DOCUMENT RESUME

ED 064 098 24 SE 013 707

AUTHOR	Pfeiffer, Carl H.
TITLE	The Monona Grove Four Year Unified Science Program.
INSTITUTION	Monona Grove High School, Monona, Wis.; Wisconsin State Dept. of Education, Madison.
SPONS AGENCY	Office of Education (DHEW), Washington, D.C. Bureau of Research.
BUREAU NO	BR-5-0646
PUB DATE	67
NOTE	56p.
EDRS PRICE	MF-$0.65 HC-$3.29
DESCRIPTORS	Curriculum Development; *Curriculum Guides; Educational Programs; *Fused Curriculum; Instruction; *Integrated Curriculum; Program Descriptions; *Secondary School Science; *Unified Studies Programs

ABSTRACT

The Unified Science Program being implemented at Monona Grove High School, Monona, Wisconsin, is a four-year, concept-centered program based on the premise that all science is concerned with the nature of matter and energy and with matter-energy interactions as a function of time. The consequence of these interactions is change and it is this "process of change" which is the central theme of the program. The rationale, philosophy, development, and implementation of the above program are discussed in this volume. (See SE 012 149, 012 151, 012 152, 012 308, 012 309, and 012 468 for related documents.) (Author/CP)

SCIENCE

UNIFIED SCIENCE CURRICULUM

MONONA GROVE HIGH SCHOOL

MONONA, WISCONSIN 53716

1967

THE MONONA GROVE FOUR YEAR UNIFIED SCIENCE PROGRAM

CARL H. PFEIFFER

Department Chairman
4400 Monona Drive
Monona, Wisconsin 53716

THE UNIFIED SCIENCE PROGRAM AT MONONA GROVE HIGH SCHOOL

ITS RATIONALE, PHILOSOPHY, DEVELOPMENT, AND IMPLEMENTATION

The Unified Science Program being implemented at Monona Grove High School is a four year, concept centered program based on the premise that all science is concerned with the nature of Matter and Energy and with matter-energy interactions as a function of Time. The consequence of these interactions is Change and it is this "Process of Change" which is the central theme of the program.

THE RATIONALE FOR A UNIFIED APPROACH TO SCIENCE EDUCATION

Prior to the close of the 19th Century the process of scientific investigation and the methods of science teaching were closely allied to philosophy. Although the quest for knowledge was being pursued in separate and well established disciplines, the scope of knowlege in any given subject field was not so overwhelming as to prevent investigators and teachers from reflecting upon the interdisciplinary nature of science and its implications for society.

During the period from 1920 to 1940 spectacular advances were achieved in all fields of science. The body of factual knowledge associated with the various disciplines experienced great "vertical" growth. Individual scientists were becoming more interested in extending the frontiers of knowledge within relatively narrow areas of their particular disciplines and less interested in the philosophical aspects of science. The era of specialization had begun! Science teaching during this period reflected these trends. Science curricula were extended to accomodate the influx of new factual knowledge and science teaching became more fact centered and specialized within the confines of the traditional science disciplines.

By mid century, specialization in science had come of age, and with it, numerous problems.

i) The frontiers of science had expanded so rapidly that communication between scientists became a serious problem.

2) Knowledge was being accumulated faster than it could be assimilated within the scientific community.

3) Research activity had become so complex and sophisticated that it became necessary to employ teams of specialists, often representing several different disciplines, to work cooperatively on common problems.

The interesting paradox in this dilemma is that the problems created as a result of individual specialization within the separate disciplines of science forced the disciplines within science to become more interdependent and interrelated. Within the vast spectrum of factual knowledge one finds threads of continuity which tie together areas of common concern and interest. This unity, which permeates all science, provides the frame of reference which makes it possible to interpret new knowledge in terms of broad concepts already established. It is this unity within science that has made cooperative inquiry possible.

The growth and change which has characterized science since 1950 has created similar problems in science education. During the past ten years there has been a major effort to cope with these problems through curriculum reform. For the most part curriculum specialists have concentrated on the development of new programs designed to emphasize contemporary ideas and factual knowledge. With few exceptions these new programs have been strictly subject oriented and highly fact centered. Although these programs have played a major role in updating science content in secondary school programs they have failed to interpret science in terms of the needs of young people.

In critically analyzing the curricular changes which have come about in the past decade one must return to the philosophy of science education. What is the purpose of science education at the secondary school level? Whose needs are to be served - those of young people whose desperate need is to understand the very nature of science and its implications for their lives - or the need of science to transmit its cultural and academic heritage?

The answer is both. Both needs must be served. However, innovations in curricula during the past ten years have reflected a greater concern for meeting the needs of science than the needs of young people. Although more factual science is being taught today than at any period of history, young people are learning less about the nature of science.

Science teachers, particularly at the secondary school level, must find ways of helping young people understand science in broad perspective. They must identify and develop concepts which make science functional at the personal level and use contemporary factual knowledge as a means to this end.

In the final analysis the rationale for any unified approach to science teaching is that it offers the greatest potential for realizing the goals of science education within the program of general education.

THE GOALS OF SCIENCE EDUCATION

The Role of Science In General Education

Science represents a significant portion of our academic heritage which must be made available to young people in some meaningful coherent pattern. The ultimate goal in this venture is more intelligent behavior. The things that students learn should be functional in the sense that they help the student to understand himself, his relationship to others, and to the environment in which he must live and work.

The educational program must be designed to enable students to see and appreciate these relationships in broad perspective. It must provide experiences which prepare students to expect and to deal effectively with the wide range of individual and group problems which characterize contemporary life. It must provide experiences which enable students to discover their own special abilities, interests, and opportunities to make worthwhile contributions to society.

In order to accomplish these goals of general education science courses must be presented in such a way that students clearly recognize that science is more than "courses in biology, chemistry, or physics", more than weather maps and dissections, "rotten egg gas", ripple tanks, formulas and equations, more than ESC and BSCS or PSSC, DNA, ATP, and numerous other mnemonic sequences devised to represent names difficult to pronounce and harder to remember.

Science courses should be presented in such a way that students see science, not simply as a course dealing with factual knowledge discovered by scientists, but even more important, as a process by which one may acquire knowledge in his own right.

Science courses should be presented in such a way that students come to realize that traditional subject area disciplines categorize man's knowledge about nature, but not nature itself - that scientific laws and theories do not actually exist in nature but merely represent man's understanding of natural phenomena.

In the final analysis, the science phase of the general educational program must provide the basis for understanding what science is and what it is not, and an appreciation of what science can do and what it cannot do for individuals and for society.

General Objectives of Science Education

In 1959 the science staff at Monona Grove High School identified the following general objectives of science education to serve as guide lines for the evaluation and development of its own program and for the evaluation of science curricula being developed elsewhere.

1. TO STIMULATE CREATIVE AND IMAGINATIVE THOUGHT AND TO PROVIDE OPPORTUNITIES FOR ITS EXPRESSION

   This objective appears so consistently in statements of educational philosophy that non-educators perhaps even teachers, assume that the realization of this objective is more or less guaranteed in every classroom, with every student. The degree to which one succeeds in acccomplishing this objective depends, to a large measure, upon the opportunities students have for direct participation in class sessions. Teachers must develop the art of asking discerning questions and discipline themselves to elicit student response. They must guard against maintaining a superior "mind set", so rigid, that the very basis for dialogue between student and teacher is discouraged.

2. TO DEVELOP AN AWARENESS OF THE PROBLEMS AND RESPONSIBILITIES ENCUMBERED BY SOCIETY AS A RESULT OF MAN'S ACTIVITY WITHIN HIS ENVIRONMENT

   Science courses must not be presented as academic areas isolated from the soical, political, and economic problems of society. The social implications associated with science teaching constitute a major concern for its inclusion in the general educational program of public high schools. It is important that all students, and most especially those who terminate their formal learning experience at the secondary school level, develop an awareness of the need for an involvement of science in many of the most difficult and critical problems that exist in the world today.

Although the majority of our students will not become technically involved with the solutions to such problems, as citizens, they most certainly must be informed to the point where they can deal with them intelligently at the personal level.

3. TO DEVELOP INTEREST IN AND APPRECIATION FOR THE HUMANISTIC ASPECT OF SCIENCE.

The ability of students to appreciate and interpret science at the personal level is markedly affected by the knowledge and interest gained through extensive reading of science literature. It was Thomas Carlyle who said "reading maketh the man". Browsing and reading for personal interest constitutes a dimension of learning which cannot be provided in the classroom. The reading habit, if developed, provides the basis for staying close to the ever expanding frontiers of knowledge.

Readings from the history of science and of contemporary work, coupled with personal experience, help the student realize that the process of science is a human enterprise dependent upon the curiosity, intuition, ingenuity, experiment, failure, and perserverance of individuals.

4. TO DEVELOP ATTITUDES AND SKILLS ESSENTIAL IN USING THE "PROCESS OF SCIENCE" AS A MEANS OF GAINING KNOWLEDGE

Science, as a process, involves the technique of using one's existing knowledge creatively to learn something new. As such, it represents a unique and personal pathway to understanding.

The science program must provide opportunities for students to develop investigative skills. Students must learn how to define problems clearly, to distinquish between what is known and what needs to be known. They need to learn how to formulate hypotheses which provide a basis for inquiry. They need experience in making judgements of what is reasonable and unreasonable. Priority must be given to the development of these kinds of attitudes and skills which make the learner resourceful as well as knowledgeable.

The range and scope of the problems which will beset young people as they grow to adulthood may be infinite. We cannot give youngsters the answers to the problems they will face in the future, but we can provide the opportunity for them to learn and develop skills which make it possible for them to continuously relate to their changing world.

5. TO PROVIDE OPPORTUNITIES FOR GROWTH IN THE UNDERSTANDING OF THE MAJOR CONCEPTS IN SCIENCE

In order to develop understanding and subsequently accomplish the goal of "more intelligent behavior" it is necessary to deal with facts. However science teaching must not be regarded as a process of transferring an inventory of factual knowledge to students.

The science curriculum should be "concept centered" not fact centered". It must be organized around and emphasize the broad generalizations within science which provide the basis for understanding contemporary factual knowledge.

This is our "point of view" with reference to the aims and objectives of science education at the secondary school level.

Our purpose is to develop an attitude toward science - an appreciation of what science is, the effects that it has on our way of life, the problems that it has created, and the opportunities that it presents. We seek to provide experiences which will help students identify with the world in which they live in order that the experience of life itself might become more purposeful and personally satisfying.

THE DEVELOPMENT AND IMPLEMENTATION

The Evolvement of the Unified Program

The unified science program now under continuing development at Monona Grove High School evolved as a result of a gradual realization on the part of the science teachers, that a unified approach to curriculum development offered the greatest potential for implementing their philosophy of science education.

The period of evolvement began in 1959 at a time when the science staff was attempting to resolve a number of problems associated with the influx of new subject matter into the curriculum. An analysis of the existing courses of study indicated that there was a significant amount of duplication of subject matter within the various courses. Questions were raised with respect to the need and justification for this duplication and with respect to the lack of communication within the department in planning for a meaningful, sequential, development of ideas. Further investigation revealed that in most instances the duplication was not relevant to the total program. Teachers were working independently and without concern for the interrelationship of ideas that obviously existed. Teachers within the various disciplines assumed responsibility for developing "anew" the skills and concepts related to the factual content of their courses.

