivation of knowledge is fundamental to critical thinking, and much of inductive reasoning may rely on an ability to enter into abstraction. Very little scientific discovery is purely inductive; many solutions to problems are founded on a great store of information. Deductively, we seek available information to assist us in designing investigations which will lead to new or novel solutions.

Critical thinking is not something we can teach or learn from a text; nor is it something that can be told to a student. Students must be actively involved in the process. Consequently, we may ask. Is our teaching of biology such that the activities lend themselves to enhancing the desired outcome of a logical thought process? To answer this question we must each evaluate our biology curriculums with regard to content, laboratory and field experiences and methods of teaching. What provisions are made for---student designed investigations; inquiry activities in the laboratory, in lecture and discussion sessions?...in contrast to straight lecture, verification laboratory exercises; and, few if any field assignments.

We will need to sacrifice some sacred content of biological knowledge to provide time to exercise those kinds of practices which will enhance the opportunities of the student to become as critical a thinker as possible.

All of us have attempted to foster inductive thinking in our classes. It is interesting to note that it is not only in recent years that we have been admonished to do so. We may reflect on the teaching of Socrates for evidence to support the premise; but, it is interesting to examine the writings of persons apart from teaching who have made observations about the process of critical thinking. As a result of his contribution to gaining for teachers the freedom of expression, through the John Scopes trial, it is relevant to look at the work of Clarence Darrow. It is revealing to discover how he viewed education and how we may establish analogies with Darrow's insights into learning.

Clarence Darrow's career in law is marked with many noteworthy cases involving among others, the struggle for equity in the labor forces of the United States; the evaluation of legislation at the federal level (the NRA: National Recovery Act); and cases involving individual clients. Two trials which drew international attention were the Leopold and Loeb case and the Dayton Case or Scopes Trial. From a brief review of these cases we immediately develop a feeling for the character and the nature of the thinking process of Darrow.
Of the Leopold and Loeb case, Darrow states,

"I endeavored in my address to make a plain, straightforward statement of facts on the case, and I meant to apply such knowledge as we now have of the motives that move men. The argument took the longest part of two court days and was printed almost word for word in some of the Chicago papers, and very extensively by the press outside the city, so that people at the time were fairly familiar with the facts in the case, and certainly of the outcome" (Darrow, 1932).

This quotation is in reference to a tragedy which occurred in 1924; the tragedy involved a boy named Robert Franks. Robert, who was 14 years of age, had not come home from school and his disappearance alarmed his parents. The next day Robert's father received a ransom note demanding $10,000.00 be delivered to a specific site in Chicago. Robert had been kidnapped by Richard Loeb and Nathan Leopold, the sons of wealthy Chicago families. These young men who were 17 and 18 years old, had out of want for something exciting to do, conceived what they thought would be the perfect crime.

Robert Franks lived in the same neighborhood and had accepted a ride home from school from Loeb and Leopold. During the ride, Franks was hit on the head with a chisel and he died. Loeb and Leopold left the naked body in a railroad culvert where it was discovered. Discovered, too, was a pair of spectacles which were traced to Leopold. Eventually, Loeb and Leopold told their terrible story and were charged with kidnapping and murder (Darrow, 1932).

Clarence Darrow was asked to defend Loeb and Leopold and he consented to take the case knowing full well the public bias and outrage against the defendants. Darrow was opposed to capital punishment and his objective for the case was to keep Loeb and Leopold from the gallows.

Darrow's insight into human nature and how man thinks under a given set of circumstances illustrates his ability to analyze a problem and how to apply the analysis to a solution. Darrow was very aware of bias and emotion as they enter the decision making process. Relative to the Loeb-Leopold case, Darrow stated,

"Everyone who thinks knows how common it is for men to set aside their views. Most men never had but one or two ideas, anyhow, and to these they hang like grim death. How often do people set aside their beliefs on politics, on religion, or any other question if in conflict with something they want to do? To set aside an opinion without evidence is not only psycho-logically impossible, but is phys-ically absurd" (Darrow, 1932).

To confirm Darrow's reference to setting aside beliefs when conflict arises we need only to refer to fraud in science reported by Broad and Wade (1982). It was Mark Spector, a 24 year old graduate student, who consistently and deliberately altered data derived from gel electrophoresis to confirm preconceived ideas about the nature of cancer cells. Spector knowingly deceived his advisor and the scientific community. Another case of fraud in medical research is cited by Roman (1988), in the use of tranquilizers known as neuroleptics; a case in which data were deliberately falsified and misleading. In each of these cases the nature of the research was oriented away from acquiring data objectively; this was accomplished by arranging the investigation to produce data which would confirm preconceived ideas.

