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Table of Contents

Articles:

News & Views:

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Editor:
John R. Jungck
Department of Biology
Beloit College
700 College St.
Beloit, Wisconsin 53511
jungck@beloit.edu
FAX: (608) 363-2052 or 363-2718

Managing Editor:
Teresa Holevas
holevast@beloit.edu

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Bioscene Editorial Board:

Suggestions for Manucripts

Announcements	Sources of Funding	Biology Policy Issues	Reviews of
Letters to the Editor	Sociology of Biology	Minority Education	Software/Hardware
Book Reviews	Courses that Work	Women in Biology	Philosophy of Biology
Laboratories that Work	Professional School	Computer Advice	History of Biology

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PARADIGM LOST: THE HUMAN CHROMOSOME STORY

Lawrence Unger, B.S., and Robert V. Blystone, Ph.D.
Department of Biology
Trinity University
San Antonio, Texas 78212

The knowledge that humans have a diploid chromosome number of 46 has an interesting history. The original "solid" estimate was either 47 or 48 depending on whether one interpreted the sex determination system in humans as XO or XY. With improved chromosome preparation techniques and common use of cell cultures, the chromosome number was reported to be 46 in 1956. Did this emerging knowledge fit into a paradigm shift of the Kuhnian type? Our argument is: not in the traditional sense.

Keywords: human chromosome number, paradigm shift, sex determination

Thomas S. Kuhn in his highly regarded work, *The Structure of Scientific Revolutions*, argued that science does not progress in an orderly way.

> "... when, that is, the profession can no longer evade anomalies that subvert the existing tradition of scientific practice, then begin the extraordinary investigations that lead the profession at last to a new set of commitments, a new basis for the practice of science." (Kuhn, 1970, p.6)

Thus Kuhn suggested that science moves quietly along punctuated by occasional "revolutions" reflecting changes in thought. Accepted scientific thought was defined by Kuhn as a "paradigm." Scientific revolutions occur with a shift in paradigm.

> "Its [new thought] assimilation requires the reconstruction of prior theory and the re-evaluation of prior fact, an intrinsically revolutionary process that is seldom completed by a single man and never overnight." (Kuhn, 1970, p.7)

Kuhn primarily uses examples from the history of physics, mathematics, and chemistry to support his ideas of paradigm shifts and scientific revolutions. We sought to find a biological example of a Kuhnian paradigm shift. Our choice for this phenomenon was the establishment of the human diploid chromosome number.

The first report providing evidence for the human diploid chromosome number of 46 appeared on January 26, 1956. (Tjio and Levan, 1956) Joe Hin Tjio and Albert Levan concluded in their research appearing in the journal Hereditas:

> "... the almost exclusive occurrence of the chromosome number 46 in one somatic tissue derived from four individual human embryos."

Using lung fibroblasts, Tjio and Levan examined mitotic figures from 256 cells and reported that all but four exhibited 46 chromosomes. They commented:

> "We were surprised to find that the chromosome number 46 predominated in the tissue cultures from all four embryos, only single cases deviating from this number."

Had these men, using Kuhn's words, found "anomalies that subvert the existing tradition of scientific practice?" Again using Kuhn's words, did this paper set into motion "the reconstruction of prior theory and the re-evaluation of prior fact?"

Prior to 1956 the accepted value for the number of diploid chromosomes in the human cell was 48. Hans de Winiwarter reached this conclusion for human oogonia in the year 1912. (as cited by Kottler, 1974) T. S. Painter provided evidence for 48 chromosomes in human spermatogonia in 1923. (Painter, 1923) Both Winiwarter and Painter had impeccable cytology credentials: Winiwarter training with von Beneden and Painter with Boveri. For more than thirty years the accepted diploid chromosome number stood at 48. This number was solidly established in the literature of the 1950's: see Darlington's *The Facts of Life*, 1953, and Storer and Usinger's *General Zoology*, 1957. Even Beatty's 1954 article titled "How many chromosomes in mammalian somatic cells?"

published in the prestigious *International Review of Cytology* concluded there were 48 chromosomes in human cells.

The body of science for nearly a half century had argued for 48 chromosomes; and now, the research team of Tjio and Levan suggest this widely accepted value was incorrect. In Kuhn's words the stage was set for "an intrinsically revolutionary process that is seldom completed by a single man and never overnight." This major paradigm shift from 48 to 46 chromosomes did not result in a "Scientific Revolution" in the sense of Kuhn. Confirming evidence was reported within the same year followed by relatively few dissenting words. The battle and war were played by few people and the war was over in less than three years.

This major paradigm shift from 48 to 46 chromosomes did not result in a "Scientific Revolution" in the sense of Kuhn. Confirming evidence was reported within the same year followed by relatively few dissenting words. The battle and war were played by few people and the war was over in less than three years.

The first scientific comment of the Tjio and Levan article appeared as an editorial in the British Medical Journal on August 11, 1956. The editorial simply summarized the techniques and findings and went on to say that Dr. Tjio showed preparations of human chromosomes at the Congress on Human Genetics in Copenhagen the week before. (Anon., 1956) The most immediate concern was that the gonadal tissue chromosome number may be different from that of somatic tissue. Winiwarter's and Painter's research dealt with sectioned gonadal tissue. Tjio and Levan used somatic cells of tissue cultured embryos. C. E. Ford and J. L. Hamerton addressed this problem in their article published in *Nature* on November 10, 1956. They cautiously reported that the majority of their counts on human spermatogonial tissue resulted in 23 bivalents. Ford and Hamerton reviewed both Painter's and Tjio & Levan's work. They raised a new question of why had so many scientists miscounted the chromosomes. Ford and Hamerton cited the personal observation of Dr. Hansen-Melander who kept finding 46 chromosomes in human liver embryo cells. Hansen-Melander's study was discontinued and never reported because 48 chromosomes could not be found. How many other scientists abandoned research because they could not find 48 chromosomes?

Pivotal to the acceptance of 46 chromosomes as the correct diploid number was the opinion of other notable scientists. Such opinions for change came quickly. T C. Hsu accompanied by Paul S. Moorhead published the following remarks in the March 1957 *Journal of the National Cancer Institute:*

> "the diploid number, whether it is 48, conventionally accepted by man for many years, or more likely 46, recently claimed by Tjio and Levan and by Ford and Hamerton... ." (Hsu and Moorhead, 1957)

Hsu with C. M. Pomerat and P. S. Moorhead a few months later produced counts that "...helped to prove that the stemline number for normal human cells is 46." (Hsu *et al.*, 1957) An acknowledged leader in chromosome-based research and following a 1952 report where he confirmed 48 chromosomes (Hsu, 1952), Hsu quickly switched to the new number paradigm based on two reports and his own new observations.

In 1958 Tjio and Theodore T. Puck published an article in which they further supported the 46 chromosome paradigm of Tjio and Levan by saying, "the chromosome number in all cultures of normal human cells was always 46." (Tjio and Puck, 1958a) They presented micrographs of a variety of normal human male and female tissues which demonstrate that the human diploid chromosome number was 46.

Despite the support that the Tjio-Levan paradigm had received, there was still some doubt as to what the actual chromosome number in humans was, as is seen by an October 1958 article written by Frank H. Ruddle, Lawrence Berman, and Cyril S. Stulberg in the journal *Cancer Research*. In this

article Ruddle *et al.* state, "at present, uncertainty exists on the actual human chromosome number." Ruddle et al. then go on to summarize how Hsu has revised his initial estimate of 48 chromosomes to 46, Kodani's claim of 46, 47 and 48 chromosomes existing in man, and finally Tjio and Levan's report of 46 chromosomes. After two years, not everyone was completely convinced by Tjio and Levan's new paradigm.

In a 1957 article, Masuo Kodani argued for a different paradigm based on a chromosomal study of the testes of Japanese men in which Kodani "found surprisingly that three different diploid numbers exist in man instead of one." (Kodani, 1957) It should be noted that Kodani worked for the Atomic Bomb Casualty Commission and his sources of spermatogonial tissue were taken from the testes of men with epididymitis. (Kodani, 1957) In a 1958 report, Kodani continued to provide evidence for a supernumerary chromosome in human males. These results were once again from non-normal sources: sterile men, some of whom had been exposed to atomic bomb radiation but showed no signs of illness. (Kodani, 1958)

In 1958, a June issue of *Nature* revealed even more support for the Tjio-Levan paradigm while providing no support for other existing hypotheses, such as Kodani's supernumerary chromosome idea. In this *Nature* article C. E. Ford et al. restate the findings of the Tjio and Levan paper and go on to cite examples of other scientists who have confirmed Tjio and Levan's chromosome counts. On the other hand Ford et al.'s article stated that in the case of Kodani's paradigm "we are unaware of any other reported instance of the occurrence of 'inert' supernumerary chromosomes." (Ford *et al.*, 1958) Once again the Tjio-Levan paradigm was reinforced.

Finally in December 1958, Tjio and Puck published an article that cited other scientists who confirmed the 1956 results of Tjio and Levan. They also performed further studies of their own which provided evidence for 46 human diploid chromosomes. By this time the combined data set from all reported sources comprised a population of 74 human individuals who had a chromosome number of 46. (Tjio and Puck, 1958b)

Clearly the shift to the 46 chromosome paradigm was swift and without much dissension. The struggle predicted by Kuhn associated with such a major change in thinking did not occur. However, Kuhn's prediction that once a new paradigm is adopted, it is done so completely, did occur. Although the chromosome number paradigm shift is a poor model for a Kuhnian scientific revolution, an appreciation of the chromosome number history is a good lesson in the process of science.

Why Did T. S. Painter Get the Diploid Human Chromosome Number Wrong?

The answer to this question is surprising and it points to a scientific revolution. A brief review of the history of the chromosome is in order to provide a backdrop for Painter's time.

The following review is based on Gardner's *History of Biology*. (Gardner, 1972) W. Waldeyer gave chromosomes their present name in 1888, after Flemming had already enunciated their role in mitosis in 1879. In 1883 van Beneden described reduction division in *Ascaris* and Boveri in 1888 implicated chromosomes as hereditary factors. E. B. Wilson and N. M. Stevens reported in 1905 two sex determination mechanisms known as XO and XY. This report built from H. Henking's 1891 publication about the "X" body found in some insect sperm. W. S. Sutton proposed the Chromosome Theory of Heredity in 1902 and C. B. Bridges provided evidence for phenotype and gene correspondence on *Drosophila* chromosomes in 1916. Painter gathered his scientific heritage from a time where the focus was on what a chromosome did, rather than how many chromosomes there were or what they looked like.

No doubt Painter was the pivotal person in the scientific investigation of the human chromosome number. Painter had an excellent educational pedigree including Yale University; he was a member of the National Academy of Sciences; and for six years he was the President of the University of Texas at Austin. Painter's data collection and interpretation were affected by at least three factors. The three factors were technique, sex determination, and chromosomal anomaly. The role of technique will be dealt with first.