Although each of the separate courses within the science curriculum were organized in a most logical way, the structure and continuity of the science program was most illogical from the standpoint of students moving from one course into another. It became painfully apparent that our entire science program was inefficiently organized and becoming more concerned with the teaching of contemporary factual knowledge than with the task of interpreting science in terms of the needs of young people. Our curriculum development and program implementation had evolved to the point where one had difficulty justifying it in terms of the goals set down in our philosophy of science education.

It was at this time that the possibility of a unified approach to science education was first considered. The idea was eventually rejected as being impractical in terms of the numerous problems anticipated in the development and implementation of such a program.

The problems of developing a satisfactory science program persisted. Three years of experience with the BSCS program provided convincing evidence that the entire curriculum needed to reflect the interdisciplinary nature of science.

In 1961 a survey of existing unified science programs was made and again the advantages and problems of this approach were discussed. Although no action was taken there was a growing awareness that a unified approach to curriculum development merited serious consideration.

In the fall of 1962, after three years of backing away, the staff decided to move in the direction of a unified program. It was apparent from the outset that a wide variety of programs, each with unique advantages, was possible. For this reason considerable time was spent in preliminary planning in an effort to structure a program consistent with our goals and objectives in science education. Six criteria were eventually established to provide guidelines for the development and implementation of a unified program.

1) The program was to be concept centered - organized around fundamental ideas significant in all discipline of science.

2) The unified program would not be introduced on a trial basis with a select group of students. All traditional courses would be phased out of the curriculum and all students would become involved in the unified program.

3) Beginning at the freshmen level, the unified program would be developed and phased into the existing curriculum sequentially over a four year period.

4) The first three years of the program would have a bi-level structure in order to provide a basis for working with students at different interest and ability levels.

5) Curriculum materials for student use would have to be prepared by the staff working cooperatively. For this reason it would be necessary that the entire staff commit itself to the project for a minimum of four years, including summer sessions.

6) The entire program would be team developed and team taught with the various members of the staff assuming leadership in their particular areas of specialization.

During the academic year 1962-63 the staff, first independently and then cooperatively, attempted to identify all the concepts of science considered significant to the development of a course of study for high school students. As one might expect, the list of concepts identified was fantastic. Long and sometimes spirited discussions continued for several months over the question "What is a concept?". Although the staff never did develop a single, all encompassing definition which reflected each teacher's point of view, it was generally agreed that concepts are "ideas possessed by individuals" and that concepts provide the basis for interpreting new experience. It was also established that certain concepts are more basic to the development of general understanding than others.

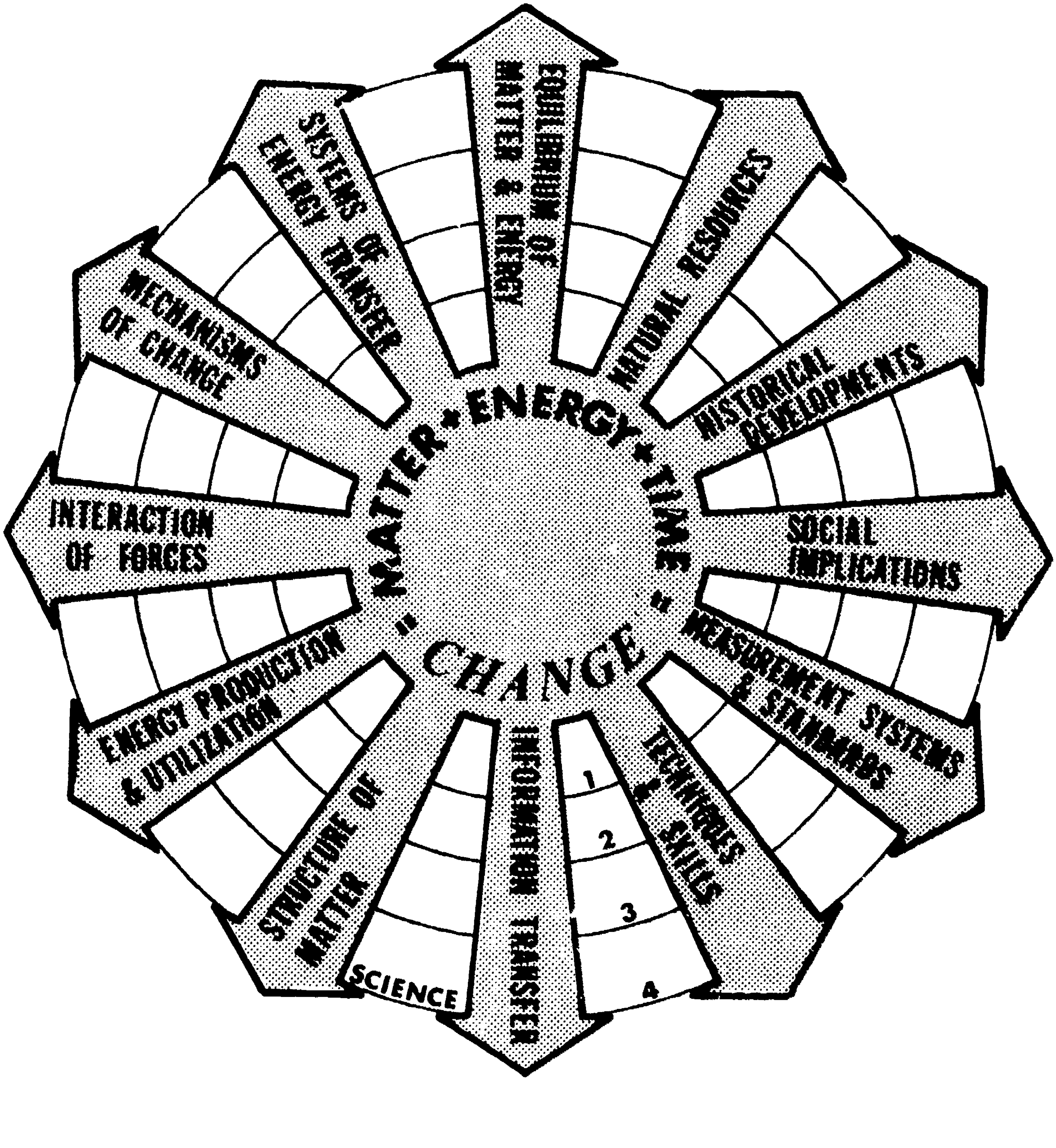
On the basis of this interpretation an effort was made to identify basic concepts which cut across the various discipline of science, concepts considered essential for interpreting experience associated with science, and concepts which would provide guidelines for the development of a unified science program. In retrospect this was probably the most difficult phase of the entire project. By the same token it was probably the most critical, for it was through this process of identifying the basic concepts of science that the staff began to understand their task as teachers of science. It was through this experience that the teachers began to develop the mutual concern and respect needed to function effectively as a team.

During the fall of 1963 the organizational structure for curriculum development was completed. The entire four year program was based on the premise that all science is concerned with the nature of Matter and Energy and with interactions between matter and energy as a function of Time. The consequence of these interactions is Change and it is this "Process of Change" (evolution) which was adopted as the central theme for the entire program.

Twelve unifying themes were selected to amplify this central idea and to serve as guidelines in the development of specific courses within the curriculum.

UNIFYING THEMES

MONONA GROVE UNIFIED SCIENCE PROGRAM



There are many interdisciplinary concepts in science which could be used as unifying themes in curriculum development. Concepts most helpful in structuring a unified curriculum have two characteristics in common. (1) They represent "big ideas" of interest in several scientific disciplines. (2) The ideas themselves are independent of time. "Systems of Energy Transfer" is one example of a concept possessing these characteristics. Although our understanding of a particular energy transport system is likely to change, energy transfers will continue to occur and continue to be of interest to those who seek understanding of natural phenomena.

By the spring of 1964 a preliminary outline for a four year, concept centered program had been completed. This program together with a proposal plan for implementation was approved by the local school administration. Curriculum materials for the first year of the unified program were prepared that summer and introduced at the freshman level during the 1964-65 school year.

The Science II, III, and IV programs were developed and phased into the curriculum, sequentially during the next three years. By the fall of 1967 the cycle was completed and all science students at the school were involved in the unified program.

CHARACTERISTICS OF THE MONONA GROVE PROGRAM

In structuring the unified program it was decided that a minimum of two years would be required in order to develop those concepts of science considered to be significant in terms of the needs of all students. For this reason all students at Monona Grove are required to complete two years of unified science. This requirement must be satisfied by the end of the junior year.

The first three years of the program have a bi-level structure. The "A" and "B" level programs in Science I and II deal with the same basic concepts but differ significantly in the way that these concepts are presented and developed. Generally, the "A" programs are more theoretical and develop ideas to greater depth. Approximately forty percent of the students in Science I are placed in the "B" level program. This percentage remains about the same in Science IIB.

The purpose of the bi-level organization is to provide for gross differences in student ability and interest. These characteristics are not always apparent in students, especially with freshmen. Interests change and errors in accessing ability do occur. Occasionally, and most frequently with freshmen, there is a need to transfer students from one level to another. In order that these transfers might be effected without the loss of continuity the IA and IB programs were organized with a parallel structure in terms of the concepts to be presented.

During the course of the freshman year, student - teacher relationships are established which provide the basis for more effective guidance in the selection of courses. Concern for the problem of students transferring between the "A" and "B" levels was not a major factor in the design of the Science II curriculum. Although the basic concepts developed in Science

