Bat Milk

and Other Life Stories

PHILOSOPHY FOR CHILDREN APPLIED TO THE TEACHING OF UNIVERSITY SCIENCE

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The disciplines of science have traditionally been regarded as a natural venue for the practice of critical thinking. Matthew Lipman (1987) notes that in the sciences critical thinking is primarily construed as a problem solving strategy but suggests that "...we see critical thinking as the internalization of inquiry in general, and not just of scientific or philosophical inquiry...." He also identifies critical thinking as only one of a complex of higher-order thinking skills that also incorporates creative and caring thinking (Lipman, 1994). All of these are essential not only for the practice of science but for the understanding and evaluation of scientific activity by nonscientists. Because of the effectiveness of the Philosophy for Children pedagogical program in fostering those habits of mind considered to be valuable in science, importing Philosophy for Children into the science classroom seems to be a logical move. Mark Weinstein (1988) has suggested three ways in which the Philosophy for Children's "pedagogical framework based on community of inquiry" might be extended to teaching in various academic disciplines:

1. The generation of curricular materials by teachers trained in Philosophy for Children.
2. The use of Philosophy for Children to establish an intellectual base from which students can explore other academic disciplines.
3. The use of Philosophy for Children to train teachers in critical thinking skills to be incorporated into the general curriculum.

Weinstein notes that the first strategy above may be the most natural way to extend Philosophy for Children into the traditional academic disciplines since "all school subjects have philosophical aspects" and "many logical skills have ready application to problem solving and analytic reading...."

While both Lipman and Weinstein suggest that Philosophy for Children is too valuable to be restricted to philosophy, Teresa de la Garza (1991) has proposed that Philosophy for Children is too valuable to be restricted to children. She notes that with university students, the exercising of higher order thinking skills may become subordinated to the "content and specific habits" of their disciplines, and that Philosophy for Children addresses both reasoning skills and moral awareness. The "Dialogue" program at the Universidad Iberoamericana seems to be implementing all three of Weinstein's strategies.

About a year ago I decided to try to apply the principles of Philosophy for Children to the teaching of university science, specifically to the teaching of biology to non-science majors fulfilling their science requirement. As focal texts, we use the reading of "life stories". These stories are not fiction, but accounts of investigations in the life sciences published in both the popular and professional science press.

Traditionally, stories capture and codify many of our beliefs about how the world is. Science is part of this world. However, the scientific culture as it is presented in the written word of scientific articles and textbooks seems not to be capturing contemporary students. Along with many of my colleagues, I have remarked that the increasingly expensive textbooks purchased by students go back to the bookstore largely unread at the end of the term for which they were assigned.

We can drive or entice students into text by various devices: making reading assignments, requiring literature reports, giving text study guides, text quizzes, chapter outlining, information searches, chapter problems, and so forth. But many students still seem to prefer to *hear* some version of what is in the text or the professional literature from the teacher. The conventional "lecture", which began as reading of a text for the students to copy, now consists of comments on material related in some way to the material of the textbook, which the students then preserve in their notes as a sort of exegetic commentary on a text they will, usually, not read.

Until recently I found this tendency puzzling, but I think I am beginning to understand it. In spite of the richness and currency of science textbook information, in spite of the relevancy boxes, in spite of the splendid graphics and photographs, in spite of the chapter introductions, chapter summaries, chapter questions, suggested supplements, behavioral objectives and self-tests, what students seem to want from us in class is a return to the story telling tradition.

The great story teller Megan McKenna has this to say about stories:

All stories are true.
Some of them actually happened.
All of them are about us.

In a recent study of the response of nonmajors students to university science classes (Tobias, 1990), a common complaint was that the information presented in science classes lacked narrative structure — that individual concepts were rarely linked either to one another or to some set of unifying principles. One student comments:

> *I always wanted to know how to connect the small parts of a large subject. In humanities classes, I searched for themes in novels, connections in history, and organizing principles in poetry.* (Tobias, p. 34)

Another criticism voiced by these students was that in their science classes they felt a lack of community — of membership in a group of people committed to a common inquiry, effort and discovery. Another student reports:

> *The lack of community, together with the lack of interchange between the professor and the students combines to produce a totally passive classroom experience. The best classes I had were classes in which I was constantly engaged...pushing the limits of the subject and of myself.* (Tobias, p. 25)

And another:

> *I wanted to digest it [the information presented] there, in class, through questions and discussion. I learn verbally. I like being put on the spot...* (Tobias, p.64)