**Having preconceived ideas about the possible solution to a problem is quite acceptable; we call these ideas hypotheses to be tested. But, manipulating investigative procedures to produce the desired data which would permit the acceptance of a hypothesis is quite unethical and may be unlawful.**

For most biologists, the name Clarence Darrow is nearly synonymous with "the Dayton Case," or the trial of John T. Scopes. This was
the only case for which Darrow volunteered his services because he "really wanted to take part in it" (Darrow, 1932). Darrow was an advocate of a free-flow of knowledge, of information, and he was dismayed that legislatures would pass laws forbidding such practice. So it was in some Southern states, including the State of Tennessee, that a bill was passed which prohibited the teaching of "...any doctrine in conflict with the Genesis story" (Darrow, 1932).

John T. Scopes was a biology teacher in Dayton, Tennessee, where the textbook Hunter's Biology was used and where John Scopes taught the students that it was conceivable that life on earth may have originated or evolved from the sea. Scopes was arrested for violating the law and his arrest set the stage for the Scopes Trial, which in reality placed the validity of the law on trial rather than Scopes. Darrow was the attorney for the defense while William Jennings Bryan, the noted fundamentalist, was the attorney for the prosecution.

Bryan's background in the sciences was summed in his comment that he was, "...not so much interested in the age of rocks as in the Rock of Ages" (Darrow, 1932). Darrow had been reared on books of science and some of his favorite subjects while in school and after he left school, were in the natural sciences. He came well prepared to argue both science and religion.

One of the chief precepts which the world learned from this famous case in 1925, was that we cannot and should not legislate the free exchange of knowledge. All through his career Darrow was a proponent, a fighter, for the dissemination of facts and the right of the individual to express his ideas. Certainly, this has been one of the underlying strengths which has enabled science to make the advances it has. However, we need only to look at the history of science to determine that this has not always been so.

Darrow must be given much credit for tearing down the curtain that shielded the student from ideas. Unfortunately, this issue has not been completely resolved and even today we continue to battle for the cause of a free exchange of ideas and scientific information.

The first Darrow to reach America from England arrived in about 1680 (Gurko, 1965). One of the descendents of the first Darrow was Amirus Darrow who graduated from the Meadville Theological Seminary and had been offered a parish by the Unitarian Church. His religious belief had been strong, but as he progressed through seminary, he began to have doubts; there were questions neither he nor his teachers could answer. Upon graduation he rejected the life of a minister. Amirus had married Emily Eddy whom he had met while a student in Ellsworth Academy in Amboy, Ohio, and together they set off on life's journey. After working at many jobs, Amirus became a carpenter and began making various kinds of furniture for the people of Kinsman, Ohio, where he and Emily had settled. Kinsman was a small village of 400-500 persons and it was here, on April 18, 1857, where their fifth child, Clarence Seward, (for William Henry Seward) was born and grew up (Gurko, 1965).

The one great passion of Darrow's parents was books, and Amirus who spent endless scholarly hours with his hundreds of books, tried to imbue his eight children with this same love. Clarence's father constantly pursued the cause of learning and reading with his children. Clarence stated that he did not remember when he could not read. Much of his father's motivation came from citing other people as examples of scholarship...his reference to John Stuart Mill's study of Greek at the age of three was a particular annoyance to Clarence, since he would rather have been playing baseball than learning Greek or Latin or studying mathematics (Gurko, 1965). Darrow had mastered the multiplication tables and he had spent endless hours on memorizing the weights and measures, but he was dismayed to learn that these tables were conveniently located in the dictionary and were at hand when needed.

He makes a valid point in stating that school books were filled with notable precepts and seemed not to have any application to real life.

Because teachers tried so hard to get them to learn, the students viewed them as natural enemies who could not see that a child's life depended on activity and exercise, the law of
life. "The mistake of maturity," he claimed, "is that maturity lives in the present and forgets the lessons of the past, that life is mostly illusions and the illusions of childhood are more alluring than those of later years" (Darrow, 1932).