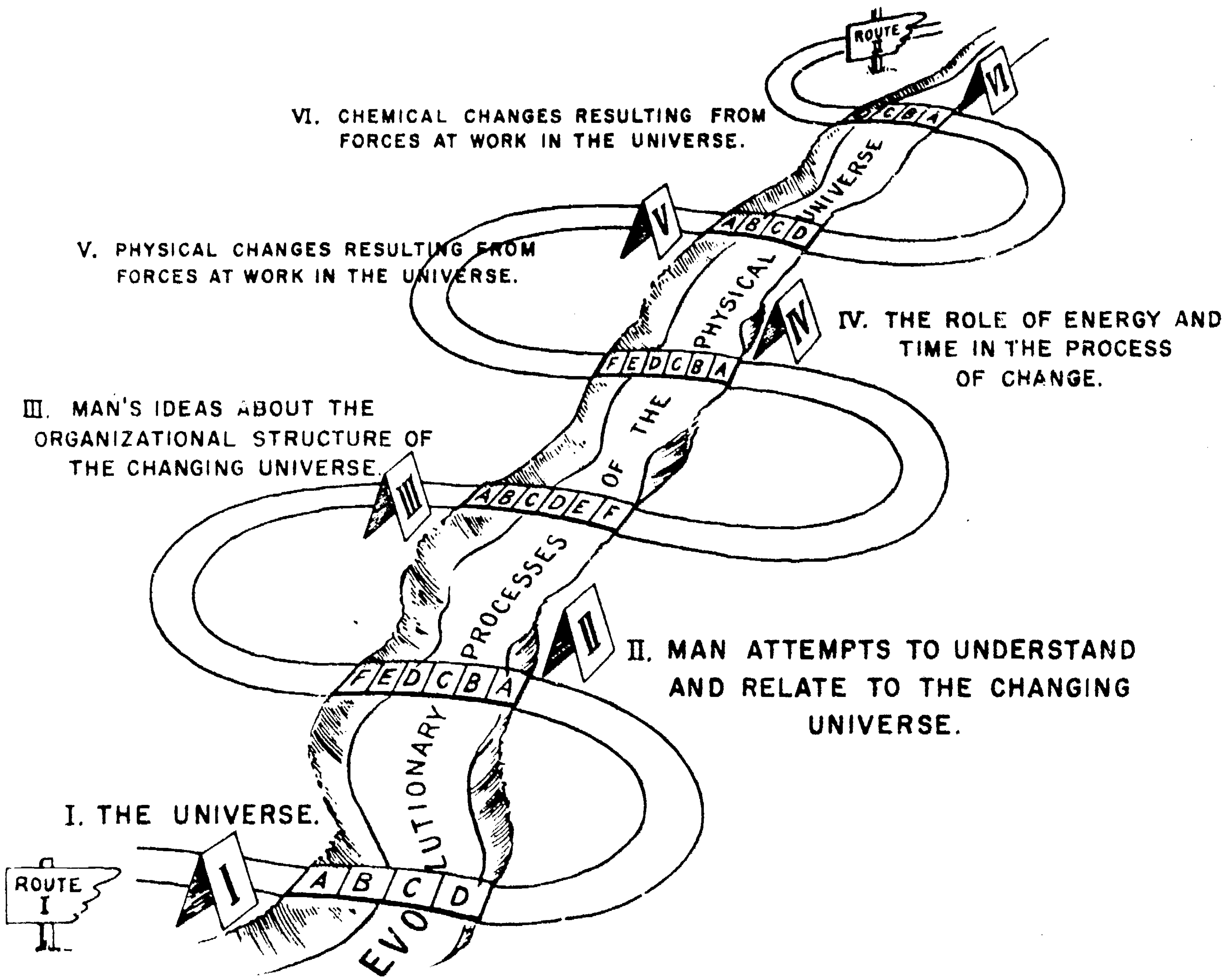
IIA and IIB are about the same, the organization of ideas and the curriculum materials developed for their implementation are very different. Transfers within the Science II program are possible but the transition is not as smooth as it would be in the Science I program.

Science III and IV, the third and fourth year programs, are elective. The "A" and "B" level programs for Science III are very different. The "A" program represents quanitative and theoretical approaches to concept development while the "B" program attempts to develop concepts in terms of contemporary, science related problems. As yet there are no plans for developing a IVB program.

The present structure of the four year unified program at Monona Grove is as follows:

Year and Course Number	Major Theme
Science IA IB	Evolutionary Processes in the Physical Universe
Science IIA IIB	The Origin and Evolution of Life
Science IIIA Science IIIB	Matter-Energy Interactions in Natural Systems The Interaction of Man with His Environment
Science IV	Matter-Energy Interactions Within Living Systems

EVOLUTIONARY PROCESSES IN THE PHYSICAL UNIVERSE



SCIENCE IA

EVOLUTIONARY PROCESSES IN THE PHYSICAL UNIVERSE

I. The Universe (3 weeks)

A. Basic Questions about the Universe

B. The Earth, it's Position in the Universe

C. Man's Early Concepts of the Earth and the Universe

D. Man and Science in the Changing Universe

II. Man Attempts to Understand and Relate to the Changing Universe (4 weeks)

A. Awareness and the Senses

B. The Use of Words to Describe Sensory Experiences

C. Knowledge, Sensory Experience, and the "Process of Science"

D. Sensory Experience and Physical Quantities

E. The Use of the Senses in the Process of Science

F. The Need for Quantitative Description

G. Understanding Through Graphic Representation

III. Man's Ideas About Organizational Structure in the Changing Universe (14 weeks)

A. Hypothesis, Theories, and the Process of Science

B. Properties of Matter and Physical Quantities

C. Classification of Matter

D. Basic Structure of Matter, Cells, Molecules, and Atoms

E. Particle Motion, the Kinetic State of Matter

IV. The Role of Energy and Time in the Process of Change (5 weeks)

A. Energy, the Prime Mover in the Universe

B. Systems and Units for the Detection and Measurement of Energy

C. Force, Work and the Concept of Energy

D. The Equivalence of Energy Units

E. Man's Early Attempts to Utilize and Understand Energy

F. Energy Resources and their Utilization

G. Evolution in the Universe; the Ways in Which it is Accomplished

V. Physical Changes Resulting From Forces at Work in the Universe (4 weeks)

A. Forces in the Universe that Act to Effect Change

B. Interactions Within Structures

C. Physical Changes Resulting from Interactions

D. Interactions With Macrostructures

VI. Chemical Changes Resulting From Forces at Work in the Universe (6 weeks)

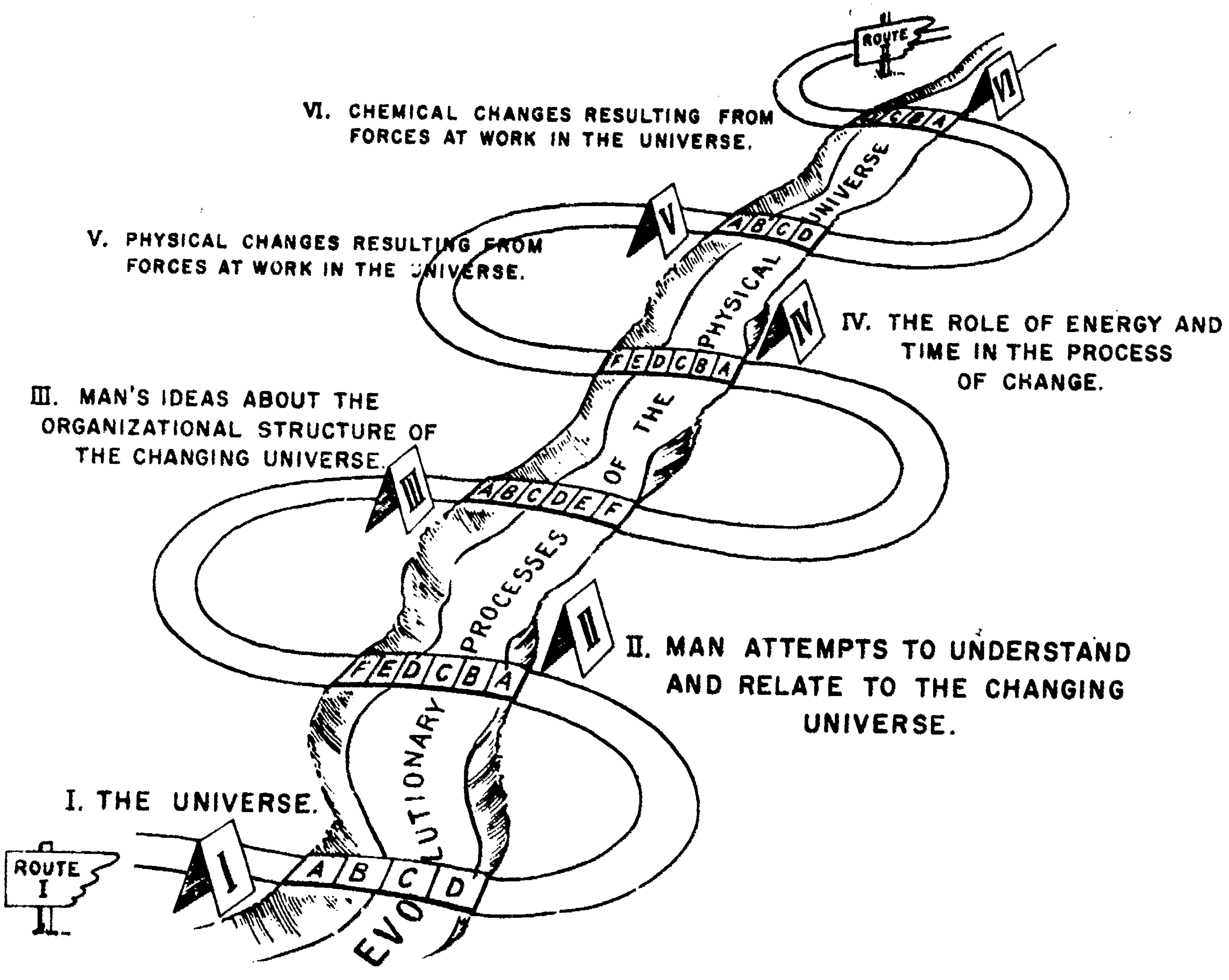
A. The Historical Development of Chemical Change