Students like this tell us that they want more from science than to learn to be good problem solvers. The telling of science stories can provide the narrative focus desired, and the classroom discussion of these stories can be used both to create an intellectual and affective community and to generate meaning. Meaning can emerge from story discussion in many ways:

1. Science stories that make the news usually have some element of wonder, mystery, or unexpectedness that draw the student naturally into questions.
2. Stories help connect what the student knows to what the student does not know, and give the student the opportunity to apply what s/he already knows to the solution of a scientific puzzle.
3. Stories usually connect several biological phenomena. Exposition of these phenomena during a story discussion puts them immediately into a tentative theoretical framework.
4. Biology stories connect the human organism to other species (all stories are about us) and thus give us a sense of inhabiting nature, rather than merely observing it.
5. Science stories usually connect observation to theory and lead to questions about investigative methodology, evidence and interpretation.

6. Science stories in the popular press (including popular science journals) usually come with a source reference, which can then lead students to the primary scientific literature.
7. Many biology stories have a clear ethical dimension and can be used to explore the social implications of biological information.

Thus the discussion of science stories offers a natural opportunity for students to practice critical, creative and caring thinking. The biology stories I have collected seem to fall into three general categories represented by the story summaries in the Story Summary Box.

1. Stories that directly involve humans (e.g. Cloned Human Embryos).
2. Stories that do not directly involve humans, but which have an discernible application to humans (e.g. Lactating Male Bats).
3. Stories that do not involve humans and whose application to the human condition may be less obvious (e.g. Naked Mole Rats).

I use stories like these in the typical Philosophy for Children format. We read the story collectively. Students suggest questions or make comments on the story; the questions are written on the board. Students then select topics for further discussion. One additional activity that I have found helpful is to ask the students to take a few minutes to write what they **know** about various elements of the story before they pose their questions. We begin the story discussion with a brief summary of this knowledge base. At the end of the discussion, I also ask the students to take a few minutes to write down what they have learned during the discussion.

The story discussions described above act as a focus for other class activities: brief essays on scientific or ethical questions related to the stories, reports on articles from the professional literature, laboratory investigations and reports, and group projects. There are no exams used to assess student performance. Periodically, the students are asked to turn in their written work for checking; at the end of the course, the students present a selection of their work that they believe best represents what they have learned during the course.

In choosing to try to teach biology around the discussion of stories like these, I believe that several goals suggested by Rutherford and Ahlgren in their report *Science for All Americans* (Oxford, 1990) can be realized:

1. A more positive attitude toward science can be fostered. Many students come into their required science courses with some combination of fear and hostility. Removing the high stress of exams does much to reduce the fear. The group environment helps to reduce the sense of competition that is often characteristic of science classes. Allowing student interest to direct content reduces hostility by involving the student as an active participant in learning and by illustrating how science can be connected with the student's own concerns.
2. Higher order thinking can be practiced. Group discussions encourage students to evaluate how arguments are conducted and information is processed. The students are encouraged to listen critically and with courtesy to the arguments of others, and to advance discussion by seeking and applying criteria, selecting appropriate data, offering examples and counterexamples, noting connections, relating evidence to arguments, checking for logical consistency or inconsistency, identifying assumptions, and other practices associated with critical thinking.
3. Extension of the student's knowledge base is assisted. Having the students first write down what they KNOW about various elements of each story focusses their attention on that base. Ideas or information that emerge during discussion can then be "attached" to the student's base knowledge in a meaningful way. Since discussion is centered around student questions, the student is more likely to link new information to what s/he already knows. In our discussions, specialized terminology is limited to the minimum necessary for unambiguous communication, and the meaningful **use** of that terminology is facilitated by the process of group conversation.

In the life sciences, students may encounter information and ideas that conflict with their belief systems: e.g., the evolutionary explanation of biodiversity. The group discussion format, with the teacher as one of many participants, increases the weight of student opinion and reduces the implicit threat that can be perceived when the teacher delivers unsettling information from a position of authority. If, during such discussions, the constantly changing nature of scientific theory is also stressed, and if currently held scientific theories are not defended as privileged truths, then students may be encouraged to note how new ideas can enrich, rather than threaten, their experience of the world.

4. Opportunities to articulate their own ideas and to modify and sharpen them in response to feedback from peers are provided. In man-

aging group discussions, the teacher can provide a model of feedback that is collegial, focussed, and analytical. As the students become aware of the several interpretations that can emerge from a single data set, they are encouraged both to value their own ideas and to acquire confidence in defending them.