Technique

In an excellent review, Malcolm Jay Kottler described the role of technique in visualizing chromosomes for counting. (Kottler, 1974) He stressed that the early chromosome work used sectioned material for examination, whereas modern work uses chromosome spreads obtained from tissue culture. Clumping of the chromosomes is a greater likelihood in working with sectioned tissue than with tissue culture material. From the first reports of chromosome numbers in human cells in the 1890's to Painter's review in 1930, reported chromosome numbers varied from as few as 8 to as many as a 100. (Painter, 1930, and Kottler, 1974) Kottler summarized it best by saying:

> "If one wishes to assess human chromosome counts prior to 1920, the 'failure' of cytologists was not so much the incorrectness of their counts as their inability to appreciate the conditions for the lifelike preservation of chromosomes and the resulting disparity between chromosomes in their material and in living cells." (Kottler, 1974)

Winiwarter and Painter were the only investigators during this period to produce chromosomes of the sort that offered the possibility of accurate counting. The most common "accurate" number for human chromosomes in a cell at that time was 24. In 1912 Winiwarter reported 47 chromosomes in human males and 48 chromosomes in human females. (As cited in Painter, 1930) Painter, of course, reported in 1923 forty-eight chromosomes in human male spermatogonia. Winiwarter used fresh tissue and Flemming's fixative for his work. Painter likewise used fresh tissue and Allen's modification of Bouin's fixative. (Kottler, 1974) It must be appreciated that fresh tissue meant working with surgical castrations at the foot of the patient. In fact, Evans and Swezy (in 1929) obtained fresh tissue from very recently executed criminals. (Kottler, 1974) The technique for chromosome preparation had everything to do with the appearance of the chromosome and the accuracy of the count.

Using his modified Bouin's preparation technique, Painter examined a variety of mammalian species for their chromosome number and their sex determination mechanism. The list included the following: housebat, hedgehog, rabbit, mouse, rat, and horse. (Kottler, 1974) In all cases Painter found an XY sex system in mammals and what proved to be the correct diploid chromosome number for the listed species.

From the mid 1930's to the early 1950's cytologists did not return to counting chromosomes. Virtually no new evidence was offered during this period. (Kottler, 1974) However, by the early 1950's, the techniques that could led to improved chromosome visualization had been developed. Kottler summarized the developments as follows:

> "The Tjio and Levan discovery was the direct and inevitable result of the combined use of four new preparative techniques in mammalian cytology. Each of the new techniques - tissue culture, hypotonic pretreatment, colchicine pretreatment, and squashes - contributed to the dispersal of chromosomes and the reduction of chromosome overlap." (Kottler, 1974)

Tjio and Levan simply had a much better chance of counting chromosomes correctly when compared to the cytologists working in the first quarter of the twentieth century. Painter found 48 chromosomes because that is what the methodology at that time would allow.

Sex Determination

The second factor influencing Painter's judgment was sex determination. In Painter's Stadler lecture, he gave insight as to his research approach in the early 1920's:

> "By 1920 because of the work of McClung, and E. B. Wilson, and many others we knew that sex determining chromosomes occurred in insects and other invertebrates... But very little was known about the chromosomes of vertebrates. ... From my study of the opossum I knew what to look for in primary spennatoctyes of man and there I found an X-Y complex quite similar in morphology to the X-Y of the opossum. ... The identification of the X-Y complex in the male has stood the test of time, and this was the main point of interest to me in making this study." (Painter, 1971)

Painter's interest in chromosomes was fixed on the sex determination process. At the beginning of the century insects were found to have an "XO" sex system: females had 2n chromosomes and males had 2n-1 chromosomes. The X sex chromosome had been isolated and identified; however, the status of the smaller Y sex chromosome was unclear. Winiwarter's superior preparation techniques led him to report that humans likewise had an "XO" sex determination system. Working with armadillo, Painter found the Y chromosome in mammals and contradicted Winiwarter's findings. Painter reasoned that if, in fact, mammals were "XY" rather than "XO" then the spermatogonial cells should have an even number of chromosomes and not the odd number reported by Winiwarter.

If one seeks to find a scientific revolution in the sense of Kuhn then the real war was fought between 1910 and 1930. The topic was the sex determination system in mammals and whether spermatogonia had an even or odd number of chromosomes.

Painter turned next to human testis as an example of mammalian tissue. He published a preliminary report in 1921 where he stated the following about human chromosomes:

> "In my own material the counts range from 45 to 48 apparent chromosomes, although in the clearest equatorial plates so for studied only 46 chromosomes have been found." (Painter, 1921)

Winiwarter and his colleagues continued to argue for 47 chromosomes in human males based on an "XO" hypothesis. Painter and others overwhelmed Winiwarter and by the mid 1930's the XY system for humans was accepted as well as an even chromosome number which happened to be calculated at 48 chromosomes.

If one seeks to find a scientific revolution in the sense of Kuhn then the real war was fought between 1910 and 1930. The topic was the sex determination system in mammals and whether spermatogonia had an even or odd number of chromosomes. Kottler (1974) argued that Painter may have accepted 48 as the number because he wanted to establish the sex determination mechanism in the literature more than the number of chromosomes. Forty-eight was an even number, one which Winiwarter obtained for oogonia and rather than argue along three fronts (XY, even number, and 46) Painter opted for just two fronts: XY and even number. Painter's 1921 counts could support either 46 or 48 as the diploid number.

Source of Material

The third factor that may have influenced Painter was the source of the human testicular material. Theophilus S. Painter in his 1923 report, "Studies in Mammalian Spermatogenesis," established that the human diploid chromosome number was 48 by saying, "48 is, in all probability, the correct diploid or somatic chromosome number for both the male and female of the white and Negro races." (Painter, 1923) He arrived at this number by studying the testicular tissue of one white and two black inmates of the Texas State Insane Asylum in Austin. He further reported in detail the "cause for the removal of the testes was excessive self-abuse coupled with certain phases of insanity which made the removal of the sex glands desirable." (Painter, 1923)

From research results obtained in the 1960's, an abnormal chromosome number is not uncommon in violent male mental patients. (DeRobertis *et al.*, 1970) Painter unknowingly may have recorded the first chromosomal anomaly associated with mental illness rather than what he thought was the normal human diploid chromosome number. As appealing as this idea may seem, Kottler argued against it by stating:

> "Since one or both of the extra chromosomes would undoubtedly be a sex chromosome, a trivalent or quadrivalent of the sex chromosomes would form and spermatogenesis would eventually break down. But Painter described just normal spermatogenesis with a normal XY bivalent." (Kottler, 1974)

Conclusion

Our original goal with this report was to demonstrate that the 46 chromosome paradigm would illustrate a biological scientific revolution

in the manner of Kuhn. However, the 48 chromosome paradigm was abandoned too easily and too quickly for it to be considered a Kuhnian revolution. From our vantage point of being 40 years from the chromosome paradigm shift, sight is lost that the original issue was not the diploid chromosome number but rather how sex determination takes place in humans. Prior to the 1950's the technique for chromosome visualization was quite arduous. Advances in cancer research during the 1950's made the knowledge of the human diploid chromosome number essential. Tjio and Levan were able to augment the Winiwarter and Painter research because at least four advances in chromosome preparation came together in 1955. Appreciating this history has caused us to reevaluate Kuhn.

The reviews from the book jacket of *The Structure of Scientific Revolutions* states the following about Kuhn's work, "... is a landmark in intellectual history ... he erects from ground up a structure in which science is seen to be heavily influenced by nonrational procedures." With timidity we offer these observations about a "landmark in intellectual history." Kuhn states on page 11, "The study of paradigms, including many that are far more specialized than those named illustratively above, ..." (Kuhn, 1970) Those illustrations named above include 'Ptolemaic astronomy', 'Aristotelian dynamics', and 'corpuscular optics'. It is not clear whether Kuhn would consider the chromosome number shift to be large enough intellectual game for one of his paradigms. Perhaps he would consider the game to be the role of chromosomes in heredity.

Kuhn acknowledges the role of equipment and technique towards progress:

> "Again and again complex special apparatus has been designed for such purposes, and the invention, construction, and deployment of that apparatus have demanded first-rate talent, much time, and considerable financial backing. ... From Tycho Brahe to E. O. Lawrence, some scientists have acquired great reputations, not from any novelty of their discoveries, but from the precision, reliability, and scope of the methods, they developed for the redetermination of a previously known sort of fact. ... The existence of the paradigm sets the problem to be solved; often the paradigm theory is implicated directly in the design of the apparatus able to solve the problem." (Kuhn, 1970, pages 25-27)

It is clear that Winiwarter and Painter were experts in the methodology of the visualization of fixed tissue chromosomes; however, they did not invent the techniques but rather applied them. In a similar fashion Tjio and Levan pulled together techniques to better visualize chromosomes. The techniques combined were not expressly invented to be applied to the chromosome number controversy. It is this habit of scientists to repurpose technology, techniques, and equipment that Kuhn seems to underappreciate in what he calls "the nature of normal science." (See chapter 3 title in Kuhn, 1970, page 23.)

Kuhn considers only the big questions in science. He does not dwell on the nuances of mixing buffers and developing tools to mince freshly castrated tissue. Kuhn looks for revolutions in thought and not to the day-to-day practice of "normal science." For Kuhn the Eureka experience has to do with thinking about planetary motion in a bath tub rather than being in a deer blind thinking about how to soften up *Drosophila* salivary glands as Painter was purported to have done. (John Biesele, personal communication) Kuhn is an observer rather than a player in the business of science.

With apologies to Milton, was the 48 chromosomes story a Paradigm Lost? Knowledge of the human diploid chromosome number became important after it was discovered. Turner's and Klinefelter's syndromes can be appreciated only if one has the knowledge that humans normally have 46 chromosomes in each somatic cell. The cytologists in this report backed into their discovery (number of chromosomes) while their focus was on something else (sex determination). Perhaps Kuhn has the perfect vision of hindsight for many scientists do not know that they are in the midst of a scientific revolution until it is over. Did Gregor Mendel know he was a part of a scientific revolution? Tjio and Levan brought the scientific community to a new embarking point with their refinement of the human chromosome number. Perhaps science is

more a series of journeys with some trips without destination rather than a series of constructed scientific revolutions.

Acknowledgement

The authors wish to extend our appreciation to Professor Emeritus John J. Biesele of the University of Texas at Austin. He provided valuable insights for this report based on his long association with T. S. Painter as a student and colleague. He also collaborated for a brief time with Albert Levan. One of us (R. V. B.) was fortunate to have heard regularly cytology lectures given by Dr. Painter and by Dr. Biesele.

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A PROBLEM-SOLVING APPROACH TO THE TEACHING OF EVOLUTION

Steve Brewer
University of Massachusetts
Amherst, MA 02150

Introduction

Evolution is undoubtedly the most important theoretical framework in biology. Unfortunately evolution is rarely accorded a place in the biology curriculum commensurate with its importance within the discipline. Evolution is often equated with natural selection and is taught from a primarily functional perspective while comparative and historical approaches, that are critical for developing an appreciation of the power of evolutionary theory, are often neglected. The result is that evolution is poorly understood and widely disparaged among both teachers and American society at large.