B. The Nature of Chemical Change

C. The Chemical Equation, an Expression of Chemical Change

D. Oxidation, a Fundamental Chemical Process

EVOLUTIONARY PROCESSES IN THE PHYSICAL UNIVERSE



SCIENCE IB

EVOLUTIONARY PROCESSES IN THE PHYSICAL UNIVERSE

I. The Universe (3 weeks)

   A. Basic Questions about the Universe

   B. The Earth, it's Position in the Universe

   C. Man's Early Concepts of the Earth and the Universe

   D. Man and Science in the Changing Universe

II. Man Attempts to Understand and Relate to the Changing Universe (4 weeks)

   A. Awareness and the Senses

   B. The Use of Words to Describe Sensory Experiences

   C. Knowledge, Sensory Experience, and the "Process of Science"

   D. Sensory Experience and Physical Quantities

   E. The Use of the Senses in the Process of Science

   F. The Need for Quantitative Description

   G. Understanding Through Graphic Representation

III. Man's Ideas about Organizational Structure in the Changing Universe (14 weeks)

   A. Hypothesis, Theories, and the Process of Science

   B. Properties of Matter and Physical Quantities

   C. Classification of Matter

   D. A Closer Look at the Basic Structure of Matter

   E. Particle Motion, the Kinetic State of Matter

IV. The Role of Energy and Time in the Process of Change (5 weeks)

   A. Energy, the Prime Mover in the Universe

   B. Systems and Units for the Detection and Measurement of Energy

C. Man's Early Attempts to Utilize and Understand Energy

D. Energy Resources, Their Utilization

E. Evolution in the Universe, the Ways in Which it is Accomplished

V. Physical Changes Resulting from Forces at Work in the Universe (4 weeks)

A. Forces in the Universe that Act to Effect Change

B. Interactions in Macrostructures

C. Physical Change Resulting from Interactions

D. Examples of Physical Change as a Result of Interactions with Various Energy Forms

VI. Chemical Changes Resulting From Forces at Work in the Universe (6 weeks)

A. The Historical Development of Chemical Change

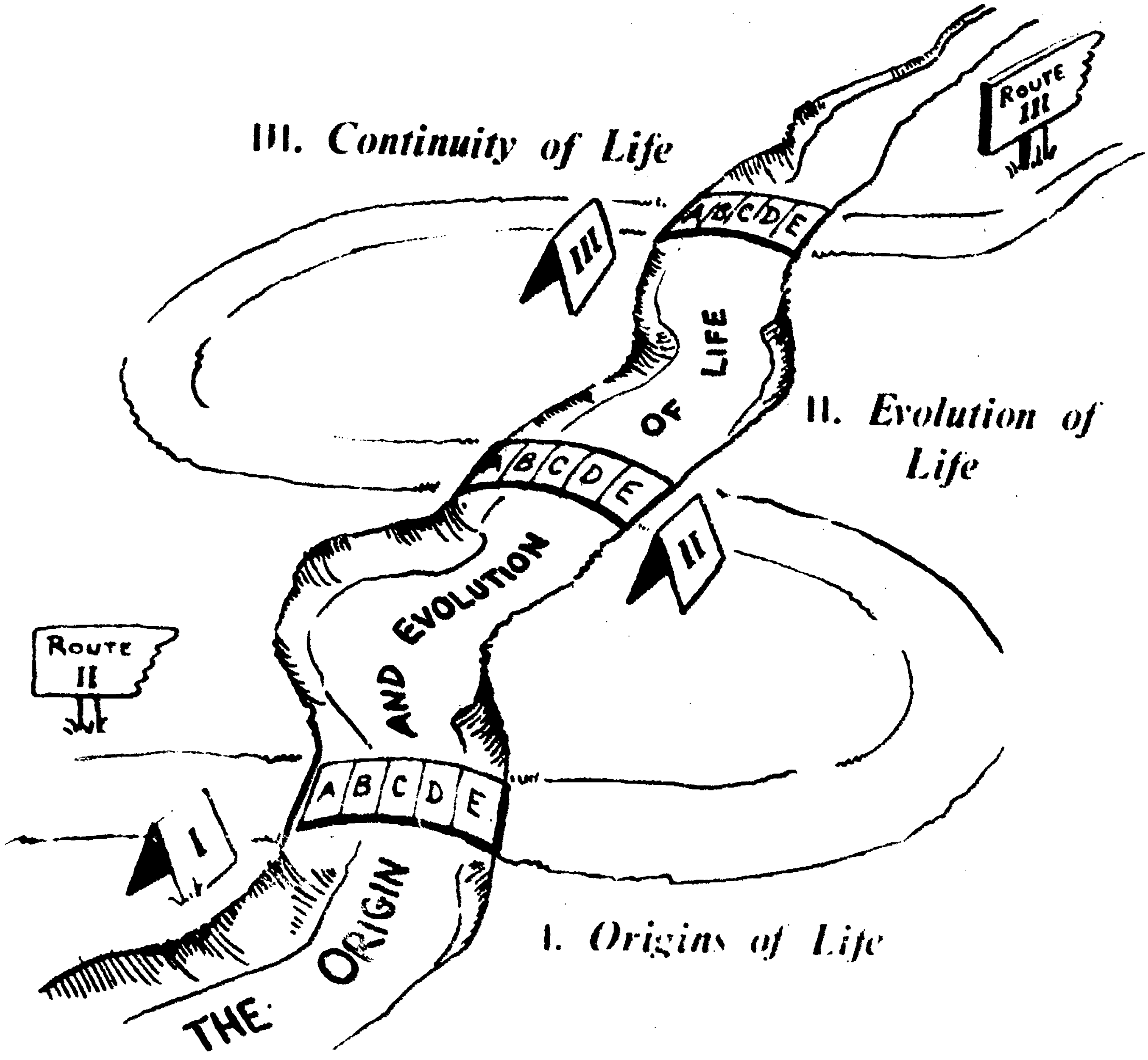
B. The Nature of Chemical Change

C. The Chemical Equation, an Expression of Chemical Change

D. Oxidation, A Fundamental Chemical Process

SCIENCE IIA

THE ORIGIN AND EVOLUTION OF LIFE



SCIENCE IIA

THE ORIGIN AND EVOLUTION OF LIFE

I. Origins of Life (17 weeks)

  A. Historical Aspects of the Origin of Life

    1. The Development of Man's Ideas About the Origin of Life
    2. The Period of Information Accumulation and Classification
    3. The Ideas of Evolution
    4. The Evidences of Evolution

  B. Origins of the Universe and Solar System

    1. Basic Questions About the Universe
    2. Origin of the Solar System
    3. The Nature of the Primitive Earth

  C. Conditions on Earth Before Life Began

    1. The Chemistry of the Primitive Atmosphere
    2. The Chemistry of the Primitive Sea

  D. Evolution of Organic Compounds

    1. Energy, Its Role in the Life Process
    2. Carbon, The Key to Life
    3. The Chemistry of Carbon and Carbon Compounds

  E. Organic Compounds in the Ancient Seas

    1. Accumulation of Complex Polymers
    2. The Formation of Coacervates

II. The Evolution of Life (3 weeks)

  A. Evolution of Coacervate Systems

    1. Coacervate - Environment Interaction
    2. Coacervates and Energy

  B. The Evolution of Simple Dependent Systems

    1. Raw Materials for Energy Release in Anaerobes
    2. Fermentation - The Process of Energy Harvest in Anaerobes

  C. The Evolution of Simple Self-Supporting Systems

    1. The Nature of Photochemical Reactions
    2. The Nature of Photosynthesis
    3. The Evolution of Photosynthesis

D. The Evolution of Aerobic Respiration

1. The Origin of Respiration
2. Process and Mechanism of Respiration

III. The Continuity of Life (16 weeks)

A. Life at the Cellular Level

1. The Cell Theory
2. Mitosis

B. Master Molecules - Blueprints for Life

1. Distribution and Nature of Nucleic Acids
2. Biological Alphabet
3. Building Protein Molecules
4. Changes Within the Biological Code
5. Replication of the Biological Code

C. Multicellularity - Problems of Complexity

1. Transitional Patterns
2. Plants - Structural and Functional Patterns
3. Animals - Structural and Functional Patterns

D. Reproduction, Growth and Development

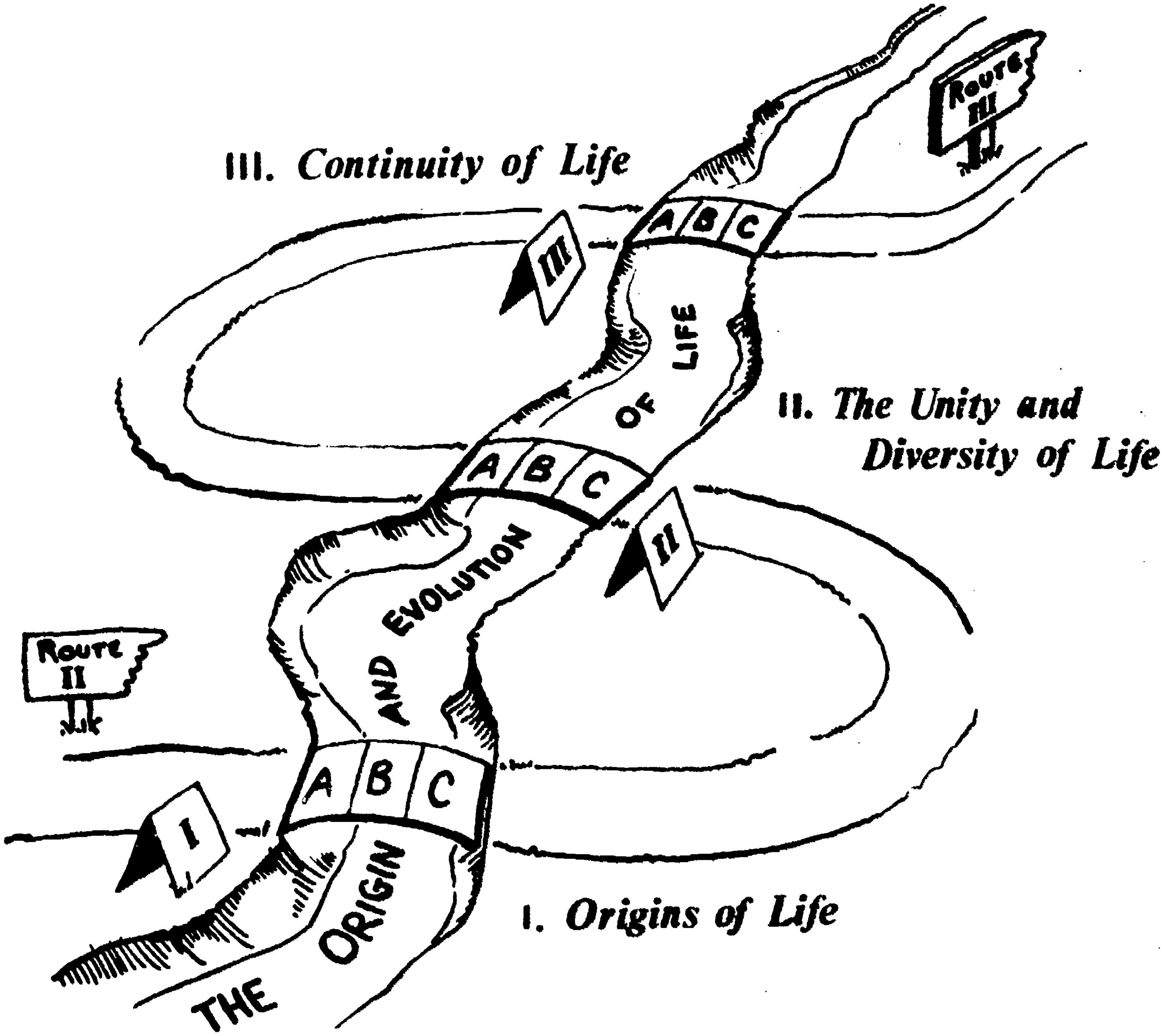
1. Sexual Reproduction
2. Growth and Development
3. Analysis of Development

E. Genetic Continuity

1. Probability
2. Patterns of Heredity
3. The Chromosome Theory

SCIENCE IIB

THE ORIGIN AND EVOLUTION OF LIFE



SCIENCE IIB

THE ORIGIN AND EVOLUTION OF LIFE

I. Origins of Life (9 weeks)
  A. Origin of the Universe and Solar System
    1. The Universe, a Perspective Review
    2. The "Beginnings"
  B. The Evolving Earth
    1. Contemporary Conditions in the Geosphere
    2. Conditions Before the "Dawn" of Life
  C. Man's Ideas About the Origin of Life
    1. The Nature of Living Organisms
    2. Historical Views About the Origins of Life
    3. Contemporary Hypothesis
    4. Evolution of Living Organsims

II. The Unity and Diversity of Life (22 weeks)
  A. The Cell Theory
    1. Historical Development of Cell Theory
    2. Composition and Variety of Cells
    3. Variety and Organization of Cells
    4. Life Functions of Cells
    5. Mechanisms of Cell Function
  B. Reproduction and Development
    1. Asexual vs. Sexual Reproduction
    2. Reproduction in Placental Mammals
    3. Frog Reproduction and Development
  C. Diversity of Life
    1. Classification
    2. Microorganisms

III. Continuity of Life (5 weeks)
  A. Genetic Continuity
    1. Principles of Heredity
    2. The Genetic Material
    3. Genes in Human Populations
    4. Applied Genetics
    5. Probability Laws