Darrow points to the futility of schools relying almost entirely on rote learning. His observation is in line with the thinking of today, that science at all levels must actively involve the student through inquiry and challenging activities; we cannot assume that lectures and readings alone will motivate students in biology.

In reference to the study of grammar, Darrow states, "The longer I live the surer I am that the chief trouble of writers and speakers is the lack of interesting thoughts, and not of proper words" (Darrow, 1932).

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One might say too, that in biology we do not lack for concepts to be learned, but rather a shortcoming may be our lack of exercises which promote inductive thinking and problem solving based on these fundamental concepts.

In general, Darrow found his school study to be too moralistic, too filled with idealistic stories and not enough focused on the real world of the person. Publishers, he thought, were hypocrites...to publish books which promoted honesty and moral and ethical values, yet they themselves practiced less than this. Honesty, he felt, was espoused by parents and teachers alike, yet he maintained, the child is fundamentally truthful and has no need to lie or cheat. This lesson in straying from the truth he contends, comes by example from parents and teachers and ultimately a child wanders from the truth out of fear of punishment or reprimand. Darrow states, "Children tell the truth as naturally as they breathe, and it is only the stupidity and brutality of parents and teachers that drive them to tell lies. In high society and low, parents lie to children much oftener than children lie to parents; it would not occur to a child to lie unless someone made him feel the need of doing so" (Darrow, 1932).

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Here one may cite a relevance to teaching, that by example we as teachers must display the virtues we wish our students to possess. If we desire students to be involved with experimentation and inquiry, we must engage in these activities ourselves. Science must be visible in our classroom and laboratory environments.

If students are to foster good reading habits in science, if students are to use the language of science properly (or for that matter, grammar in general) then biology teachers must be conscious of these objectives and make concerted efforts to assist the student to achieve acceptable levels of learning.

Darrow was not a psychologist but he was astute enough to recognize that success in school and elsewhere in life depended on some extrinsic motivation and reinforcement. Rewards in Sunday School (to which his parents sent him) took the form of colorful cards; yet his father for all of his emphasis in the classics, was remiss in not providing a word of encouragement when Clarence did well in school or on the baseball field. So disappointed was Darrow in the methods of teaching and learning that he said he, "...used to beg my father to throw away my stupid books and apprentice me to learn the blacksmith trade" (Darrow, 1932). His father guided him, but Clarence was not sure that his father was right. How easy it can be for teachers to provide the appropriate word at the appropriate time which may well send a student on to greater successes. Compassion, understanding and respect for the dignity of the student need not be viewed as weaknesses in the teacher. Darrow comments on the worth of the individual in this way..."After much reflection I have reached the conclusion that all people are envious to a greater or less degree, and of course each one's goodness and importance increased in proportion as those of others are made to grow less" (Darrow, 1932).

Darrow had a high regard for nature, for life. His favorite subjects in school were biology and the natural sciences. When Darrow was
practicing law in Chicago, a large room in his apartment was devoted to weekly meetings of the Biology Club, whose members lectured on and discussed scientific topics (Gurko, 1965). Darrow comments about his school science:

"We were given certain rules as to our treatment of animals, (and) we were told to be kind to them, but no effort was made to awaken the imagination of the child so that in a way he might put himself in place of the helpless beings with whom he lived" (Darrow, 1932).

All through Darrow's long and distinguished career as an attorney, one is able to discern this attitude toward his clients; he placed himself in the position of the client and then constructed a defense in keeping with the virtues of the person he was defending. Would not this be appropriate for teachers of science, to put ourselves in the place of the student and ask...If I were this student, how would I like to have this course taught? There is a great deal to be learned from placing ourselves in the other person's position to develop more than one perspective on any issue, whether the issue is scientific, political or aligned with teaching method.

Darrow was not known to be the epitome of sartorial splendor. His wife would buy fine suits of clothing for him; silk shirts; and appropriate ties. Yet, when he dressed in these well-chosen items, Darrow had a knack for making even the most expensive suits look rumpled and ill-kept. It is important that we look behind the facade which may clothe a person.

In the final analysis, we may have to look at ourselves and make a more concentrated effort to help students learn science, rather than losing our perspective of teaching through trying to impress students with our "vast" knowledge of science. For the most part, telling a student, or dispensing information, may not be teaching.

References


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Dear Members:

Please send all resolutions to the Chairman of the Resolutions Committee:

Marvin C. Williams
Dept. of Biology
Kearney State College
Kearney, Nebraska 68849