A problem-based approach to the teaching and learning of evolution may offer a number of benefits to students. Stewart (1988) has outlined four classes of potential learning outcomes from the use of problem-solving in genetics:

(a) the conceptual structure (laws, theories, and their organization) of a particular discipline;
(b) problem-solving heuristics that are not specific to a particular discipline;
(c) content-specific problem-solving procedures (domain-specific instantiations of general heuristics and problem-solving algorithms specific to the domain); and
(d) insight into the nature of science as an intellectual activity (Stewart, 1988).

A problem-based approach to the teaching and learning of evolution could be facilitated through the use of a problem-solving environment.

A Model of Desired Performance

One of the fundamental goals of my research (Brewer, 1996) was to generate a model of desired student performance that could guide curriculum development and instruction. In my review of literature, I was able to identify seven significant questions necessary for constructing good phylogenies (see Table 1). A model of desired performance was constructed based upon the most commonly used expert strategy: inclusion/exclusion. The inclusion/exclusion strategy was the only strategy that was successful at finding multiple topologies across all problem types. In addition, the inclusion/exclusion strategy was applied successfully both in my computer program, Phylogenetic Investigator and on paper. The revised version of Phylogenetic Investigator (2.0), Brewer and Hefner (1996a) permits the reordering of both taxa and characters in the data matrix. This ability may facilitate display-based methods for constructing inclusion/exclusion hypotheses which could substantially reduce the need for working memory necessary to implement this strategy (Larkin, 1989). The model of desired performance provides a basis for developing an approach to teaching evolution based on effects-to-causes problems (Table 2).

Problem Solving in Biology

Problem-solving research in biology has focused primarily upon genetics (See Stewart & Hafner, 1994, for a review). Collins (1986), Stewart (1989), and Hafner and Stewart (1995) studied genetics problem solving in the context of a particular problem-solving environment: *Genetics Construction Kit (GCK)* (Jungck and Calley, 1984). Model-based conceptions of problem solving have been particularly fruitful in the domain of genetics as applied to problem solving using GCK. Between genetics and tree construction there are many similarities, but also at least two important differences.

In genetics problems, as studied by Collins (1986), Stewart (1989), and Hafner and Stewart (1995), knowledge production is possible when there is a space of potential experiments in addition to a space of potential models. In phylogenetic tree construction, as presented here, knowledge production is not possible. GCK permits the practically limitless generation of new data whereas in this research, experts were provided with a matrix of data. In practice, it is

Table 1. Methods Necessary for Answering Phylogenetic Questions.

QUESTION	FORM OF DATA: PHYLOGENETIC TREE	FORM OF DATA: DATA MATRIX
Is a character a uniquely-apomorphic or a shared-apomorphic character?	Find unique characters between a species that possesses it and its ancestor. Shared-apomorphic characters are found below common ancestors	Perform phylogenetic inference
Has a given species been previously described or is it unknown?	Look at the branches sequentially and consider whether the species has each apomorphy until reaching a taxon or an inconsistency	Compare a row of the matrix with all othe rows
Which groups of species represent evolutionarily complete units (clades)?	Identify all taxa descended from postulated ancestor	Perform phylogenetic inference
How closely related are two or more species?	Find the most recent common ancestor and count the number of steps (character transitions) between taxa	Perform phylogenetic inference
Given a species, what other species may have the same or similar characteristics?	Look at sister taxa to estimate shared properties	Perform phylogenetic inference
When did a character change in state (in relative terms)?	Find the transition on the tree	Perform phylogenetic inference
What similarities and difference exist among patterns of evolutionary change?	Follow the links between taxa and ancestors	Perform phylogenetic inference

possible for additional knowledge production to occur in phylogenetic inference: a researcher can look for additional characters or taxa. In fact, researchers attempt to present the most complete data matrix possible before beginning phylogenetic analysis. The goals of phylogenetic methods are to produce those trees that summarize present knowledge. These results are often used to guide subsequent knowledge production, however. In this wider context, the concept of an experimental space may take on greater significance.

The tasks of genetics and phylogenetic tree construction are not parallel and genetics heuristics that relate to knowledge production and experimental spaces are not necessarily applicable to phylogenetic tree construction. The differences in the construction of problems in these two areas reflect that the study of genetics has primarily taken place within the experimental/functional tradition in biology whereas the study of phylogeny is situated within the comparative/ evolutionary tradition.

A second important difference relates to the different complex of relationships among and between models, data, and activities in the two domains. Stewart and Hafner (1991) suggested that, in the context of Mendelian genetics, problem solving could be seen as using, elaborating, or revising models. Model-using problem solving encompasses the inquiry involved in the testing and justification of well structured problems that are primarily empirical in nature. Research into model-elaborating and

model-revising problem solving seeks to describe how scientific inquiry addresses problems of conceptual depth and reasoning in the context of discovery.

Phylogenetic tree construction is, at one level of organization, a model-building activity. The tree that is being constructed can be considered a model that helps to explain the data in the matrix. This model does undergo elaboration and revision during its construction and at these levels model-elaborating and model-revising problem solving can offer insight into the nature of the processes being used. Hafner and Stewart (1995) described heuristics from genetics model-revising problem solving. Some of these heuristics match phenomena observed in phylogenetic tree construction (Table 3).

At another level, phylogenetic tree construction is a form of model-using problem solving. Experts use a model of phylogenetic inference, supported by models and assumptions, that reflects beliefs about evolutionary process. These models of phylogenetic inference result in a well-structured conception of the nature of correspondence between a data matrix and a finished tree. Problems of phylogenetic tree construction are probably incapable of presenting anomalous data that would lead to a reevaluation of the model that underlies phylogenetic inference. In this sense, the process of tree construction seems to fit the model-using problem solving category closely.

Stewart and Hafner (1991) described several observations regarding model elaborating problem solving which appear to parallel phenomena in phylogenetic tree construction. Their statement that model-elaborating problem solving may result in "Developing within model conceptual insights" appears similar to expert observations that a particular node will be true in any most parsimonious tree. Their statement that model-elaborating problem solving may result in "Linking models because they share objects, processes, or states" parallels one method of tree construction based on linking subtrees together based on shared taxa. Also, some participants recognized that families of potential solutions could be identified and evaluated based on common criteria. One participant said, while solving a problem:

> This is the one. This only adds one extra step. All the other ones add 2, that the nice thing recognizing these are basically just permutations of the same thing means that basically if one of these tries adds more

Table 2. A Model of Desired Performance for Phylogenetic Tree Construction.

(1) Organize the characters, mentally, in the matrix, or on paper, to find the largest inclusion/exclusion character group hypothesis or hypotheses. (Consider the order of the taxa in the matrix as a mechanism of enhancing inclusion/exclusion patterns).

(2) Translate a hypothesis into taxa by organizing the taxa in the drawing field.

(3) Postulate an ancestor for each character or group of identical characters in the inclusion/exclusion hypothesis.

(4) Link the most inclusive ancestors, to the next less inclusive ancestors, and continue until reaching the terminal taxa.

(5) Distribute homoplasious characters.

(6) Considering each homoplasious character, starting with the character that requires the most steps:
- 6a) Evaluate whether options that improve its distribution always result in matching losses in other characters.
- 6b) Evaluate whether other homoplasious characters have similar distributions that reinforce each other.

(7) Construct other topologies based on additional inclusion/exclusion hypotheses from (1) or parsimony hypotheses from (6a) or (6b)

(8) For each topology consider alternate optimizations for each homoplasious character.

Table 3. Model-Revising Heuristics With Instantiations in Phylogenetic Tree Construction.

General Heuristic	Phylogenetic Instantiation
1. Conduct a systematic search of the initial experimental space (initial because the experimental space is reconceptualized as a result of model revision.	Not applicable to tree construction. (The construction of the hypothesis being revised represents a systematic evaluation of the data prior to revision).
2. Use existing models as templates to interpret features of the cross space search that: conform to the expectations of the model; do not conform to model expectations (anomaly recognition).	Construct homoplasious characters in parallel and look for matched duplicated characters at the tips of branches in order to find possible alternate topologies
3. Use existing models as templates to postulate additional causal factors (changes in objects, states and processes) operating in a new problem type.	Optimize new characters and taxa onto existing trees.
4. Utilize/build upon model revisions that have worked in the past. A model that can accommodate a large number of problem types, and thus which provides for explanatory unification within a discipline, is valued.	Not applicable to tree construction. (Phylogenetic trees (i.e., the models being revised) are different from one problem to the next.)
5. Bracket the case of interest with cases on either side (interpolation).	Not applicable to tree construction. (A phenomenon similar to bracketing is described in the context of model-elaborating problem-solving below). Remove problematic taxon, solve the problem without taxon, and then map taxon back onto finished tree.
6. Break problems of increased complexity into independent subproblems, applying existing models to each. Subsequently focus upon the nature of the possible dependence between the subproblems.	Find all topologies for a problem and construct a consensus tree.
7. Use limiting/defining relations within existing models to: postulate additional causal factors; explore the implications of a change in one component of a model for other components of that model.	Consider parsimony, e.g., compare the savings of fixing one character with the cost of breaking other affected characters.
8. Generally match a revised model to data prior to making specific mappings.	Map new data onto old tree to provide a baseline before constructing different topologies.
9. Use model revisions to determine the structure of the revised experiment space, and systematically explore previously unsearched portions of that space.	Not applicable to tree construction. (The concept of an experimental space does not correspond directly between genetics and tree construction.)
10. Use external memory aids to represent search through both model and experimental spaces.	Not applicable to tree construction. (The concept of an experimental space does not correspond directly between genetics and tree construction.)

than that does then they're all out the window.

Regarding the nature of model-revising problem solving, Stewart and Hafner (1991) posed a series of questions. Among these they asked:

> Do solvers use initial over-simplified models as starting points to develop a series of models of increasing complexity and realism? (Stewart and Hafner, 1991, p. 115)

This statement closely characterizes the nature of considering inclusion/exclusion. The solver begins by finding the largest group of completely inclusive/exclusive characters. This hypothesis is used to construct the initial hypothesis. Subsequently, homoplasious characters are mapped onto the tree and the finished hypothesis is then evaluated for parsimony. Using inclusion/exclusion results in generating an over-simplified model which is then revised, using parsimony, to create a finished tree or trees.

> What anomalous data is overlooked by solvers, and is it possible to account for differences in the oversights in terms of different models that different solvers use? (Stewart and Hafner, 1991, p. 115-116)

The concept of anomalous data does not correspond exactly between genetics and phylogenetic tree construction. In genetics, anomalous data refer to differences between observed phenotypic ratios and those predicted by a model. Phylogenetic tree construction represents model construction *de novo* in response to available data. In genetics, problem solving revolves around model-using, elaborating, and revising problem solving. In phylogenetic tree construction, the primary activity can be seen as either model-using (with respect to a model of tree construction) or model-building (with respect to any particular tree being constructed). Phylogenetic data can only be anomalous in the second conception of tree construction. In this context, anomalous data can be characters or taxa that do not appear to "fit" with the others. In general, participants overlooked incompatible characters until an initial model had been constructed and then the incompatible characters were added and their effect on the structure of the tree was evaluated. Several participants noted taxa that appeared incompatible with the others and one participant removed this taxon, constructed a solution, and then evaluated how the taxon could be placed back into the solution. See the strategy "Seeking the culprit:" in Brewer (1996a) for more detail.