SCIENCE IIIA

MATTER - ENERGY INTERACTIONS IN NATURAL SYSTEMS

EXTENSIONS OF THE PARTICLE THEORIES

Interactions in Gases

Mole Concept

Mechanism of Chemical Reactions

ENERGY - TIME RELATIONSHIPS IN MACROSYSTEMS

Analysis of Vector Quantities

Interactions in Static Equilibrium Systems

Interactions in Dynamic Systems

ENERGY - TIME RELATIONSHIPS IN PARTICULATE SYSTEMS

Energy Distribution

Reactions Rates

Equilibrium in Particulate Systems

EXTENSIONS OF ENERGY - FORCE RELATIONSHIPS

Electromagnetic Forces

Electromagnetic Energy

Nuclear Reactions

SCIENCE IIIA

MATTER - ENERGY INTERACTIONS IN NATURAL SYSTEMS

I. Extensions of the Particle Theories

  A. Interactions in Gases (6 weeks)

    1. Particle Motion - A Review
    2. Pressure, Temperature, Volume Relationships
    3. Ideal Gases
    4. Partial Pressures

  B. Mole Concept (5 weeks)

    1. The Development and Implications of the Avogadro Hypothesis
    2. Significance of the Avogadro Hypothesis in Contemporary Science
    3. Ideal Gas Law

  C. Mechanism of Chemical Reactions (8 weeks)

    1. Refinements of Our Atomic Model
    2. Periodicity
    3. Quantitative Descriptions of Reaction Mechanisms in Gases
    4. Quantitative Descriptions of Reaction Mechanisms in Solution
    5. Oxidation - Reduction Reactions

II. Energy - Time Relationships in Macrosystems

  A. Analysis of Vector Quantities (2 weeks)

    1. Characteristics of Vector Quantities
    2. Trigonometric Resolution of Vectors
    3. Graphic Resolution of Vectors

  B. Interactions in Static Equilibrium Systems (4 weeks)

    1. Equilibrium Systems with Forces Acting at One Point
    2. Equilibrium Systems with Forces Acting at More Than One Point

  C. Interactions in Dynamic Systems (3 weeks)

    1. Dynamic Systems in Equilibrium
    2. Dynamic Systems Not in Equilibrium

III. Energy - Time Relationships in Particulate Systems

  A. Energy Distribution (2 weeks)

    1. Energy Changes in Reactions
    2. Activation Energy
    3. Reaction Pathways

B. Reaction Rates (1 week)

1. Factors Influencing Rate of Reaction

2. Law of Mass Action

C. Equilibrium in Particulate Systems (4 weeks)

1. Qualitative Aspects of Equilibrium

2. Quantitative Aspects of Equilibrium

3. Equilibrium in Aqueous Solution

IV. Extensions of Energy - Force Relationships

A. Electromagnetic Forces

1. Electrostatic Forces

2. Magnetic Forces

3. Electro-Magnetic Induction

B. Electromagnetic Energy

1. The Nature of Electromagnetic Radiation

2. Photons - Energy, and Electromagnetic Waves

C. Nuclear Reactions (2 weeks)

1. Fluorescence to Fusion

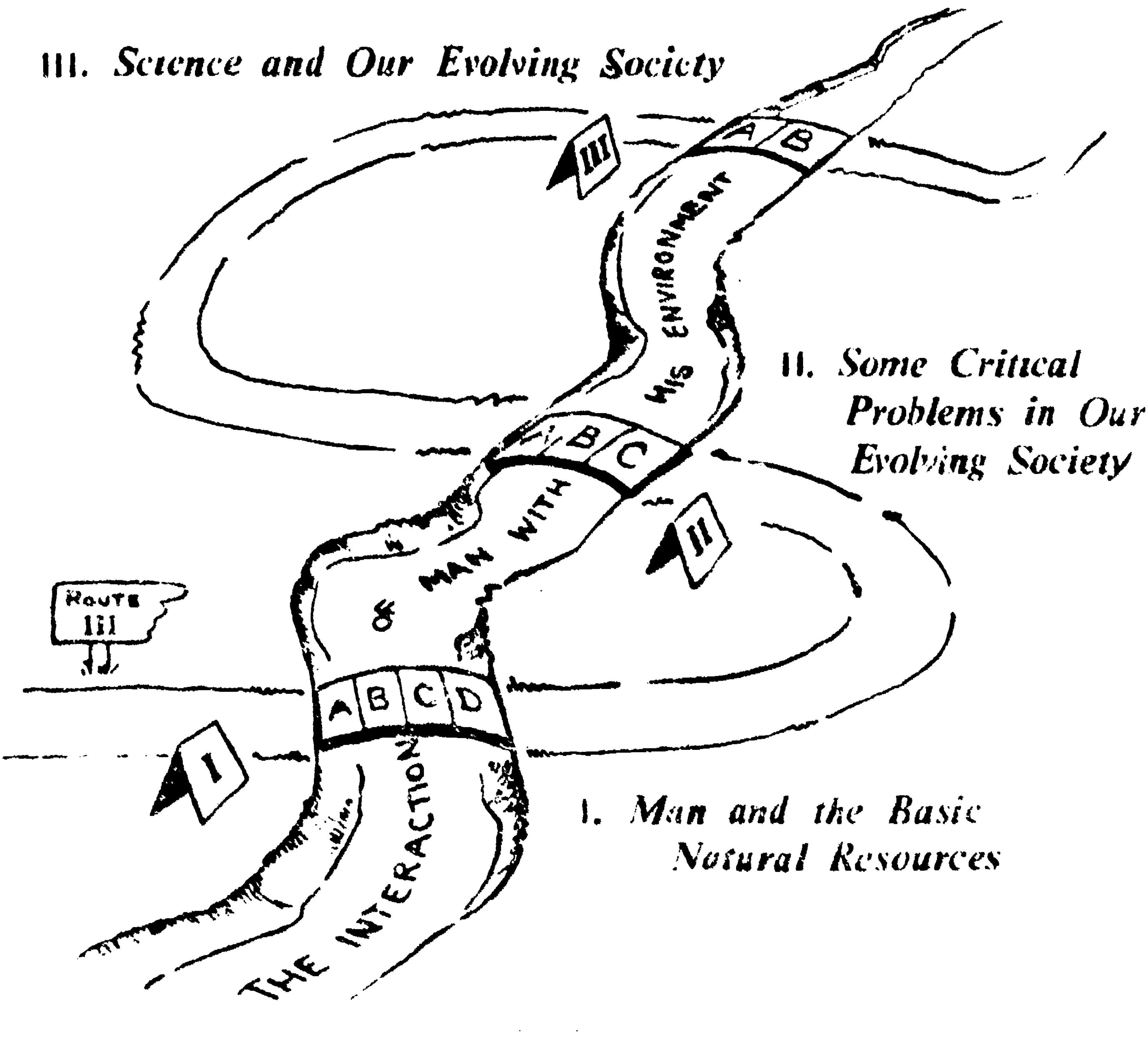
2. Natural Radioactivity

3. Artifical Radioactivity

4. The Uses of Nuclear Energy

SCIENCE IIIB

THE INTERACTION OF MAN WITH HIS ENVIRONMENT



SCIENCE IIIB

THE INTERACTION OF MAN WITH HIS ENVIRONMENT

I. Man and the Basic Natural Resources

A. Minerals (3 weeks)

1. Characteristics of a Resource
2. Distribution
3. Supply and Demand

B. Water (5 weeks)

1. The Importance of the Water Resource
2. The Uniqueness of Water
3. The Distribution of Water
4. Society's Water Requirements
5. Problems of Water Pollution
6. Expansion of the Available Water Supply

C. Air (5 weeks)

1. Problems of Air Pollution
2. The Atmosphere as a Resource

D. Energy (5 weeks)

1. Energy - Forms and Equivalents
2. Contemporary Energy Resources and Utilization
3. Energy Resources of the Future

II. Some Critical Problems in Our Evolving Society

A. Population (5 weeks)

1. Past and Contemporary Demography
2. Problems Inherent in the Contemporary World Community
3. Implications for the Future of Society

B. Food and Soils (5 weeks)

1. Present Food Requirements
2. Existing Problems
3. Possibilities for Increasing Food per Capita

C. Health (5 weeks)

1. Major Health Problems of Contemporary Society
2. Health Implications for Future Generations

III. Science and Our Evolving Society (3 weeks)

A. The Nature of Science

1. Science and Scientists

2. Goals and Limitations

B. Interaction Between Science and Society

1. Moral and Ethical Structure

2. Political and Economic Structure

SCIENCE IV

MATTER - ENERGY INTERACTIONS WITHIN LIVING SYSTEMS

THE CELL

Structural Patterns - Order

Maintenance of Order - Dynamic Equilibrium

Perpetuation of Order

MULTICELLULAR ORGANISMS

Transitional Patterns

Structural Patterns

Maintenance of Order - Dynamic Equilibrium

Regulatory Patterns

Perpetuation of Order

POPULATIONS

Structural Patterns - Order

Maintenance of Order - Dynamic Equilibrium

SCIENCE IV

MATTER - ENERGY INTERACTIONS WITHIN LIVING SYSTEMS

I. The Cell (15 weeks)
   A. Structural Patterns - Order
      1. Cytological Techniques
      2. General Features of Cell Structure
   B. Maintenance of Order - Dynamic Equilibrium
      1. Functional Patterns of Order
      2. Regulatory Patterns
   C. Perpetuation of Order

II. Multicellular Organisms (9 weeks)
   A. Transitional Patterns - Order
      1. Evolutionary Origins of Multicellularity
      2. Advantages of Multicellularity
      3. Borderline Organisms - Some Distinctions
   B. Structural Patterns - Order
      1. Cohesiveness
      2. Differentiation of Cells
      3. Arrangement of Cells - Organ Systems
   C. Maintenance of Order - Dynamic Equilibrium
      1. Functional Patterns
      2. Regulatory Patterns
   D. Perpetuation of Order
      1. Reproduction
      2. Growth and Development

III. Populations (12 weeks)
   A. Structural Patterns - Order
      1. Water Communities
      2. Land Communities
   B. Maintenance of Order - Dynamic Equilibrium
      1. Succession
      2. Climax

The unified science program at Monona Grove is team taught at every level. The key factor in the scheduling of students for team teaching is the large group room facility. At Monona Grove two existing science classrooms were slightly modified to provide areas for meeting students in "large groups". Each of these areas accomodates fifty four students and this represents the maximum number of students that can be scheduled for a particular science course during a given period. The school operates on a seven period day. At the present time two large groups are scheduled for science each period of the day.

One feature of the scheduling plan is the complete flexibility afforded the teacher team in working with these groups. Six staff members comprise the teacher team. They make the decisions as to which team members will be working with the various groups and the type of activity scheduled for each group. Each large group may be divided into two or three sections for laboratory or discussion sessions, or they may meet as a large group. The nature of the activity planned for the development of particular concepts and not the program schedule determines how each class will be grouped. The teacher team projects a grouping schedule on a weekly basis but has the freedom to adjust the schedule daily in light of student response.

An analysis of grouping for instructional purposes during the first year of the totally unified program follows.

