AN ABSTRACT OF THE THESIS OF

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Title SUBJECT MATTER PRINCIPLES BASIC TO ORGANIZING AND TEACHING FUNDAMENTALS OF PLANT SCIENCE

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The purpose of this study was to develop a minimum number of subject matter principles basic to organizing and teaching fundamentals of plant science. A secondary purpose was that of assuring that any materials developed would reflect consolidation, delimitation, and scientifically accurate content which would encourage teachers of agriculture to consolidate fragmented and compartmentalized subject matter knowledge in agriculture into sound and useable units of instruction in the development of curriculum.

Related literature and resource materials reviewed in connection with this study revealed a successful attempt by agricultural education authorities in California to upgrade and consolidate subject matter in agriculture by showing an outward relationship to the science of biology. A unit in soils and plant nutrition developed at Oregon State University was based on one of the biological principles proposed by the California project. This unit, along with other significant activities carried out in the procedures of this study pointed out the value of the principle approach in consolidating large amounts of subject matter materials into useable outlines of

teaching material based on the principles of a specific subject or group of subjects.

Procedures in this study included a committee of subject matter specialists who assisted the investigator in developing and authenticating principles of plant science.

The body of this study is built around a framework of four principle categories. Each of the four categories is supported by several sub-principles of related agricultural subject matter in plant science. Each sub-principle is, in turn, supported by a series of important facts which are intended to lend clarification to the meaning of the statement of principle. The four categories have been placed in a progressive relationship to each other beginning with fundamentals and progressing through process to product and the ecological effects which influence that product. A functional glossary of definitions of terms which support the outline of principles is appended to the study.

The conclusions of the study are: the procedures used in carrying out the study are valuable for the purposes of consolidating and upgrading content in agricultural subject matter; that a unit in soils and plant nutrition developed as one of ten procedural steps in the study has been proved useable on the high school level; that consolidating fragmented knowledge into whole units of instruction is advantageous in teaching; and that students benefit when subject matter specialists synthesize subject matter into basic, related principles.

SUBJECT MATTER PRINCIPLES BASIC TO ORGANIZING AND TEACHING FUNDAMENTALS OF PLANT SCIENCE

by

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CHAPTER I

INTRODUCTION

Need for the Study

Teachers of agricultural subjects are annually faced with extensive curriculum revision and reorganization each year encompassing a wider variety of subject matter areas. These teachers must, at the same time, evaluate the total program of instruction in agriculture from the standpoint of method, content, and relationship to other areas of student learning.

There is need for a base upon which to build annual curriculum revision in agriculture. This should be a base which lends itself to consolidation and delimitation of the many subject matter areas covered annually by a course of study in agriculture. The need for such a base has been pointed out by administrators, school boards, officials in college schools of education and agriculture, and most importantly by teachers of agriculture. Each of these individuals and groups of professional educators has evidenced concern in a variety of ways and at various times over the past decade. In almost all cases the consensus has been that a basic approach to the problem is necessary.

Statement of the Problem

Specialization and compartmentalization have fragmented knowledge in agriculture. Teachers of agriculture need guiding statements, principles of agricultural subject matter, with which to unify and delimit the material they teach.

Because nearly all agricultural science, especially the plant and animal sciences, is based on biology in one form or another, this area becomes a common core from which to develop certain principles in agricultural subject matter areas. The problem inherent in this study is how best to correlate and consolidate a specific area of agricultural subject matter within a biologically related framework and to develop a minimum number of statements of principle which reflect consolidation, correlation, and scientifically accurate subject matter information.

Purpose of the Study

The purpose of this study is to develop, within certain stated limitations, a minimum number of subject matter principles in the agricultural area of plant science. These principles are intended for the use of the teacher to enable him to consolidate his own teaching material and to unify his courses in general terms with those of other teachers. The principles should allow the teacher to apply many aspects of the closely related science of biology directly to the teaching of many facets of plant science. The latter, while not a specific purpose, may be a complementary result of the process and could result in a gradual upgrading of content in general.

Hypotheses

The following hypotheses are proposed by the investigator:

1. That fragmented knowledge in agriculture can be consolidated into guiding statements called principles and that from a given outline of subject matter principles can be developed specific units of instruction for one or more aspects of the area of plant science.

2. That university level specialists in the area of plant science can develop sound and scientifically accurate statements of principle which will be accepted by teachers of agriculture for purposes of consolidation, correlation, delimitation of scope of materials, and teaching of content in plant science.

3. That teachers of agriculture can and will organize and teach specific aspects of a given area of agricultural science based on the principle approach.

4. That material developed as a result of this study can be taught beginning at the ninth grade level of difficulty.

5. That subject matter specialists in the area of plant science at the university level will work together and assist the investigator in developing the important subject matter principles in their fields of agricultural science.