> A second question asked by Stewart and Hafner was:
> Do solvers use two models to define the extremes of a continuum of cases in which the real case is presumed to lie? (Stewart and Hafner, 1991, p. 116)

Solutions in phylogenetic tree construction are not generally organized along a continuum, although one such continuum is used to consider character optimizations: the ACCTRAN optimization constructs homoplasy as the earliest possible gain with subsequent losses and the DELTRAN optimization results in latest possible acquisition of apomorphic character states. Using these two extremes becomes important during interpretation of phylogenetic trees. Solutions related to multiple topologies are not easily conceptualized as existing along a continuum. A phenomenon similar to bracketing exists, however, in which the initial inspection does not seem to lead to a single likely solution to the problem. One way to proceed is to follow what seems to be the best path then optimize that topology to seek others. In this example, a participant has found what appears to be the best inclusion/exclusion hypothesis, but is concerned that there may be another less obvious path to a solution: while solving a problem s/he said:

> I can tell with these that [...] this break is going to be at least one of the options. ... if you take a situation like this and you push all these putative homoplasies way down the tree, that's the easiest way to tell if membership in these is going to collapse and you're going to have to consider moving things around, if you push them way, way down, then you're going to remove as much support above as possible and if you've made a mistake in that initial allocation, you'll see it much more quickly ... when I see something like that, I always want to consider two possibilities: one is that these are not right and the other is the possibility that you can move all that mess way down

Another way is to identify all of the likely paths

toward solutions and construct each *de novo*: In this example, another participant found out that there are two paths that seem equally likely of producing a solution:

> So here it's hard to pick a sort of a set of characters that you think you ought to just go with because there are actually sort of 2 sets and it's basically 1 and 2 vs. 4 and 5 and so what I might actually do is draw trees based on those two sets initially and see what they say about each other.

In both these examples, the solvers are using a process that is analogous to bracketing in order to estimate where solutions are and how best to ensure that all of the best solutions are found.

> A third question asked by Stewart and Hafner was:
> Do solvers use incomplete models as templates to capture larger or more obvious effects which can then be "factored out" to detect phenomena which would otherwise be masked or be too small to be seen. (Stewart and Hafner, 1991, p. 116)

This question closely characterizes the overall aims of phylogenetic inference. Scientists construct phylogenetic trees for the purpose of recognizing which characters can be explained most easily as the result of descent and which require some other explanation. Phylogenetic tree construction identifies those characters which closely fit a larger pattern and allows the scientist to focus research effort on the more problematic characters. Solving another problem a different participant said:

> What cladograms do is give you a very efficient way to curtail the range of appropriate questions in investigations. Cladograms keep you from running off and asking questions that you shouldn't be worrying about. ... the cladogram doesn't ... use the data to test the initial hypothesis, but everything that you postulate as a homoplasy on that cladogram, you've actually done a test against evidence, you say, this doesn't fit, and there are obviously two reasons for that, one is that its real homoplasy, in which case you've got all these really interesting evolutionary things to research, or you made a mistake in which case, so what?

This aspect of model-revising, however, does not take place during phylogenetic tree construction. It is a higher level phenomenon by which phylogenetic trees are used to revise biological models in general.

Phylogenetic Investigator

This research has implications for the on-going development of Phylogenetic Investigator. PI was originally designed to allow someone to pose and solve phylogenetic problems, and draw representations for peer persuasion. This study examined its capability to facilitate posing realistic problems of tree construction, solving problems, and drawing phylogenetic trees. There was no disagreement that it was capable of presenting realistic problems. Although some experts had reservations about the biological significance of the contentless problems presented in this research, everyone agreed that these problems as represented in PI, were consistent with practices in phylogenetic biology. In terms of solving problems, PI permitted, but did not facilitate expert problem solving and most experts felt the need to supplement the environment by using paper and pencil. Below I discuss how the results of this research inform modifications to the interface for PI in terms of matrix modification and tree drawing.

Reordering data in the matrix appeared to facilitate pattern recognition and display-based reasoning. Participants (1, 3, 5, 6, 8, 9) used PI's ability to reorder rows in the data matrix and participants (1, 4, 6, 8, 9) said that the ability to move columns in the matrix would be useful as well. In addition, S7 said that she had previously engaged in this activity, although it was no longer a feature of her problem solving. One problem that was observed in moving rows was that the row selected to be moved was not highlighted. This sometimes caused confusion about which row had been selected and whether it was actually moved to the correct new location. These insights were used to improve the data matrix in a subsequent version of PI. In the new version, both rows and columns can be moved. When they are selected, the row or column of data is outlined with a box. After a new location is selected, the column and box are moved to the new location and the box flashes to indicate the new location of the data.

The drawing environment offered several difficulties to experts. The primary complaint was that it was too cumbersome and slow. Several steps were taken to streamline its interface and improve performance. In the revised version, postulated nodes can be placed directly in desired locations rather than needing to be moved. Nodes and links can be removed using the delete key, rather than a special purpose command. Link reassignments can now be invoked more easily, either through a keystroke or by selecting a link and a node, and operate through a menu system, rather than requiring the user to enter node designations. The issue of speed was addressed by redesigning some sections of the program and by restructuring some activities and data structures. This improved the response of the program during performance critical activities, like selecting and moving items, and drawing links.

Some difficulties with the interface represent inherent differences between approaches used by experts and the environment as constructed in PI. The duplicated taxa strategy used by one participant requires multiple copies of nodes to construct single character trees. This conceptualization of the problem and its representation is simply different than that presented by PI. Experts methods and strategies are adapted to a pre-existing series of tools and representational media. Although the PI drawing environment did not facilitate expert performance on the part of most experts who used it, several participants used it successfully. Further study is required to evaluate whether it can be used successfully to teach fundamental phylogenetic tree construction to novices.

Conclusions

The research program described here has provided insights into the nature of phylogenetic problems and problem-solving methods and how these might be applied to teaching evolution. This report includes a new description of the nature of phylogenetic problems and factors contributing to their difficulty that can inform the construction of problems for educational use that encompass the full range of phylogenetic phenomena. The procedural model of phylogenetic tree construction adds to the knowledge of problem-solving research and can inform desired performance for students. The results of this research contribute to the creation of a knowledge base that can inform curricula that address the teaching of evolution and provide a foundation for subsequent research in the problem solving of phylogenetic inference.

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Continued on page 33

News and Views

In Memoriam: John R. Carlock

John R. Carlock, a founding member, past President, and long time Executive Secretary of AMCBT, Professor Emeritus at Illinois State University, died on Saturday December 23, 1995. He was born July 30, 1921, in Bloomington, IL, a son of Claud B. and Myrtle Skelton Carlock. He married Janice Kemp December 27, 1979, in Springfield, IL.

Professor Carlock was a teacher, biologist, author, nature photographer and producer of programs to enhance environmental awareness. He attended Bloomington High School. He received bachelor's and master's degrees from Illinois State University. He completed additional work at the Massachusetts Institute of Technology, Harvard and University of Wisconsin. He was a Navy veteran of World War II, serving as a lieutenant.

We express our deepest sympathy to his survivors: his wife, Janice C. (Kemp) Carlock, also a former AMCBT President, Monmouth, IL; three sons, John M., Virginia Beach, VA; Claude M. Bloomington; and Kevin E. R., Geneseo, IL. Memorials may be made to the Association of Midwestern College Biology Teachers, in care of Edward Kos, Biology Department, Rockhurst College, 1100 Rockhurst Road, Kansas City, MO, 64110-2561.

A Day in the Life of the Planet: Project World-wide Monitor
http://www.ccn.bctel.com/pearson/planet/planet.htm

* **Provide an opportunity for your students to collaborate with other students from around the world on environmental investigations.**

* **Here is a simple, hands-on laboratory/field experience in environmental science for middle school through advanced undergraduate levels.**

* **Develop problem-posing, problem-solving, and peer persuasion skills while comparing the environment near your campus to other habitats of your choice.**

Have you ever thought how motivating it might be for your biology or environmental science students to become involved in collaborative investigations with scientists at other locations? Have you had as a goal in teaching ecology or environmental science that your students should develop a "sense of place" with their immediate habitat, or a "sense of community" with their collaborators? Do you strive to offer hands-on laboratory/field activities in which students develop analytic and critical thinking skills while having flexibility to use their creativity in design and peer-persuasion, so important to the process of doing science? Those are some of the issues that several participants at a recent *BioQUEST* Curriculum Development Workshop addressed.

Out of those discussions and the realization of the tremendous potential of the World Wide Web has come a new forum for international student collaboration in environmental science investigations: A Day in the Life of the Planet: Project World-wide Monitor.

Students at several schools, colleges, and universities will collaborate in an environmental investigation on 8 to 10 October 1996 (and again in the following January and April). Students will collect data, mainly temperatures using a standard format, from a habitat of their choice and enter them into a World Wide Web data base. From these preliminary data, students can make comparisons, identify patterns, raise questions, and identify hypotheses about their "place" in relation to other habitats.

Following the initial investigation, the project will continue in directions that will be determined by the participants. Students can, for example, contact at least one other participating group and jointly plan an investigation inspired by the preliminary data. As these collaborative studies are finished, the web site will serve as a forum for presenting posters and eliciting commentary on a "whiteboard."

If you wish to engage your students in this effort, visit the project web site:

(http://www.ccn.bctel.com/pearson/planet/planet.htm)

or contact one of its developers:

Garry Fletcher
(gfletcher@ pearson-college.uwc.ca)
Ann Larson
(larson.ann@uis.edu)
Don Mansfield
(dmansfie@ stimpy.acofi.edu)

1996 American Society for Microbiology Audioconference Program

The Programs:

8 October	A12	**Working Safely I the Microbiology Laboratory**
22 October	A13	**An Update on *E. coli* O157:H7 and Related Shiga-like toxin-reducing *E. coli***
29 October	A14	**Case Presentations of Unusual Pathogens II**
12 November	A15	**Amplification for *M. tuberculosis***
19 November	A16	**Viral Serology**
3 December	A17	**Update on Taxonomy and Clinical Relevance of Nonfastidious, Glucose-Nonfermenting Gram-Negative Bacilli**
17 December	A18	**Managing Multiple Projects, Objectives, and Deadlines**

The Details:

Unless otherwise noted, all audioconferences:

- *start at 1:00 p.m. Eastern time
- *consist of a 40-minute presentation and a 20-minute question and answer period
- *are accompanied with outlines

Participating in a conference requires:

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- *a speaker phone
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20 rooms blocked for AMCBT-Loras College
Thursday 9/19 & Friday 9/20 nights

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MAKE YOUR RESERVATIONS EARLY!