		# of Groups	Large Group	Small Group	Laboratory
SCIENCE	IA	3	46%	40%	14%
	IB	2	39%	46%	15%
SCIENCE	IIA	3	45%	24%	31%
	IIB	2	5%	60%	35%
SCIENCE	IIIA	2	54%	34%	12%
	IIIB*	1	73%	0%	27%
SCIENCE	IV**	1	78%	0%	22%

* Twenty students are enrolled in IIIB
** Twenty seven students are enrolled in IV

At the present time laboratory and small group facilities are inadequate to accomodate the program. With the addition of new facilities the percentage of time in laboratory sessions will increase. The team also believes that too much time is spent in large group sessions, especially with Science I students. The addition of a seventh team member in 1968-69, plus additional classroom space, will make it possible to schedule a larger percentage of the time for small group instruction.

Another characteristic of the Unified Program at Monona Grove is the development of a science resource center for student use. It became apparent during the implementation of Science I in 1964, that students in the unified science program needed to have an opportunity to work with a wide range of text materials.

The science resource center is now regarded as an essential part of the unified program for it is through this facility that it becomes possible to individualize instruction. One of the science classrooms has been equipped to serve as a resource center. The facility now includes a modest but selective library of hardbound and paperback books, an extensive file of reprinted articles, and 17 periodicals covering most science disciplines. The center will accomodate twenty students at carrels designed for independent study plus a maximum of twelve at tables arranged for cooperative work.

In 1965 an audio tape system was added. The system is composed of four repeaters, machines with playback capabilities only, and two recorder-repeaters. The four repeaters are connected to remote stations at the study carrels. Each carrel position has its own remote selector switch and start button which permits a student to select one of four tapes and to start the machine.

The repeaters use cartridge tapes which, once started, run to completion, turn off automatically when finished, and are immediately ready for reuse. The two recorder-repeater units are used to prepare tapes and may also be used for individual or group monitoring.

Most of the tapes used in the system are prepared by the science staff although a number of commercially prepared tapes have been accumulated. The philosophy in the preparation of audio tapes is to develop a program which allows the student to participate. The tape itself should be very personal, giving the listener the impression that you are talking directly to him. The context of the tapes should also be personalized, dealing with a wide range of problems that become apparent in working with students in larger groups. The audio system should not be used to substitute for large group instruction. It must be used to provide enrichment and remedial experiences which supplement the activity which goes on in the classrooms.

At the present time an audio-visual facility is being added to the center. This facility will couple an audio tape system with loop films, 35 mm film strips converted to film loops, and 2 x 2 slide sequences.

Students use the resource center during their regularly scheduled study periods. The center is open before and after school, at noon, and every period during the day, provided that at least one member of the team can be present to work with students. The resource center facilities provide a wide range of opportunities for students to pursue individual interests and problems but its most important feature is that it provides an opportunity for students to sit down and talk with members of the teacher team on a one to one basis. This is when individualized instruction begins.

PRELIMINARY ANALYSIS OF THE UNIFIED SCIENCE PROGRAM AT MONONA GROVE HIGH SCHOOL

The continued analysis of an educational program is a difficult but essential aspect of curriculum development. A thorough program of evaluation must be centered around two basic issues:

1. the degree to which the educational experience provided for students enables them to realize the objectives established within the philosophical framework of the curriculum, and
2. the extent to which these objectives are relevant in terms of the maturing needs of young people.

Obviously one cannot evaluate the second of these issues until there is some assurance that the first has been accomplished. The first issue is of immediate concern. This aspect of evaluation cannot be separated from the teaching process. Teachers have a professional responsibility to establish educational goals and to continuously evaluate the effectiveness with which these goals are being realized.

Once an educational program has evolved to the point where there is evidence to indicate that its objectives are being accomplished, the objectives themselves must be evaluated.

The science staff at Monona Grove is still in the process of evaluating the degree to which its education objectives are being realized. During the period from 1959-63 it became increasingly apparent that a traditional subject oriented science program no longer provided the most desirable organization for accomplishing the educational objectives of the science program, that is;

1. To stimulate creative and imaginative thought and to provide opportunities for its expression.
2. To develop an awareness of the problems and responsibilities encumbered by society as a result of man's activity within his environment.
3. To develop interest in and appreciation for the humanistic aspect of science.

4. To develop attitudes and skills essential in using the "Process of Science" as a means of gaining knowledge.
5. To provide opportunities for growth in the understanding of the major concepts in science.

The Unified, Concept Centered, Program was developed in the belief that this approach provided the basis for a more complete realization of these objectives. The purpose of this continuing evaluation is to determine whether there is any evidence to support this point of view.

Three of the educational objectives established (1-3) have to do with student attitudes and abilities which are not directly related to the mastery of the subject matter. At the present time there is virtually no reliable basis for a quantitative evaluation of the extent to which these objectives are being achieved.

The major concern in shifting to a unified program was that this organization would provide more opportunities to focus attention directly upon the attainment of these important objectives.

Both traditional subject oriented science programs and unified programs provide many opportunities for creative and imaginative thought. The realization of this objective depends more upon pedagogical techniques than curriculum organization. The team approach used to develop and implement the unified science program allows teachers to work cooperatively in planning activities that do stimulate creative and imaginative thought.

The social implications of science have always been stressed when justifying the role of science in general education. However, this important educational objective became relatively insignificant in practice, amid the factual content associated with subject oriented curricula. The unified science program is based on the premise that the social implications of science constitute one of the major themes which provide the frame of reference for the selection and ordering of concepts to be included in the program. Although this theme is apparent in the materials developed for use in the unified program, as yet, it has not had the impact on the total program that is needed.

One of the major problems associated with the subject oriented science curriculum was that it failed to provide a logical basis for enabling students to make the transition between the academic and functional nature of science. Science, at the secondary school level, needs to be functional. It becomes functional when it helps individuals interpret and evaluate new experience. The subject oriented program emphasized the academic nature of science, but lacked the continuity needed to clearly establish the big ideas needed to make the process of science a personal experience.

The unified program was designed to make the science experience functional, to personalize the process of science. At the present time there is no objective evidence to indicate that this has happened. However, in the unified program there is a conscious effort to use contemporary factual science to develop fundamental ideas useful in interpreting new experience. The subject oriented program treated the academic nature of science as an end in itself.

In spite of the importance of these humanistic goals in science education there is a tendency to evaluate the success of a program in terms of those objectives which can be measured quantitatively. Educational psychologists have developed a wide variety of objective tests designed to measure academic ability, interest, proficiency, and acheivement. These instruments provide a quantitative basis for evaluating those educational goals which are associated with the academic success of students. Objectives (4) and (5) are concerned with this aspect of science education.

In order to compare the degree to which these objectives were being accomplished in the traditional and unified science programs, the following objective instruments were used:

1. Henman Nelson Test - native intelligence
2. Iowa Test - Quantitative Thinking
3. Iowa Test - Natural Science, subject matter mastery
4. SCAT Test - Quantitative Thinking
5. SCAT Test - Natural Science, subject matter mastery
6. SCAT Total -
7. ACT - college entrance test (science)
8. WISP Test - inventory of understanding processes of science.

The sample representing the traditional science program includes 908 students graduated over the four year period from 1964-67. The unified sample includes 212 students graduated in 1968.

The students from both programs have been divided into four groups based on the number of years of science taken in senior high school.

# of years of science taken	Traditional Program (908)	Unified Program (212)
1	30.7%	25.9%
2	38.4%	35.4%
3	18.3%	23.6%
4	12.6%	15.1%

The students in each group were tested twice. The first test was given in the fall of the freshman year (graduating classes of '64, '65, and '66) or in the spring of the year prior to entering senior high school (graduating classes of '67 and '68). For all students the second testing followed the first by a period of two years.

The ACT and WISP testing was done during the senior year only.

Since the group sample involves c[illegible] differing in native ability and because the testing program was carried out at different times, over an eight year period, all test results have been interpreted in terms of the Henman Nelson test data. Performance on all tests have been presented as a percentage deviation (±) from the Henman Nelson percentile for each test group. All percentiles represented are the arithmetical averages of each test group.

In the graphic presentation of results the traditional and unified groups are represented, respectively, by shaded and clear areas.

In graphs (1) and (2), which present the "Natural Science" and "Quantitative" test data, the first bar in each cluster represents the performance of the group prior to entering the high school science program. The second bar represents the performance of the same group two years later.

Test data from the ACT Science Test provides a limited basis for evaluating the academic acheivement of senior students. Fifty-nine percent of the graduating class of 1968 (unified science) participated in the college board examination. Thirty-five percent of the graduating classes of 1964-67 (traditional science) took these tests.

The data presented graphically shows the average score for each group as a percentage deviation from the average Henman Nelson score for that group.

The WISP test, designed to measure understanding of processes of science, was published in 1967. This test was administered to 188 Monona Grove seniors, class of '68, involved in the unified science program. The performance of these students is shown as a percentage deviation from the average score of 2,994 students, with subject oriented science backgrounds, from other Wisconsin high schools.

All percentile scores used in the analysis of these test data are national norms except for the WISP test data for which Wisconsin norms were used. When national norms are used as the basis for establishing percentile rankings it must be recognized that norms at the upper grade levels do not include the scores of a significant number of individuals who drop out of school before or during high school. This has the effect of shifting the median point for national percentiles upward. Consequently it would not be unusual for a student who scores at a specific percentile as an eighth grader to score at a lower percentile as an eleventh grader.

The statistical data presented in this initial study has many implications for the evaluation of those objectives for science education associated with academic achievement. In virtually every phase of the quantitative study the performance of students with experience in the unified program is clearly superior to that of the students in the traditional subject oriented program. Although the sample of students involved in the unified program is small, especially for the ACT data, the difference appears to be significant.

In conclusion, it appears that there is evidence both subjective and objective, to indicate that the unified science program has merit and represents a more effective means of realizing the educational objectives established for the science program at this high school than was possible through a subject oriented program.

This phase of the program of evaluation must be continued in the years ahead. The problem of determining the relevance of these educational objectives is wholly before us.