5. Examples of scientific reasoning are introduced. The thinking of practicing scientists is a mixture of analogical reasoning, intuitive leaps, justifiable inference and testing that is not adequately captured in the conventional "steps" of the scientific method. Sharing in the speculations and reasoning of professional scientists presented both in informal news reports (and in the professional literature to which the student may be directed by the report) helps students to see how "scientific thinking" is related to common human curiosity.

The sorts of questions and conversations that may arise from the discussion of a "life story" are illustrated in the following summary of questions and possible avenues of inquiry related to one such story recently presented at a meeting of the North American Association for the Community of Inquiry (Austin, April 1994). The story chosen for discussion was one of the stories summarized in the Story Summary Box: Lactating Male Bats.

Some of the questions that emerged in response to the bat story included the following:

1. Are there animals that lactate besides mammals?
2. Was Batman's costume in the movie anatomically correct?
3. Why do males have breasts?
4. Why do female mammals produce milk?
5. Were the animals killed to get the data described in the story?
6. If it turns out to be the plants that stimulate the males to produce milk, should human males be fed the same plants to enable them to participate more fully in child rearing?
7. Do captive male mammals ever produce milk?
8. Why do the investigators suggest a connection between monogamy and male milk production?
9. How could we figure out whether male lactation is a normal activity in these bats or whether it is induced by environmental estrogens?
10. What are estrogens?
11. Are there animal species in which males participate in infant care?

Some of these questions provide a natural "window" for the instructor or a knowledgeable student to insert brief expositions of biological information into the discussions. The questions above suggest the following topics:

1. What features are characteristic of mammals?
2. What are hormones? What are steroid hormones and how do they work? What are estrogens and what activities do they stimulate?
3. Mammalian embryos are initially undifferentiated. How does an embryo's genetic and hormonal environment contribute to sex differentiation?
4. What is the relationship of sex hormones (both from the gonad and from the pituitary gland) to the production and expression of milk?
5. How do behavior, brain activity and other hormones contribute to steroid hormone levels?
6. What are the typical anatomical features of bats?
7. What is the relationship of bats to other mammals and to humans?
8. What kind of parenting behavior is seen in various animals?

Such topics range from fairly elementary (what is a mammal) to more complex (how are hormonal levels regulated), but can all be meaningfully connected in the context of the bat story. The following ethical questions are also relevant:

1. Should "normal" biological function be altered to achieve social goals?
2. Should animals be sacrificed to satisfy human curiosity about an unusual phenomenon?

Biology stories are a series of episodes or snapshots representing the continuing drama of life. Clearly, telling and talking about such stories is more fun for both teacher and student — the academic equivalent of soap opera — than walking into class every day with a fixed and carefully organized lecture agenda. However, story discussions can also be perilous experiences. The teacher does not have the assurance that comes from having prepared a high-gloss lecture. Some teachers may become uncomfortable when questions to which the teacher does not in fact have ready answers emerge from discussion. Many biological topics can lead to emotionally fraught issues, e.g. homosexuality, therapeutic abortion, AIDS, or drug and alcohol abuse. Above all, the question is demanded: do the students actually learn any biology?

At the end of the course, I give the students an informational assessment to help me answer that question. This assessment is not used in determining the student's grade unless the student chooses to make it part of her/his grading file. Average performance on this assessment has not been impressive: students could answer only about 55% of the informational questions. On the other hand, some of the questions they COULD answer were complex, e.g. "What is the maximum number of chromosomes you might inherit from your grandmother?" or "What role for cell death has been suggested to account for immunosuppression in AIDS?"

Moreover, the general classroom atmosphere (and this is admittedly a subjective judgement) seemed positive. Attendance was good and only one student, in the two semesters the "story" course has been given, has failed to complete the course. Class discussion was lively and student responses to course questionnaires indicated that the story discussions were the class activity that the students most enjoyed and from which they believed they had learned the most. Students sometimes reported that discussions of issues raised by the stories continued outside of class, both with their classmates or with other friends and family members. Students might also follow up a class discussion with other news materials relating to a story previously discussed.