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Note: There are 2 Heartland Inns in Dubuque!
4025 Dodge St (Hy. 20 west)

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$50 + tax / night for 1,2 or 4 people
20 rooms blocked for AMCBT-Loras College
Thursday 9/19 & Friday 9/20 nights

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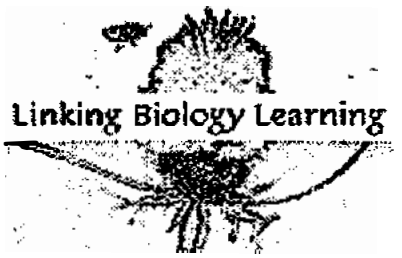

LINKING BIOLOGY LEARNING

Loras College, Dubuque, Iowa

AMCBT 40th Annual Meeting

September 19-21, 1996

PRELIMINARY PROGRAM

THURSDAY, September 19th

6:00 PM - 8:00 PM **Registration & Reception** ..... Concourse of Alumni Campus Center (ACC)

8:00 PM Opening Session ..... ACC Ballroom
Welcome for AMCBT
Ethel Stanley, Beloit College, Program Chair
Tom Davis, Loras College, Local Arrangements Chair,
Tim Mulkey, Indiana State University, AMCBT President

Welcome to Loras College
Joachim Froehlich, President, Loras College

****

8:15 PM **OPENING ADDRESS** (Public Welcome to Attend)
"Novae - The Spectacular End to a Double Star's Life "
Mary Jane Taylor, Loras College

****

Orientation to Fall Constellations ..... Heitkamp Planetarium

9:30 PM **Executive Committee Meeting** ..... Room 544 Arizona Room, ACC

FRIDAY, September 20th

7:00 AM Early Registration ..... ACC Concourse

7:00 AM - 8:15 AM **Buffet Breakfast** ..... ACC Ballroom
Tables as Interest Groups

8:15 AM - 11:00 AM Continuing Registration ..... Foyer of Science Hall

8:15 AM - 10:45 AM FIELD TRIPS & **WORKSHOPS I**
(All field trips depart from the foyer of Science Hall on Alta Vista)

1. Plankton/Diatom Collecting Trip ..... Limit: 10, Van $3
   on the Mississippi River
   Dave Czarnecki, Loras College
2. Antibodies as Tools in Biology Workshop ..... Room 54, Science Hall
   Karen Klyczek, University of Wisconsin- River Falls

3. Dubuque Arboretum and Botanical Gardens Tour .....Limit: 25
Joe Kapler, Loras College (Van $3)
4. Goat Prairie/ Four Mounds Bluffland Habitat Preserve Tour .....Limit: 15
Ed Cawley, Loras College (Van $3)
5. Mississippi River Backwater Habitat/ .....Limit: 12
Wildlife/Ecology Boating Trip
Jerry Kaufmann, Loras College (Van $3)
6. Swiss Valley Park Birding/ Hanging Bog Hike .....Limit: 15
Bob Walton, Dubuque County Conservation Board (Car pool)

****

11:05 AM- **KEYNOTE ADDRESS** .....ACC Ballroom
12:00 PM *"Connecting Biology: Learning with Cases"*
Margaret Waterman, Southeast Missouri State University

****

12:00 PM - **Lunch** (Open)
1:30 PM Exhibitors (Room 109) Posters (Hall) InfoShare (Room 122)...Science Hall
Preview AMCBT Logo Submissions (Room 122)

12:00 PM - FIELD TRIP II
2:15 PM 1. Lunch at the Garden Room Cafe/Dubuque Historical Trolley Tour
Barb Davis, Loras College
(Trolley leaves ACC Concourse at 12:10 to Garden Room Cafe, $9)

1:30 PM -
2:15 PM CONCURRENT SESSIONS I — Science Hall

1. The Independent Research Project: An Opportunity for Teaching-On-Demand .....Room 49
Dianne Bell, Avila College
2. Field Investigations on a Shoe String: Do-It-Yourself .....Room 54
Judy Parrish, Millikin University
2. Workshop for Prospective Authors .....Room 142
Ricki Lewis, William C. Brown and Company
3. A Reform of Science Education: A Case for Local Action and Global Thinking .....Room 125
Jo Handelsman, University of Wisconsin

2:20 PM - **Afternoon Break** Refreshments (Room 109).....Science Hall
3:05 PM Exhibitors (Room 109) Posters (Hall) InfoShare (Room 122)
Preview AMCBT Logo Submissions (Room 122)

2:30 PM - FIELD TRIP III
5:30 PM 1. Galena Sights and Sounds .....Car pool
Departs from Keane Hall parking lot on Alta Vista
Barb Davis, Loras College

3:00 PM - FIELD TRIP IV
5:00 PM 1. William C. Brown and Company Tour.....Car pool
John Bamrick, Loras College

3:10 PM - 5:00 PM **WORKSHOPS II** ..... Science Hall

1. CASE IT! Student Generated Case Studies *Limit: 12* ..... Room 39
   Mark Bergland & Karen Klyczek, Univ. of Wisconsin-River Falls
2. AMCBT/Web Page Construction Workshop ..... Room 110
   Tim Mulkey, Indiana State University (Hennessee Hall)
3. Generating Gastropod Graphics: Using Fossils, Shells and Computers to Investigate Evolutionary Morphospace ..... Room 118
   John R. Jungck, Beloit College
4. Plankton/Diatom Identification and Biology (Limit: 20)
   Using samples collected in morning field trip ..... Room 19
   Dave Czarnecki, Loras College

5:05 PM - 5:45 PM **Bioscene Editorial Board Meeting** ..... Arizona Room ACC

6:00 PM - 7:00 PM **Social Hour** ..... ACC Ballroom/Hall

****

7:00 PM **BANQUET** ..... ACC Ballroom

8:15 PM **BANQUET ADDRESS**
"Aldo Leopold, Cranes and Conservation Biology: Lessons from History"
Curt Meine, International Crane Foundation

****

9:30 PM - 10:45 PM **Late Night WORKSHOP III**
Environmental Biology and the World Wide Web (Limit: 12) ..... Room 110
Buzz Hoagland, Westfield State College (Hennessee Hall)

9:30PM **Late Night Mississippi River Excursion**
Trolley leaves ACC Concourse at 9:30 PM
Boat tour is 90 minutes, includes cash bar and educational narrator ($9)
Tom and Barb Davis, Loras College

SATURDAY, September 21st

7:30 AM- 8:30 AM **Continental Breakfast** ..... Room 109
Balloting from 8:30 AM through 9:45 AM ..... Foyer

8:30 AM - 9:15 AM **CONCURRENT SESSIONS II** ..... Science Hall

1. A Day in the Life of the Planet: ..... Room 49
   Collaborative Learning on the Internet
   Ann Larson, University of Illinois at Springfield
2. Emerging Diseases: A Workshop Approach ..... Room 54
   Marion Fass, Beloit College
3. Fears, Problems, and Successes of Students Conducting Field Investigations ..... Room 125
   J. H. Kruper and T. L. Derting, Murray State University
4. Making Anatomy Useful for the Health Science Student: ..... Room 142
   Incorporating Clinical Applications with Cadavers
   Connie Vinton-Schoepske, Hawkeye Community College

9:20 AM - 9:45 AM **Morning Break Refreshments** (Room 109) ..... Science Hall
Exhibitors (Room 109) Posters (Hall) InfoShare (Room 122)
Preview AMCBT Logo Submissions (Room 122)

Balloting Closes at 9:45 AM

9:50 AM - 10:35 AM **CONCURRENT SESSIONS III** Science Hall

1. Developing a Personal Land Ethic: Aldo Leopold ..... Room 125
   Tom Davis, Loras College
2. Arachnophilia: A Service Learning Approach to Biology ..... Room 54
   Marianne Robertson, Millikin University
3. AMCBT Revisited ..... Room 142
   Ed Kos, Rockhurst College, *David Fagle and Norm Jensen*, Millikin Univ.
4. Flow Chart Use Problem Solving in Anatomy and Physiology .... Room 49
   Pat Bowne, Alverno College

10:40 AM - 11:05 AM **CONCURRENT SESSIONS IV** Science Hall

1. Students Tell Us ..... Room 125
   Bill Brett, Indiana State University
2. Lableless Labs ..... Room 54
   Debbie Lively, Community College of West Kentucky University
3. Creative Thinking for Teachers ..... Room 142
   Alan Nowicki, Highland Community College
4. A Microbiology Lab for Nursing Students:
   Culture and Sensitivity Techniques ..... Room 49
   Gopal Krishna, Moberly Area Community College

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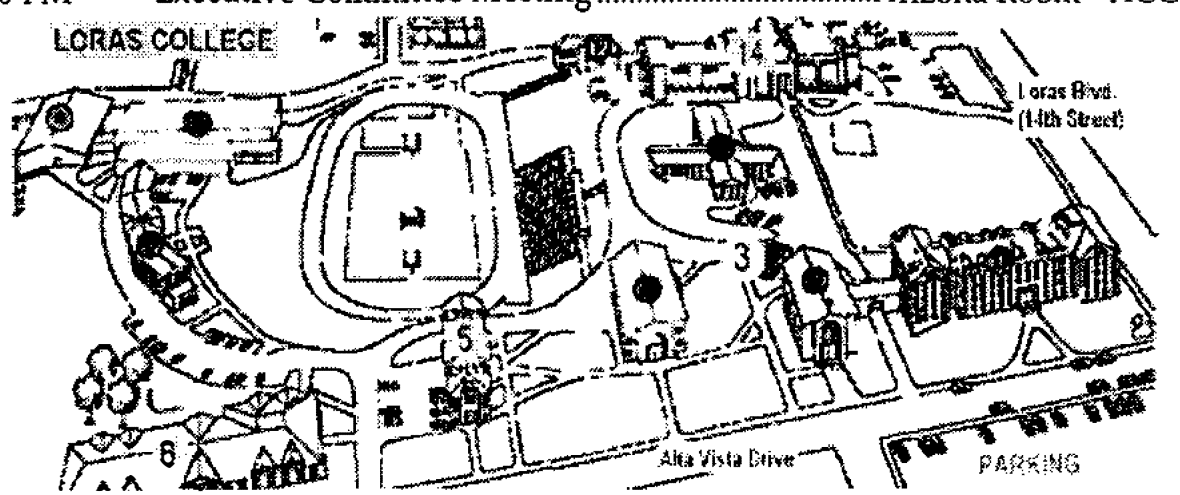
11:15 AM - 12:45 PM **Brunch** ..... ACC Ballroom
BUSINESS MEETING
Presidential Address: *Tim Mulkey*, Indiana State University
Election Results: *Marc Roy*, Beloit College
Bioscene: *John R. Jungck*, Beloit College
Executive Secretary Report: *Ed Kos*, Rockhurst College

12:50 PM - 1:30 PM **Executive Committee Meeting** ..... Arizona Room - ACC



Abstracts of Sessions

CONCURRENT SESSIONS

C.I.1 The Independent Research Project: An Opportunity for Teaching-On-Demand
Dianne Bell, Avila College

Allied Health and Nursing students take Human Physiology, a required 4 credit course with a 3 hour weekly lab, when they are sophomores. Students are self-assigned to groups for 2-4 investigations with one-half of the laboratory experience assigned as an independent research project. After instruction in experimental design with access to completed projects of earlier students, students submit a full research proposal with a consent form / subject questionaire. Teaching is then "by demand." Students request instruction with equipment, data management methods, and assays.