COMPARATIVE STUDY OF SCIENCE ENROLLMENTS; TRADITIONAL VS UNIFIED

CLASS OF '64 = 291			CLASS OF '65 = 215			CLASS OF '66 = 193			CLASS OF '67 = 199		
YEARS SCIENCE	#	%	YEARS SCIENCE	#	%	YEARS SCIENCE	#	%	YEARS SCIENCE	#	%
1	82	28.2	1	70	32.6	1	53	27.5	1	74	37.2
2	103	35.4	2	77	35.8	2	87	39.9	2	82	41.2
3	62	21.3	3	39	18.1	3	38	19.6	3	26	13.2
4	* 44	15.1	4	29	13.5	4	25	13.0	4	17	8.4
		100			100			100			100

CLASS OF '68 = 212			CLASS OF '69 = 242			CLASS OF '70 = 241			CLASS OF '71 = 275		
YEARS SCIENCE	#	%	YEARS SCIENCE	#	%	YEARS SCIENCE	#	%	YEARS SCIENCE	#	%
1	55	25.9	1	13	5.3	1	25	10.4	1	250	90.9
2	75	35.4	2	156	64.5	2	216	89.6	0	25	9.1
3	50	23.6	3	73	30.2						
4	32	15.1									
		100			100			100			100

COMBINED (TRADITIONAL SCIENCE) GRADUATING CLASSES '64, '65, '66, '67

YEARS SCIENCE	H.N.	IOWA N. SCI.	IOWA QUANT.		
1	[138] 50	[184] 55	[120] 55		
2	[157] 66	[217] 70	[146] 69		
3	[62] 81	[106] 82	[85] 83		
4	[50] 85	[72] 91	[58] 88		

GRADE 9 (NOV)

YEARS SCIENCE	H.N.	IOWA N. SCI.	IOWA QUANT.		ACT SCIENCE
1	[168] 56	[250] 48	[251] 55		[34] 66
2	[203] 78	[302] 63	[303] 73		[137] 75
3	[97] 81	[160] 74	[163] 83		[81] 82
4	[69] 89	[109] 87	[111] 90		[60] 90

GRADE 11 (NOV)

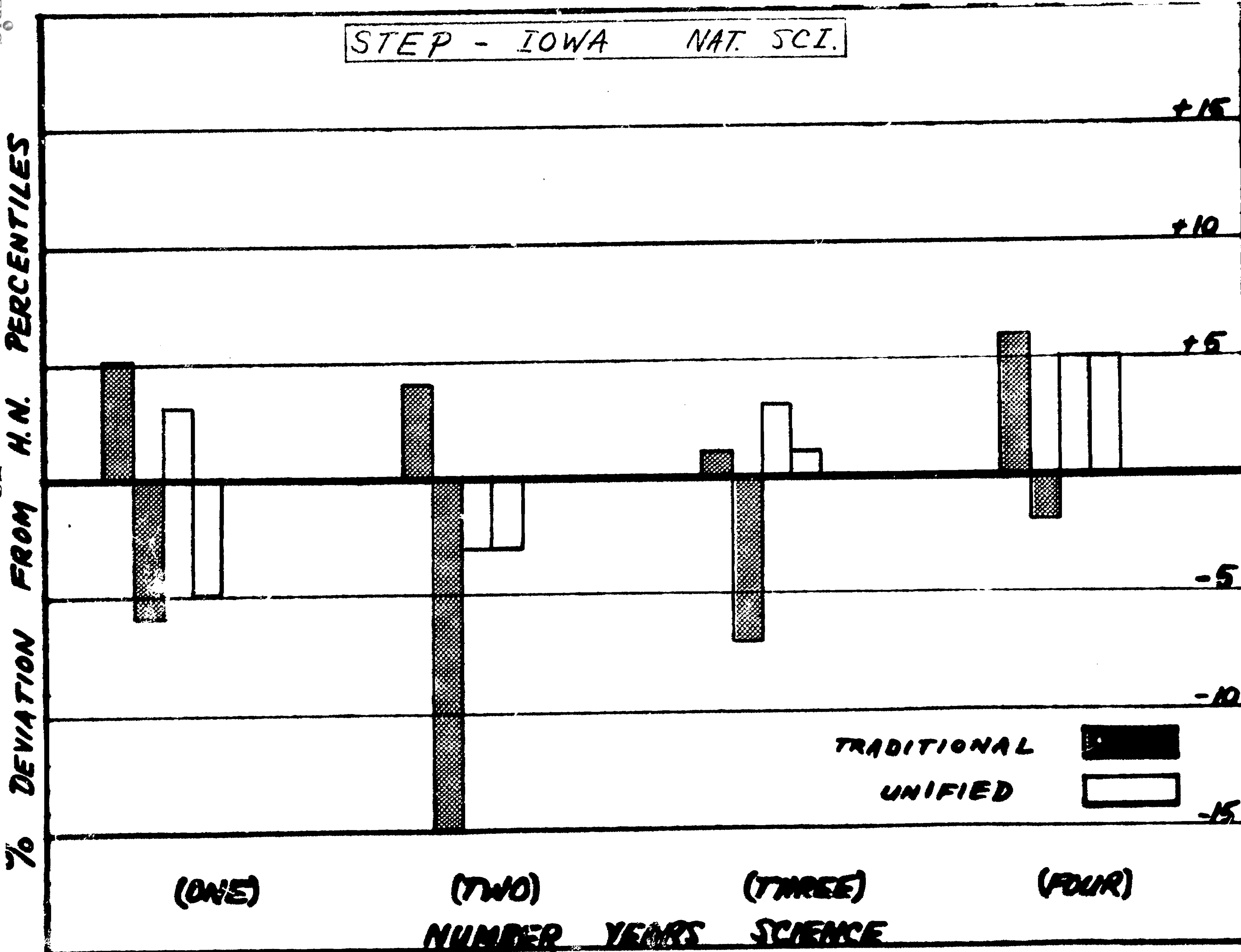
UNIFIED SCIENCE
GRADUATING CLASS 1968

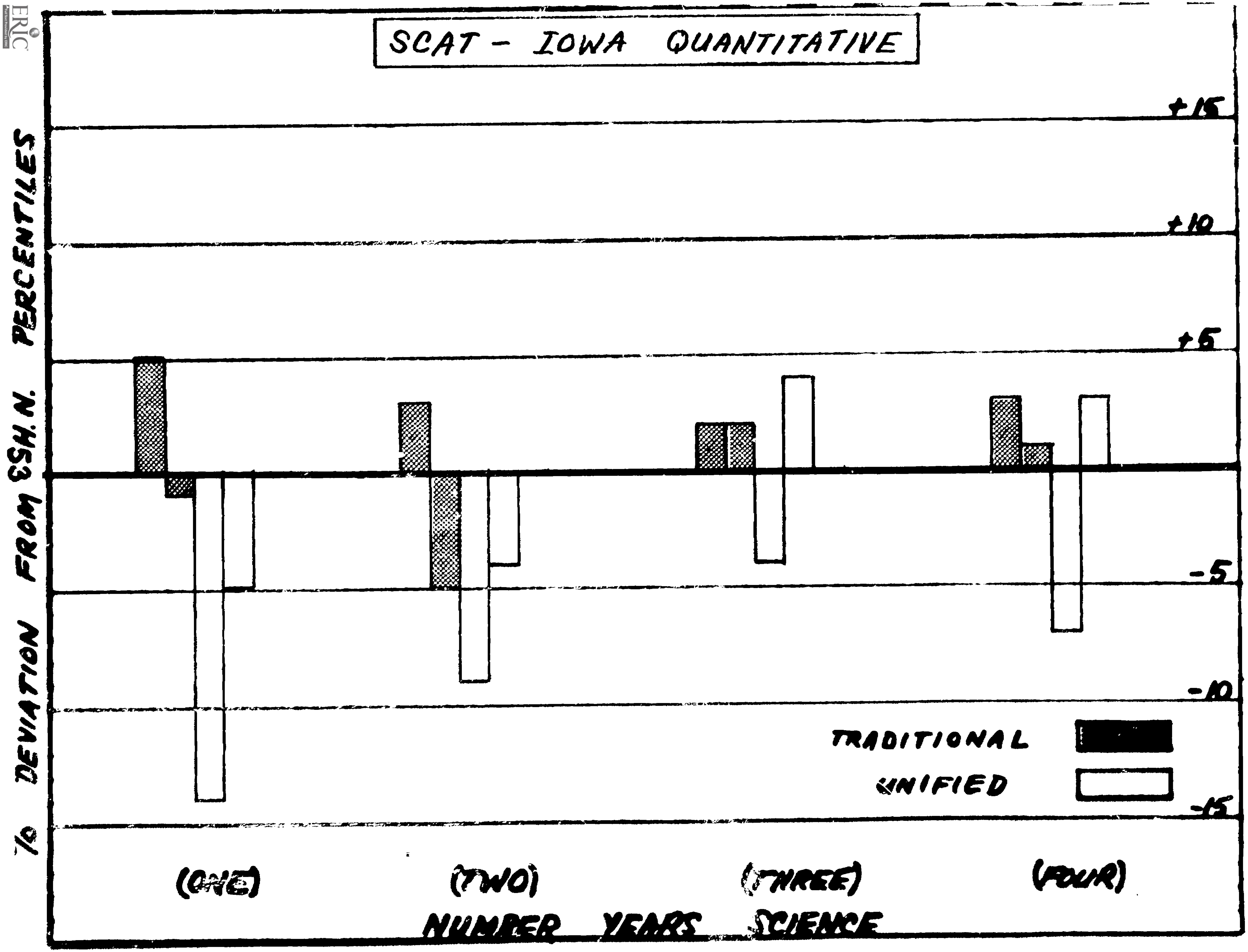
YEARS SCIENCE	H.N.	STEP SCIENCE	SCAT QUANT.	SCAT TOTAL	
1	[37] 56	[40] 59	[41] 42	[40] 45	
2	[59] 81	[65] 78	[65] 72	[65] 74	
3	[42] 77	[43] 80	[43] 73	[43] 76	
4	[24] 86	[24] 91	[24] 79	[24] 80	

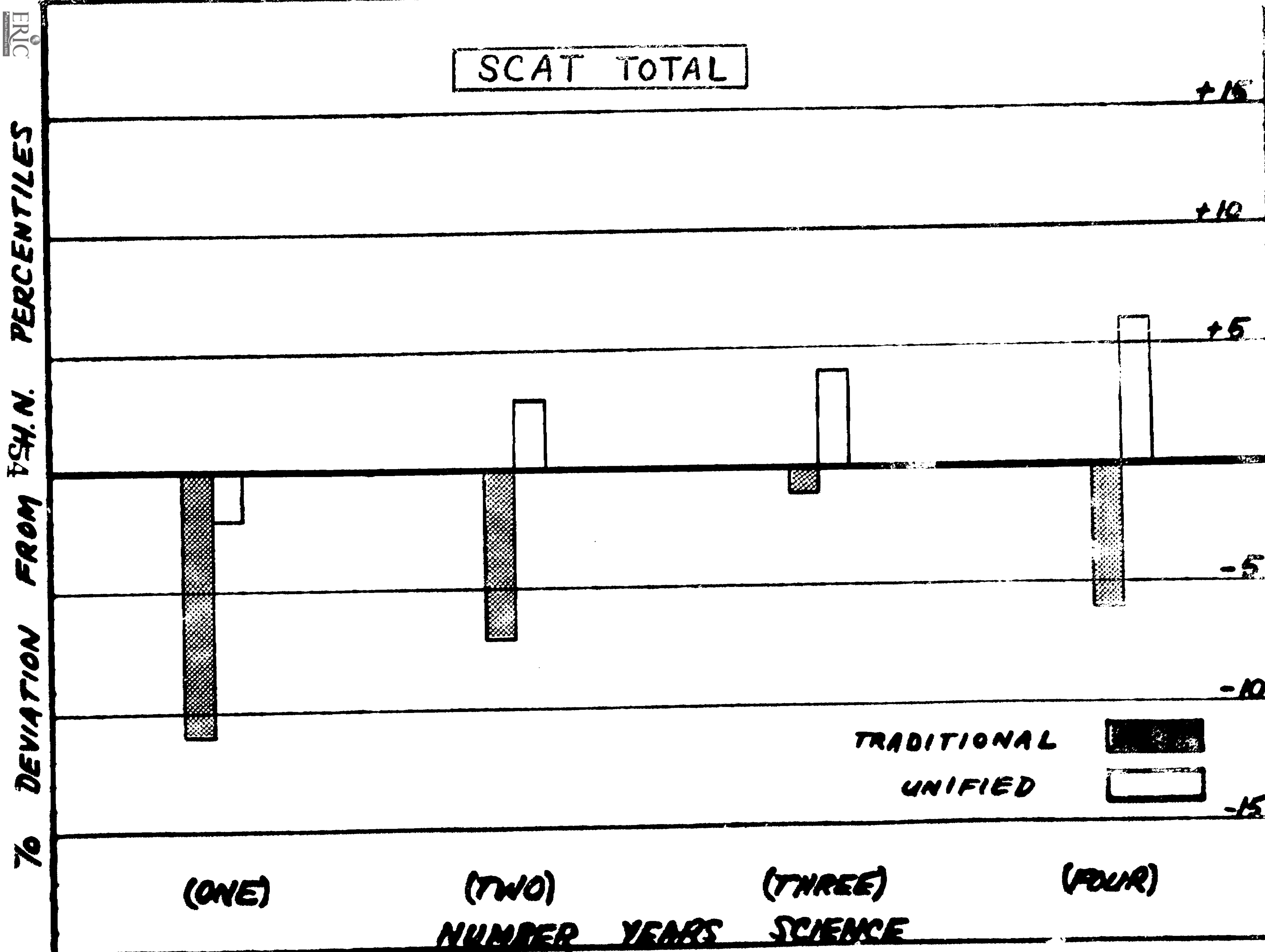
GRADE 8 (MARCH)