It seems clear to me that the "life story" approach can establish a community of inquiry in science classrooms. But is it a true extension of Philosophy for Children? Weinstein warns that "it is by no means guaranteed that teachers will make the transfer from the specific IAPC curriculum to standard school subjects in a fashion that is consistent with the high standard embodied in IAPC programs." As heady as the active participation of students discussing questions they have generated themselves is, these discussions are not sufficient to align the sciences with Philosophy for Children. The Philosophy for Children curriculum is carefully structured to elicit and support specific thinking skills in addressing specific philosophical issues. To gain maximum advantage of this powerful pedagogy, similar exercises must be developed that address and support critical thinking applied to fundamental scientific issues.

Tyser and Cerbin (1991) have developed a set of exercises in which students are given a series of news stories, six or seven over the course of the semester, each of which is accompanied by an instructor-generated list of 10-20 questions. The questions include both informational reviews and critical thinking operations like identification of evidence, evaluation of claims, and construction of logical arguments. Eisen, Morgan and Marsteller (1992) have described a program developed at Emory University in which teams of students learn investigative skills by designing and executing their own laboratory experiments. Activities like these add a valuable dimension to classroom story discussions.

In addition, to achieve informational coherence over the course at large, the stories must be shown to be linked through a set of important biological principles. If, as we claim, there is unity in the biological world and in the biological theory we use as a framework for understanding that world, then a given set of principles may be illumined by any of many stories of a certain "type". For example, the lactating bat story exemplifies a "principles of neurohormonal regulation" story. These principles can be used not only to identify the significance of a specific story, but to link the stories themselves together. Such principles can be articulated at the beginning of the course and reference made to them throughout. In addition, the teacher may use a developing inquiry along one line to point the way to the next story to be discussed. Careful selection and linking of the set of stories used in a given biology course can lead to exposition of the central theories and phenomena related to that part of the biological world to be covered within the course.

The inquiry is always unfinished; i.e., all possible threads to be teased out of a story cannot be followed to some definitive end. However, this is a feature of all inquiry, including scientific inquiry: the story always ends in more questions. At the meeting in which the bat story was presented, discussion was necessarily closed before all possible issues could be addressed. One participant objected: "But I still have a million questions about bats." My response to this irresistible opening was: "Yes, but how many questions about bats did you have when you came in?"

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STORY SUMMARY BOX:
Three Life Stories

Cloned Human Embryos (Associated Press, 1993)

Jerry Hall, director of the in vitro fertilization laboratory at George Washington University, has applied to human embryos cloning techniques previously restricted to animals. Embryos obtained by in vitro fertilization, but rejected for human implantation, were divided into their individual cells and each cell used to generate a new embryo. Seventeen embryos at the 2-8 cell stage produced 48 cloned embryos. The cloned embryos were allowed to continue their development only for six days, and none were implanted into human hosts. Hall defended this controversial project by noting that the source embryos were flawed and thus would not have survived if implanted, that the cloned embryos were kept for only a few days, and that he had no plans for applying the technique to normal human embryos. Nevertheless he has been criticized by the Vatican, which called Hall's work "intrinsically perverse", and by Jeremy Rifkin, who said that human cloning is a "destructive" application of reproductive technology. Cynthia Cohen, who heads the National Advisory Board on Ethics and Reproduction, identified a "total moral vacuum in this whole area" and expressed misgivings about the possibility of treating humans like industrial products.

Lactating Male Bats (Fackelmann, 1994)

In a group of fruit bats captured in Malaysia, Charles Francis, a research associate with the New York City Wildlife Conservation Society discovered that several males seemed to have active mammary glands. Microscopic examination revealed similarities to female bat breast tissue, although the lactating males seemed to have normal testes. Francis suggested two possible explanations for the phenomenon. One is that male lactation is an unusual but normal parenting behavior for the species and would represent an evolutionary adaptation for increasing survival of their infants. The other is that the male lactation is an abnormal event stimulated by the ingestion of local plant estrogens.

Naked Mole Rats (Brody, 1994)

Researchers at Cornell University and the University of Cape Town have been studying naked mole rats, which seem to be the mammalian equivalents of honeybees and other eusocial insects. Like honeybees, the burrowing mole rats live in colonies, and most individuals of the colony are nonreproductive workers, whose tasks seem to be assigned on the basis of body size and include housekeeping, foraging, infant care, and burrow defense. The single very large reproductive "queen" can give birth to some two dozen offspring every 70 to 80 days. Like bees, members of a colony also have very close genetic similarity, so that in protecting the reproductive queen, nonreproductive workers assure the continuity of genes like their own. Another eusocial characteristic of naked mole rats is the use of scent to mark trails and to regulate the composition and activities of the colony; the rodents also communicate with complex vocalizations.

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