C.I.2 Field Investigations on a Shoe String: Do-It-Yourself
Judy Parrish, Millikin University

Taking students to the field is an excellent way to generate interest—and questions. These questions do not necessarily require high-cost technology to investigate, but rather, creative planning on a real-world budget. This workshop will focus on examples of student field projects, especially in aquatic systems. Bring ideas to share!

C.I.3 Workshop for Prospective Authors
Ricki Lewis, W. C. Brown & Company

Learn more about textbook publishing in this interactive session with biology textbook author, Ricki Lewis.

C.I.4 A Reform of Science Education: A Case for Local Action and Global Thinking
***Jo Handelsman,* University of Wisconsin**

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C.II.1 A Day in the Life of the Planet: Collaborative Learning on the Internet
Ann Larson,
University of Illinois at Springfield

A demonstration of a project developed during a Bio*QUEST* workshop using the 3Ps of Problem Posing, Problem Solving and Peer Persuasion in which field data is shared, patterns analyzed, and then used as the basis for collaborative projects between sites. Find out how your students can join in with the first collection day in October.

C.II.2 Emerging Diseases: A Workshop Approach
Marion Fass, Beloit College

This presentation explores the use of contemporary issues to introduce non-majors to scientific problem posing, research and analysis. It also provides examples of linkages of biology and the humanities and social sciences. Non-majors face the challenge of understanding complex scientific issues in the years ahead. The course "Biological Issues: Emerging Diseases," taught at Beloit College, engages students in an analysis of the ecological, evolutionary and poliltical factors which infulence the emergence of new diseases. Students anlayze World Health Organization (WHO) data on health, development and mortality and develop a class study on upperrespiratory disease and flu vaccinations on their campus. Students share independent library research on tropical diseases. "Wet" labs explore basic microbiology and antibiotic resistance. Bio*QUEST* modules mGCK and Epidemiology are used as well for student problem solving.

C.II.3 Fears, Problems, and Successes of Students Conducting Field Investigations
J. H. Kruper and T. L. Derting,
Murray State University

Life is the basic theme of biology, yet all too often life is studied only in artificial laboratory conditions. Despite the inherent appeal of the "outdoors" in young and old alike, the idea of conducting investigations of biological phenomena in the field is met with trepidation. We present a case study of a field ecology class in which groups of students

initiated and completed independent field investigations. Many of these students had no prior field experience. Throughout the course we monitored the feeling, problems, and successes of each group of investigators. We will present the views and thoughts of the students and instructors. We believe that discussion of this information will provide useful insights to instructors and students interested in field investigation in biology.

C.II.4 **Making Anatomy Useful for the Health Science Student: Incorporating Clinical Applications with Cadavers**
Connie Vinton-Schoepske,
Hawkeye Community College

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C.III.1 **Developing a Personal Land Ethic: Aldo Leopold**
Tom Davis, Loras College

This interdisciplinary course attempts to connect students to their natural environment as well as to develop a basic understanding of ecology through computer models and research papers. Historical views of how land was and ought to be used including Aldo Leopold's book titled *"A Sand County Almanac"* are discussed. Students listen to the land ethics of farmers, soil conservationists, Army Corps of Engineer hydrologists, spokespeople for the Nature Conservancy, The Iowa Natural Heritage Foundation, and local County Conservation officers in an attempt to better build their own relationship to the land. Two field trips, one to Leopold's Shack and another to a local natural area are included. How this 3 credit sophomore level course in the Honors Program at Loras College is run, its successes and its shortcomings, will be presented.

C.III.2 **Arachnophilia: A Service Learning Approach to Biology**
Marianne Robertson, Millikin University

During the spring semester of 1996, I received a mini-grant from Illinois Campus Compact for Community Service to incorporate a service learning component into the Animal Behavior course at Millikin University,, Decatur, IL. The objectives of this project were to promote inter-disciplinary collaboration between biology, theatre, and education students, expose university students to the real life situation of teaching science in a low-income, diverse community, and provide an ENTHUSIASTIC, interactive learning program and resources to a local elementary school. Students presented their programs to fourth grade students at Washington Elementary School. Animal behavior students each chose a topic of interest in the area of insect or spider behavior and developed oral and visual presentations centered around these themes. Theatre students developed skits and games that supported the science presentations, thus giving the fourth grade students an active role in learning. Education students, with an emphasis in science teaching, taught the animal behavior and theatre students how to present information to younger learners. These students relayed a love of science and an ENTHUSIASM FOR LEARNING that was invaluable. We are currently setting up a science laboratory at Washington Elementary.

C.III.3 **AMCBT Revisited**
Ed Kos, Rockhurst College, *David Fagle,* and *Norm Jensen,* Millikin University

This informal discussion session will focus on AMCBT experiences over the past 40 years. You don't have to be a founding member to join in! What did the organization set out to do, what have we done, and what are some future directions?

C.III.4 **Flow Chart Use and Problem Solving in Anatomy and Physiology**
Pat Bowne, Alverno College

Two classes of sophomore students in Human Anatomy and Physiology received different levels of instruction in the use of flow charts to show cause-effect relationships in physiology. The extent to which the students used flow charts on examinations was then compared with their success in correctly solving case-study problems. Flow chart use was more strongly correlated with correctly stating normal physiology than with correctly inferring the consequences of altered physiology.

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C.IV.1 **Students Tell Us**
Bill Brett, Indiana State University

C.IV.2 **Labless Labs**
Debbie Lively, Community College of West Kentucky University

Many biology courses for non majors do not have a lab component. Because of a strong philosophical belief that all science courses should include labs, a lab component was introduced into a general biology course which formerly included no labs. Due to lack of budget, lack of space and lack of resources, all of the labs can be done in a classroom setting with a minimum of equipment and with little or no set up and tear down time. These labs are also appropriate for any class size.

C.IV.3 **Creative Thinking for Teachers**
Alan Nowicki, Highland Community College

Few people recognize the creativity and excitement of science. Certainly most science textbooks and science teaching fail to transmit these aspects to students. This presentation will focus on creativity in scientists and creative ways of helping students learn about science. We will define creative thinking and discuss barriers to and strategies for creativity.

C.IV.4 **A Microbiology Lab for Nursing Students: Culture and Sensitivity Techniques**
Gopal Krishna,
Moberly Area Community College

Activities discussed include culturing bacteria by streak plate method, observing morphology and identifying by gram staining, performing sensitivity by Kirby Baur Method, and reading the zone of inhibition around the anti-microbial discs. Although our lab room is small and our time limited, we organize these activities so that the group (20+ students) gets everything done within two lab periods. This lab relates to their practical, hospital or clinical experience, so the nursing students tend to enjoy it.

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WORKSHOPS

W.I.2 **Antibodies as Tools in Biology Workshop**
Karen Klyczek,
University of Wisconsin-River Falls

In this hands-on lab session on antibodies as tools, biology participants will try a couple of readily available, rapid antibody-based test kits (pregnancy tests, crop disease tests, etc.) and figure out how they're set up. Where's the antibody? the antigen? How is the color produced? Some relatively simple and inexpensive techniques for detecting antigen-antibody binding will be discussed as well as how these immunoassays can be used to develop simulated research problems in any area of biology.

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W.II.1 ***CASE IT!* Student Generated Case Studies**
Mark Bergland and Karen Klyczek, University of Wisconsin-River Falls

Case It!, a collaborative project conceived at the 1995 *BioQUEST* Summer Workshop, will enable students to study problems in molecular biology using a case-study approach. These problems can be taken from a variety of disciplines including human genetics, forensics, ecology,, evolution, and taxonomy. Participants at this workshop will use *Case It!* software to filter DNA sequences obtained from GENBANK, and then run restriction analyses and Southern blots of the filtered sequences. For example, participants could use this software to examine differences in DNA sequences between normal persons and persons with sickle-cell anemia, Huntington's disease, or Duchenne muscular dystrophy, as a means of diagnosing these illnesses. Time will be allowed for participants to explore the GENBANK repository and come up with their own applications for the software. A discussion of how this software could be used in various classroom situations will also be a part of the workshop.

W.II.2 **AMCBT/Web Page Construction Workshop**
Tim Mulkey, Indiana State University

This workshop will introduce web basics and provide an opportunity for participants to create their own web pages. We will begin by exploring the AMCBT's own web site.

W.II.3 Generating Gastropod Graphics: Using Fossils, Shells and Computers to Investigate Evolutionary Morphospace

John Jungck, Beloit College

Seashell diversity includes such variant forms as cockles, mussels, cones, oysters, clams, scallops, augers, murexes, tritons, tusks, helmets, cowries, screws, limpets, turbans, tusks, abalones, and, of course, chambered spirals. The famous Yale ecologist, G. Evelyn Hutchinson, asked the question: "Why are there so many kinds of animals?" It would seem that such tremendous neontological and paleontological diversity of gastropod, bivalve, brachiopod, and cephalopod specimens would offer a good empirical collection to examine Hutchinson's thesis. Herein the notion of an "evolutionary morphospace" developed by David Raup at the University of Chicago which demonstrates the counter hypothesis will be demonstrated through computer simulations. Participants will employ a variety of shell and fossil specimens to generate data for input into computer programs (all freeware or shareware used by our undergraduates) that generate quite beautiful graphical models of seashells and be asked to discuss these two contradictory hypotheses.

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W.II.4 Plankton/Diatom Identification and Biology

Dave Czarnecki, Loras College

Using samples collected in morning field trip, up to 20 participants can join us in the laboratory for identification and discussion of these freshwater organisms.

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W.III.1 Environmental Biology and the World Wide Web

Buzz Hoagland, Westfield State College

In colleges and universities today,, most students learn biology through one of two processes: (1) reading or listening to lectures about biological discoveries made by other scientists, and (2) conducting experiments. Unfortunately, many teaching institutions lack sufficient equipment, time, or expertise to conduct a wide range of experiments that yield sufficient data for meaningful analyses. Imagine 50 different biology courses conducting the same experiment and making their data available on the WWW? Participants in this workshop will learn how to develop webpages containing data on Macintosh computers. Additionally, participants will learn what WWW resources in Environmental Biology are available and how to access them.