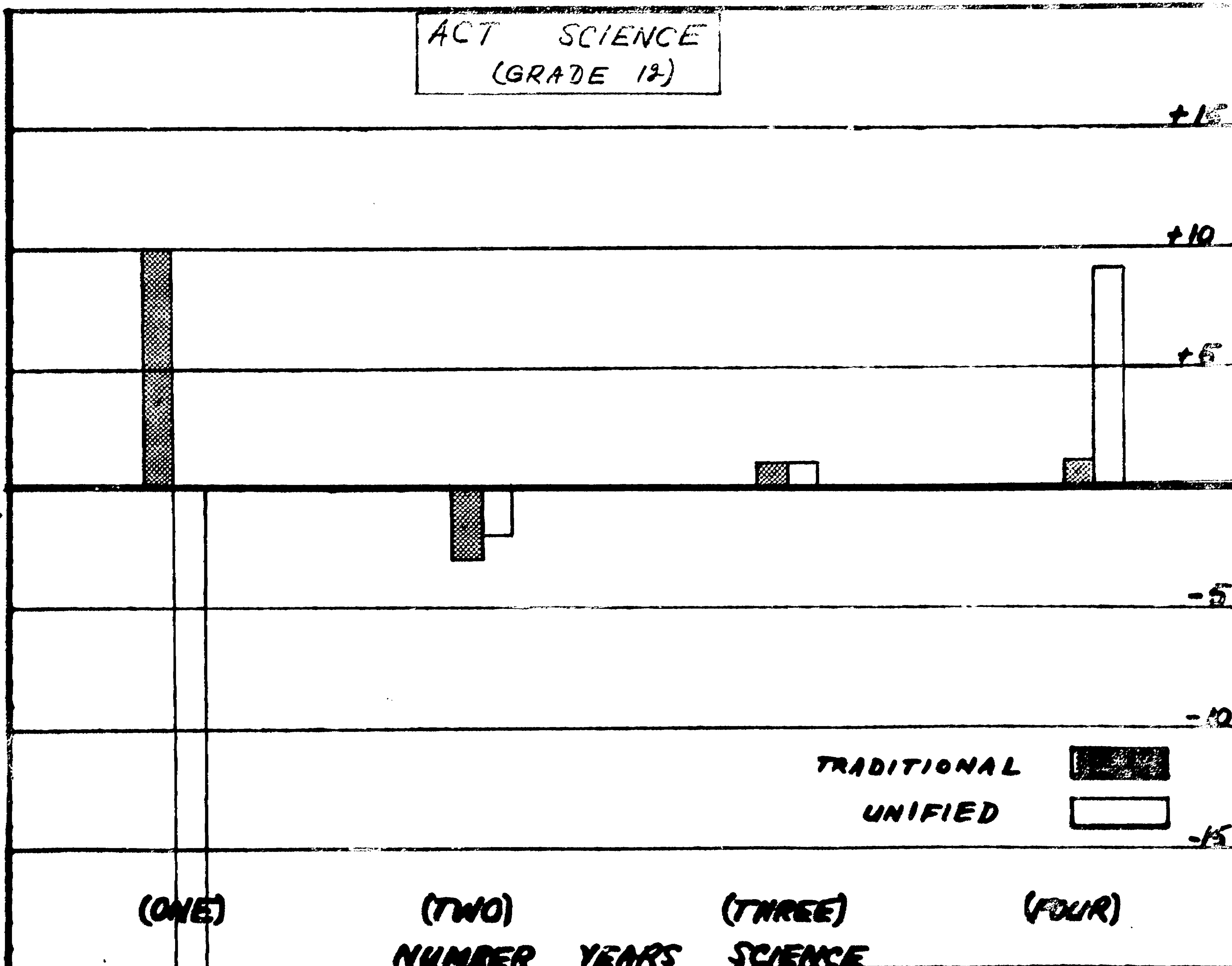
YEARS SCIENCE	H.N.	STEP SCIENCE	SCAT QUANT.	SCAT TOTAL	ACT SCIENCE (12)
1	[49] 60	[47] 55	[48] 55	[48] 58	[12] 39
2	[71] 81	[73] 78	[72] 77	[72] 84	[54] 79
3	[47] 82	[46] 83	[47] 86	[47] 86	[33] 83
4	[30] 86	[30] 91	[29] 89	[29] 93	[25] 95

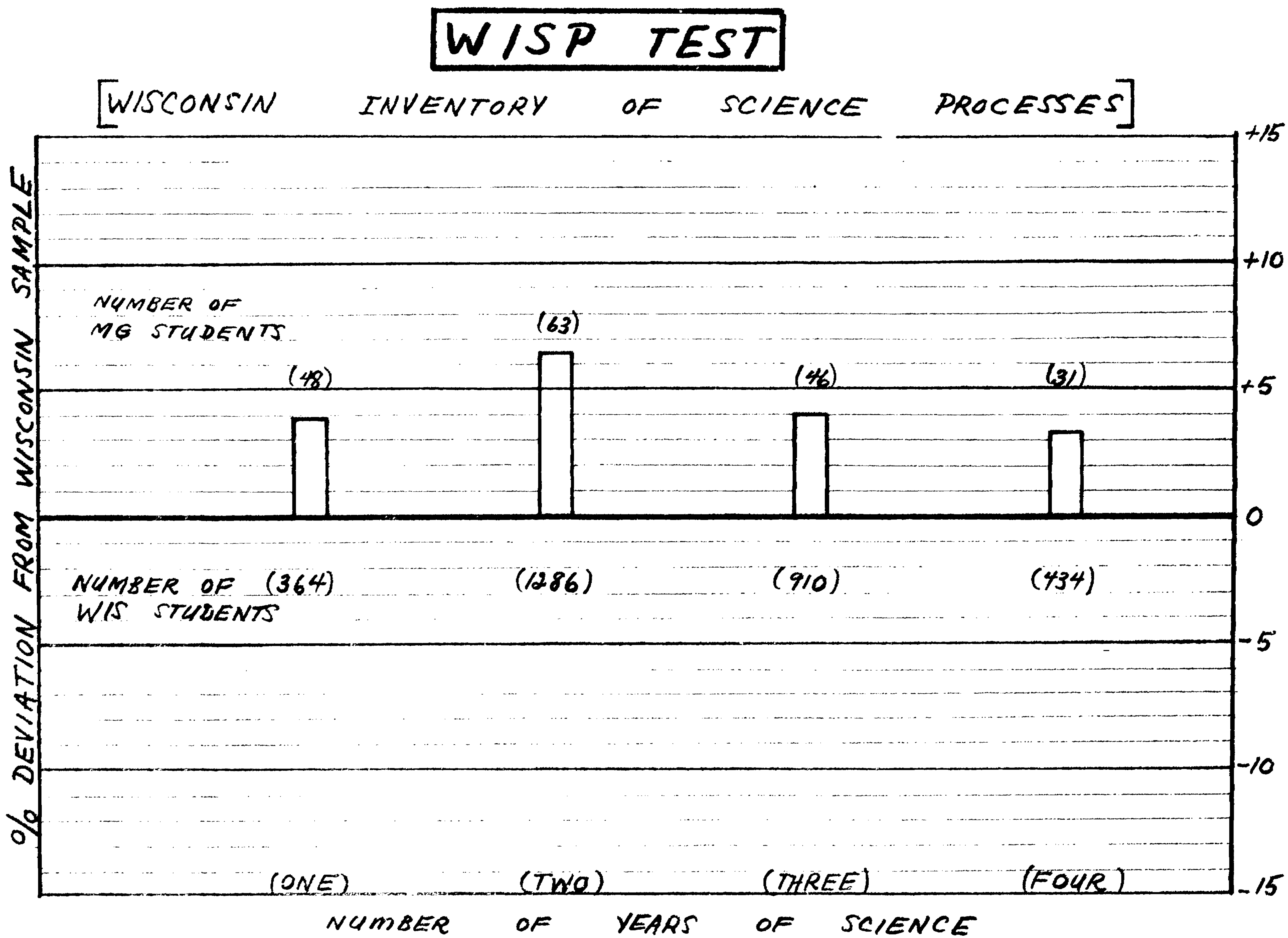
GRADE 10 (MARCH)


STEP - IOWA NAT. SCI.
+15
+10
+5
-5
-10
-15
% DEVIATION FROM H.N. PERCENTILES
TRADITIONAL
UNIFIED
(ONE)
(TWO)
(THREE)
(FOUR)
NUMBER YEARS SCIENCE


SCAT - IOWA QUANTITATIVE
+15
+10
+5
-5
-10
-15
% DEVIATION FROM ESH.N. PERCENTILES
TRADITIONAL
UNIFIED
(ONE)
(TWO)
(THREE)
(FOUR)
NUMBER YEARS SCIENCE


SCAT TOTAL
% DEVIATION FROM H.N. PERCENTILES
+15
+10
+5
-5
-10
-15
TRADITIONAL
UNIFIED
(ONE)
(TWO)
(THREE)
(FOUR)
NUMBER YEARS SCIENCE


ACT SCIENCE
(GRADE 12)
% DEVIATION FROM H.N. PERCENTILES
+15
+10
+5
-5
-10
-15
TRADITIONAL
UNIFIED
(ONE)
(TWO)
(THREE)
(FOUR)
NUMBER YEARS SCIENCE


WISP TEST
[WISCONSIN INVENTORY OF SCIENCE PROCESSES]
% DEVIATION FROM WISCONSIN SAMPLE
NUMBER OF MG STUDENTS
(48)
(63)
(46)
(31)
NUMBER OF W/S STUDENTS
(364)
(1286)
(910)
(434)
(ONE)
(TWO)
(THREE)
(FOUR)
NUMBER OF YEARS OF SCIENCE
+15
+10
+5
0
-5
-10
-15