The American Society for Microbiology's Board of Education and Training announces the culmination of its two year Biofilm CD Project. The CD-ROM is a digitized database demonstrating the diversity of biofilms. Each image is accompanied by a legend describing the biofilm, including what organisms are present, as well as how and where the biofilm was formed. The collection is designed not as pre-packaged software, but rather as a data base of resources that a teacher can utilize to custom tailor their own unique teaching materials. Included on the CD-ROM are sample presentations and instructions for the educator on how to create presentations for the classroom. The Biofilm CD-ROM will be launched at both the Conference on Microbial Biofilms, September 30-Oct. 4 at Snowbird, UT and at the NABT meeting, Oct. 16-19 in Charlotte, NC. If interested in more in more information concerning the Biofilm CD-ROM, please see our web page:

http://www.asmusa.org/edusrc/edu3.htm

The American Society for Microbiology will sponsor the 4th Undergraduate Microbiology Education Conference 2-4 May, 1997, in Miami, Florida. Presentations and work sessions will focus on improving curriculum options used in microbiology instruction. For more information contact:

Betty Eidemiller
American Society for Microbiology
1325 Massachusetts Ave., N.W.
Washington, DC 20005

beidemiller@asmusa.org

Curriculum Vitae of Candidates for President

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CHARLES J. BICAK
University of Nebraska at Kearney
Kearney, NE 68849

Education:

1982	Ph.D., Range Plant Ecology, Colorado State University, Ft. Collins
1978	M.Sc., Plant Science, University of British Columbia, Vancouver
1974	B.Sc., Biology, Kearney State College

Professional Experience:

1993-	Professor, University of Nebraska at Kearney
1992-1993	Associate Professor, University of Nebraska at Kearney
1991-1992	Professor and Chair, Dept. of Biology, California State University, Bakersfield (CSUB)
1990-1992	Professor (CSUB)
1987-1990	Associate Professor (CSUB)
1983-1987	Assistant Professor (CSUB)
1982-1983	Research Assistant, Eli Lilly Company, Herbicide Division

Honors and Awards (Partial List):

1994-	Member, Board of Directors, Platte Natural Resources District
1992-	Member, Advisory Board, Edgerton Education Center
1991-1992	President, California Biology Educators Association (CBEA)
1991-1992	Member, Board of Governors, Kegley Institute of Ethics
1990	Meritorious Performance Award, Teaching & Scholarship (CSUB)
1989	CSUB Team Member, Lilly Endowment Workshop, Liberal Arts

Grants (Partial List):

1996	Nebraska Game and Parks Commission
1993-1995	U.S. Fish and Wildlife Service
1992-1994	Research Services Council, Univeristy of Nebraska at Kearney
1989-1991	University Research Council, California State University
1987-1990	California Academic Partnership Program

Select Publications:

Bicak, C.J., H.G. Nagel, and M.C. Williams. 1995. Ecological Modeling as a forum for student decision-making. *Bioscene: Journal of College Biology Teaching. 21(3)*:3

Nagel, H.G., C.J. Bicak, L. Spessard-Schueth, S. Rothenberger, M.C. Williams, M. Biddlecome, J. Crawford, J. Osterhaus, and T. Walz. 1995. A comparison of 279 prairies in central Nebraska. *Proceedings: Platte River Basin Ecosystem Symposium.* 89-119.

Bicak, C.J. and D. Sternberg. 1993. Water relations of an annual grass in the Central Valley of California. *Bulletin of the Southern California Academy of Sciences. 92(2)*:54-63.

Bicak, J.S., C. J. Bicak, and L.J. Bicak. 1993. Preserving our urban wilds... A biology education resource. *The American Biology Teacher. 55*:350-357.

Bicak, C.J. and L.J. Bicak. 1990. Connections across the disciplines. *Journal of College Science Teaching. 19*:336-340.

Bicak, L.J. and C.J. Bicak. 1988. Scientific method: historical and contemporary perspectives. *The American Biology Teacher. 50*:348-353.

Horton, J.C. and C.J. Bicak. 1987. Modeling for biologists. *BioScience. 37*:808-809.

KAREN KLYCZEK
Biology Department, University of Wisconsin-River Falls
410 South Third Street
River Falls, WI 54022
Email: karen.k.klyczek@uwrf.edu

Education:

1984	Ph.D., Biochemistry, University of Wisconsin-Madison, WI
1980	B.A., Biology and Chemistry, Augustana College, Rock Island, IL

Professional Experience:

1993-	Associate Professor, Univeristy of Wisconsin-River Falls, WI
1989-1993	Assistant Professor, Univeristy of Wisconsin-River Falls, WI
1987-1989	Research Assistant Professor, Temple University School of Medicine, Philadelphia, PA
1984-1989	Postdoctoral Fellow, University of Pennsylvania School of Medicine, Philadelphia, PA
1980-1984	Graduate Research Assistant, Univeristy of Wisconsin-Madison, WI

Honors, Awards and Professional Service (partial):

1995	Outstanding Faculty Award, UW-River Falls College of Arts and Sciences
1995	Review Panel, NSF Instrumentation and Laboratory Improvement Grants
1993-1996	Steering Committee, Association of Midwest College Biology Teachers
1993-	Advisory Board, Wisconsin Youth Apprenticeship Program in Biotechnology
1993-	Institutional Advisory Committee, Wisconsin Academy Staff Development Initiative in Science Education
1992-1994	NSF Undergraduate Biotechnology Curriculum Development Project, Georgetown University Medical School
1992-	Advisory Cmte, UW-Madison Teacher Enhancement Program in Biology
1991	Phi Kappa Phi

Memberships:

American Association for the Advancement of Science; American Society for Microbiology; Association of Midwest College Biology Teachers; Council on Undergraduate Research; Minnesota Society of Science Teachers; National Association of Biology Teachers; National Science Teachers Association; Wisconsin Society of Science Teachers

Courses Taught:

Cell Biology, Biological Greek and Latin, Bacteriology, Immunology, Virology, Animal Cell Culture, Molecular Biology

Selected Grants:

1995-1998	NSF Course and Curriculum Development Program, "Interactive Multimedia Simulations of Experimental Biotechnology Laboratories for Introductory Biology Students" (Co-PI with Mark Bergland)
1991-1997	NSF Teacher Enhancement Program, "Inservice program in biotechnology for secondary Biology and Agriculture teachers."
1992-1995	National Cancer Institute, NIH Academic Research Enhancement Award, "MHC class I gene regulation in tumor cells."
1991-1993	NSF Instrumentation and Laboratory Improvement Program, "Molecular Biology for Biotechnology Majors."
1990-1991	UW-River Falls Faculty Research Grant, "Regulation of gene expression in tumor cells."
1989-1990	Dwight D. Eisenhower Math and Science Education Act, "Contemporary Biology Workshop for Teachers" (Co-PI with Linda Treeful)

Selected Publications:

Klyczek, K.K., and M.S. Bergland. 1996. CaseIt! Collaborative development of a potential BioQUEST module. *BioQUEST Notes* 6(2):11.

Klyczek, K.K. 1994. "Gel Diffusion/Oucherlony," "Antibodies as tools: Using commerically available kits," and "Identification of lymphocyte populations' in *The Science of Biotechnology: Theory and Practice*, Chirikjian, J.G., ed., Jones and Bartlett Publishers, Boston, MA.

Rosenthal, L.A., K.K. Klyczek, and K.J. Blank. 1992. Interferon-a, pentoxiphylline, and caffeine synergize with interferon-y to induce MHC class I expression on a sconstitutively class I negative tumor cell line. *J. Interfieron Res. 12*:403.

Rosenthal, L.A., K.J. Blank, and K.K. Klyczek. 1992. Introduction of the H-2Dk gene into a class I negative tumor cell line confers interferon-y responsiveness upon the silent endogenous H-2Kk gene. *Cell. Immunol. 145*:43.

Moors, M., S.M. Jones, H.R. Buckely, K.K. Klyczek, T.J. Robers, and K.J. Blank. 1990. Effect of Friend murine leukemia virus infection on susceptibility to Candida albicans. *Inf. Immun. 58*:6.

Summary of AMCBT Involvement:

Member since 1990; Steering Committee Member, 1993-1996; Presentations at 1993, 1994, 1995, 1996 (scheduled) Annual Meetings; Attendance at 1990, 1992, 1993, 1994, 1995, 1996 (planned) Annual Meetings

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Curriculum Vitae of Candidates for Steering Committee

THOMAS A. DAVIS
Department of Biology
Loras College
1450 Alta Vista
Dubuque, IA 52004-0178

Education:

1987	Ph.D., Zoology (Physiology), Iowa State University, Ames, IA
1983	M.S., Zoology (Physiology), Iowa State University, Ames, IA
1979	B.S., Biology, University of Wisconsin-Stevens Point, WI

Professional Experience:

1994-	Associate Professor, Dept. of Biology, Loras College, Dubuque, IA
1989-1994	Assistant Professor, Dept. of Biology, Loras College, Dubuque, IA
1987-1989	Postdoctoral Fellow-American Heart Association Ovine Fetal Lung Physiology, Dept. of Physiology, College of Medicine, University of Florida, Gainesville, FL
1981-1987	Teaching and Research Associate, Dept. of Zoology, Iowa State University, Ames, IA
1980-1981	Teaching Assistant, Dept. of Biology, University of Wisconsin-Stevens Point, WI

Courses Taught:

Vertebrate Physiology, Human Anatomy, Anatomy and Physiology, Life Science, Experimental Design, Field Ornithology, Subtropical Ecology, Mountain Ecology, First Year Seminar, Developing a Personal Land Ethic

Research Interests:

Avian, reptilian and amphibian egg physiology; Fetal and embryonic respiration, circulation, and fluid balance; Physiological adaptation of fetus or embryo to disturbances in its physiological environment during development

Memberships:

American Physiological Society, Human Anatomy and Physiology Society, Association of Midwest College Biology Teachers, National Association of Advisors for the Health Professions

Summary of AMCBT Involvement:

Davis, T.A. 1993. Alternate Teaching Methods in Vertebrate Physiology Labs. *Bioscene* ??

Meeting Presentations: "Alternate Teaching Methods in Vertebrate Physiology Labs," Fall Meeting 1992; "Mountain Ecology: A New Biology Course at Loras College," Fall Meeting 1993; "Developing a Personal Land Ethic: Aldo Leopold and His Legacy," scheduled at Fall Meeting 1996. Steering Committee Nominee, 1994; Local Arrangements Chair/Host for 1996 AMCBT Fall Meeting; Bioscene Editorial Board Nominee, 1996.

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TERRY L. DERTING
Department of Biological Sciences
Murray State University
Murray, KY 42071

Education:

1982-1986	Ph.D., Ecology, Evolution, and Organismal Biology, Indiana University, IN
1978-1981	M.A., Zoology, Virginia Polytechnic Institute and State University, VA
1974-1978	B.A., Biology, Mount Holyoke College, MA

Professional Experience:

1993-	Assistant Professor, Dept. of Biological Sciences, Murray State University, KY
1991-1992	Visiting Assistant Professor and Teaching Fellow for BioQUEST, Beloit College, WI
1989-1991	Assistant Professor, Non-tenure track, Dept. of Biology, Hollins College, VA
1987-1989	Assistant Professor, Non-tenure track, Dept. of Biology, Radford Univ., VA

Courses Taught:

Animal Physiology, Comparative Anatomy of Vertegrates, Conservation, Developmental Biology, Ethics in Biology, Ethology, Field Studies in Ecology (Belize, C.A.), General Biology, Zoology, Genetics, Histology, Human Anatomy, Human Physiology, Mammalogy, Physiological Ecology, Vertebrate Ecology, Vertebrate Embryology

Memberships:

American Association of University Women, American Society of Mammalogists, Association of Midwestern College Biology Teachers, Council on Undergraduate Research, Kentucky Academy of Science, Phi Sigma, Sigma, Xi

Recent Publications:

Derting, T.L. Undergraduate views of academic misconduct in the biological sciences. *Amer. Biol. Teacher*, In Press.

Derting, T.L. 1996. Changes in gastrointestinal characteristics of an omnivorous species, the raccoon (*Procyon lotor*), with season and lactation. *J. Mammalogy, 77*(2):440-448.

Derting, T.L. and E.B. Noakes.* 1995. Seasonal changes in gut capacity in the white-footed mouse (*Peromyscus leucopus*) and the meadow vole (*Microtus pennsylvanicus*). *Can. J. Zool. 73*:243-252.

Derting, T.L. 1994. Teaching ethics in the sciences: How and why? *Bioscene: J. College Biol. Teaching 20*:16-21.

Derting, T.L. and B.A. Bogue.* 1993. Morphological responses of the gut to moderate energy demands in a small herbivore, *Microtus pennsylvanicus*. *J. Mammalogy 94*:59-68.

Derting, T.L. 1992. Energize it! An Ecologically integrated approach to the study of the digestive system and energy acquisition. *Bioscene 18(2)*:3-10.

ANN M. LARSON
Professor of Biology
University of Illinois at Springfield,
(formerly Sangamon State University)

I am a relatively long time member of AMCBT. My first meeting was at Milliken and my second at Carroll College, somewhere in the dark past. I have only missed one or two meetings since I joined the organization. Over the years, I have served as Board member, program and local arrangements chair with Malcolm Levin when the meeting was at Sangamon State University, and President of the association. I have never come to a meeting that I did not go home with at least one idea to add to my teaching repertoire. I value the spirit of sharing that permeates the organization rather than the aggrandizement or competition. As we celebrate our anniversary and get ready to enter the twenty first century, I would like to see the organization continue to grow and serve its members and our students.

Other information:
Ph.D. Oregon State University
M.S. Syracuse University
B.A. College of St.Catherine, St. Paul, MN

I have taught at the junior high, high school and, of course, the college level. If it's green and not money at my university, it's mine. Today my teaching focus is Cell Biology and Botany and I am particularly interested in the interface between structure and function. I also pay the price of being the senior facluty member and chair by pushing paper and counting pennies.

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WALLACE R. WEBER
Department of Biology
Southwest Missouri State University
Springfield, Missouri 65804

Education:

1968	Ph.D., Botany, The Ohio State University
1959	M.S., Botany, Southern Illinois University
1956	B.A., Botany, Southern Illinois University

Professional, Research and Consulting Experience:

National Park Service	Botanical Survey of the Ozark Scenic Riverways; A Study of Seven Pleistocene Relict Localities on the Jack's Fork River Within the Ozark Scenic Riverways.
Private Consulting	Williams Brothers Environmental Services (Nevada and Hempsted Counties, AR); KAMO & Empire Power Companies (Impact studies of various transmission lines in Wright, TX, LaClede, Christian, Greene, Hickory, and Taney Counties.
National Guard	Floristic Studies of Camp Clark, Camp Crowder, and Macon Training Site.
Other Research Activities	Biosystematic studies in the Silphium asteristics complex; Ecophysiological studies of Geocarpon minimum (an endangered species); proposed atlas of vascular plants of Missouri.
Publications/Reports	Thirty-eight, most dealing with the floristics of Missouri
Graduate Students	Seven students completed Master's Degrees under my direction; five students in progress.

Courses Taught:

General Botany, Advanced Plant Taxonomy, Identification of Aquatic Vascular Plants; Plant Morphology, Plant Taxonomy, Identification of Woody Plants, Identification of Ferns & Fern Allies

Research and Scholarly Interests:

Flora of Missouri, Atlas Project on Missouri Flora Distribution, Biosystematics of Silphium asteriscus complex, Ecophysiology of *Geocarpon minimum*, ongoing project of manual writing for use in local flora courses ("Missouri's Spring Flora" and "Woody Plants of Missouri"), the floristics of Camps Clark, Crowder, and Macon in Missouri

Memberships:

Society of Sigma Xi, Tri-Beta Biological Society, Botanical Society of America, American Society of Plant Taxonomists, International Society for Plant Taxonomy, American Institute of Biological Science, Southern Appalachian Botanical Club, Missouri Prairie Foundation, Missouri Native Plant Society, Ozark Society, Nature Conservancy, National Audubon Society, Sierra Club, The Wilderness Society, The Union of Concerned Scientists, Carrying Capacity Network, Zero Populatiion Growth, National Association of Biology Teachers, Association of Midwestern College Biology Teachers

Summary of AMCBT Involvement:

Member of Steering Committee, Association of Midwest College Biology Teachers, 1989-1991

Panel Discussion Participant with M. Levin, N. Jensen, R. Wilson, & Sr. Jeannene Yackey, "Perspectives on Teaching: Ecology & Field Biology," Oct. 1992, St. Xavier University, Chicago, IL.

Presented workshop with Barbara Newman, "Teaching About Human Population Growth in Introductory Biology Courses," Oct. 1992, St. Xavier University, Chicago, IL.

Selected Educational Activities:

Presented workshop with Barbara Newman, "Overpopulation-The root of our Environmental Problems," to public school teachers at state education meeting, Feb., 1992, Tan-Tara-a Resort, Lake of the Ozarks, MO.

Presented workshop with Dr. Albert Gordon on Population to Association for Biology Education (ABLE), at annuam meeting, June, 1990, Springfield, MO.

Organized field trip, "Natural History of Arizona," for Springfield, MO, science teachers during spring break, 1990.

Organized workshop for elementary and secondary science teachers on "The Prairie--A Classroom;" Co-sponsored by SMSU Continuing Education and the Missouri Prairie Foundation, 1987 & 1988.

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continued from page 17

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Association of Midwest College Biology Teachers
40th Annual Meeting

September 19-21, 1996
Loras College

InfoShare

Biology faculty and their students are invited to share:

- posters featuring research in biology or science education
- software currently used in their courses or under their development
- field or laboratory exercises developed for their courses

Posters:

The title, author(s), and a short abstract of the poster content must be submitted to the program director by **September 6, 1996**. This information will appear in the final program and be published in the Bioscene after the meeting. Posters will remain on display from Friday morning following breakfast through the Saturday morning break. Poster stands will be provided in the second floor hall area off the foyer of St. Joseph Science Hall.

Software:

The title, author, platform(Mac/PC), and a short summary of the use of the program must be submitted by **September 6, 1996** to the program director. Mac and PC (Windows 3.1/ DOS) computers will be provided in Room 122 of Science Hall for display/investigative use of the program. Freeware, shareware and individual software developed by the presenter who wishes to distribute copies must be clearly labelled "For Distribution" otherwise no copying of software is permitted.

Field or Laboratory Exercises:

The title, author, and a brief description of the lab must be submitted by **September 10, 1996** to the program director. Each presenter should bring 50 printed copies of the exercise to distribute. A table will be set up in Room 122 of Science Hall for these copies. A disk copy of the exercise in a standard word processing format or text file would be appreciated as well. These exercises will be entered into an AMCBT file that can be accessed electronically. The steering committee wishes to rebuild the field/laboratory exercises archive the organization used to maintain for distribution.

ALL submissions are greatly appreciated!

Ethel Stanley, Program Director
Beloit College
700 College Street
Beloit, WI 53511
stanleye@beloit.edu

Application For Membership

ASSOCIATION OF MIDWESTERN COLLEGE BIOLOGY TEACHERS

NAME:_____ DATE:_____

TITLE:_____

DEPARTMENT:_____

INSTITUTION:_____

STREET ADDRESS:_____

CITY:_____STATE:_____ZIP CODE:_____

ADDRESS PREFERRED FOR MAILING:_____

CITY:_____STATE:_____ZIP CODE:_____

WORK PHONE:_____FAX NUMBER:_____

HOME PHONE: _____ E-MAIL ADDRESS:_____

MAJOR INTERESTS:
( ) 1. Biology
( ) 2. Botany
( ) 3. Zoology
( ) 4. Microbiology
( ) 5. Pre-professional
( ) 6. Teacher Education
( ) 7. Other_____

SUB DISCIPLINES: (Mark as many as apply)

( ) A.	Ecology	( ) H.	Molecular
( ) B.	Evolution	( ) I.	Developmental
( ) C.	Physiology	( ) J.	Cellular
( ) D.	Anatomy	( ) K.	Genetics
( ) E.	History	( ) L.	Ethology
( ) F.	Philosophy	( ) M.	Neuroscience
( ) G.	Systematics	( ) N.	Other_____

RESOURCE AREAS:

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How did you find out about AMCBT? _____

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PLEASE MAIL **MEMBERSHIP APPLICATION** FORM TO:

Edward S. Kos
Executive Secretary, AMCBT
AMCBT Central Office
Department of Biology
Rockhurst College
1100 Rockhurst Road
Kansas City, MO 64110-2561
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CURRENT DUES ARE **$25.00**
$15.00 for Graduate Students

AMCBT 40th Annual Meeting Registration

September 19-21, 1996

Loras College Dubuque, IA

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Office Phone: (_____)_____ FAX: (_____)_____

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Name (to Appear on Name Tag): _____

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Meeting Registration and Fees (LATE registration at meeting = $65)	Fees
Regular ($55.00)	_____
High School Teacher, College Student, Grad Student ($20.00)	_____
Guest Banquet Fee ($9.50)	_____

Please check the field trips and activities in which you would like to participate on the list below. Indicate 1st and 2nd choice for Friday morning trips. If more than one person will be participating (i.e.spouses, friends), please note in parentheses.

	First Choice	Second Choice
Plankton Diatom Collecting ($3)	_____	
Dubuque Arboretum/Botanical Gardens	_____	
Kaufmann Ave. Hill Prairie ($3)	_____	
Mississippi Backwater Biology ($3)	_____	
Swiss Valley Birdwatching/Hanging Bog	_____	
Dubuque Sights and History	_____	
Galena Sights and Sounds	_____	
Wm. C. Brown Publisher Tour	_____	
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To help us plan for receptions and meals, please estimate your arrival and departure times:

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Mail this form and check by **SEPT. 6** to:

Tom Davis
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Department of Biology
Loras College
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Other useful AMCBT information includes:

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Position Announcements
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The Association of Midwest College Biology Teachers has developed its own list server to facilitate communication between its members. The purpose of the AMCBT mailing list is to provide announcements, information and discussion of a wide variety of topics.

Information mailed to:

amcbt-l@biology.indstate.edu

will be sent to all members of the list.

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