Assumption

The following assumption is made by the investigator:

That the job of the teacher of agricultural subject matter is to deal primarily in general terms and to demonstrate application whenever and wherever possible.

Definition of Terms

The following definitions are stated for clarification of terms particular to this study:

1. Agricultural subject matter: The basic materials taught in agriculture in the areas of the plant sciences, animal sciences, farm management and economics, and farm mechanics.

2. Principle: A fundamental truth; a law of conduct which has general applications, is usually applicable, and which is a basis for action. Often a generalization based on proven facts and supported by repeated observance of applicability (1, p. viii).

3. Plant science: A broad curriculum area including such subjects as soil science, crop science, plant breeding, horticulture, floriculture, plant pathology, fruit and nut culture, and vegetable culture.

4. Subject matter specialists: Professors, associate professors, assistant professors, and instructors who teach or do research in the various areas of plant science, noted above, at Oregon State University.

5. Biologically related: Of or having a relationship to the broad science of biology.

6. Teacher trainer: A professor of agricultural education at Oregon State University who has responsibility for the training of

prospective teachers of agriculture.

7. Supervising teacher: A fulltime teacher of agriculture in an Oregon high school who supervises an intern or student teacher assigned to his department for training.

8. Intern teacher: A student majoring in agricultural education who has earned a Bachelor of Science degree in agriculture before being placed in an approved teacher training center in one of several high school agriculture departments in Oregon. The intern works on a half-time basis for no less than six months and up to one full year for which he receives a partial salary.

9. Student teacher: A senior college student majoring in agricultural education who is placed in an approved teacher training center similar to that for the intern teacher for a period of no less than 18 weeks of training.

Limitations of the Study

This study will be limited by the following factors:

1. Only one biologically related agricultural subject matter area, plant science, will be considered.

2. The level of difficulty of the resultant material developed through the procedures involved in the study is set at the ninth grade level.

3. The applicability of the material developed from this study will not be tested as a part of this study.

4. The procedure involving the committee of subject matter

specialists is a form of action research from which little if any statistically significant data can or will be developed. All results will be general in nature as a result of this limitation.

CHAPTER II

SURVEY OF THE RELATED LITERATURE AND RESOURCE MATERIALS

Introduction

An extremely limited amount of secondary data relating to the subject of this study is available. Such publications as are available are primarily of a general and descriptive nature and are results of studies and experiments conducted in a manner somewhat similar to that employed in this study.

The investigator has been involved in work and study of the principle approach to organizing and teaching fundamentals of the agricultural sciences for more than two and one-half years as an upper division and graduate student of agricultural education. During that time the investigator has participated in writing an experimental unit on soils and plant nutrition based upon the principle approach, attended and conducted classes on the college level involving this procedure, and participated in several other activities included in the long range program of his department aimed at standardizing the principle approach for organizing and teaching agricultural subject matter.

The unpublished plant nutrition materials noted above, along with four other published works, comprise the literature related closely enough to this study to be considered functional and worthy of reference and subsequent use as background material. The following survey of this literature is presented in sections, each dealing with a particular aspect of the background of this study.

The California Study

In 1959 the California State Department of Education, with Dr. Sidney S. Sutherland of the University of California at Davis as project director, undertook the development of an experimental unit of material aimed at improving the teaching and content of agriculture in California high schools. The study, according to a progress report presented in April, 1962, "has been designed to explore the feasibility of integrating instruction in biological principles with instruction in vocational agriculture in the eleventh and twelfth grades of the senior high school" (2, p. 1). Two primary purposes for undertaking the project were noted, the first "... was the apparent realization that the time had come when the instruction in high school vocational agriculture should become more science-oriented in order to meet present day needs" (2, p. 1). The second purpose, and probably the one which originally started the project states that

> There is quite a rigid pattern of high school subjects prescribed for admission to the University of California, and pupils who take vocational agriculture in high school had in the past experienced difficulty in completing these required subjects. The experimental admissions program which was in effect for several years, in which agriculture as a subject could be substituted for foreign language as an entrance requirement proved something less than satisfactory and it was thought that this course, integrating biology with agriculture might be accepted as meeting the laboratory science requirement for admission to the University (4, p. 1).

The project first involved defining the specific principles of biology upon which agriculture is based. The result of this step was a set of 22 "biological principles basic to agriculture" (1, p. 1). The format of the work based on these principles, each considered separately, provides definitions of terms, a section on suggested problems, suggested demonstrations and experiments, and a statement of application to agriculture for each portion of this breakdown. A working draft published in 1962 is intended for the use of the teacher, not the student, and serves as a guide for teaching from the principle approach. An early form of the work was taught experimentally in seven high schools in California, then reviewed, edited and reorganized into the latest working draft. The latest draft is now being used by instructors in 12 high schools in the state and is available to others who will attend a three-day short course dealing with the procedures involved in using such material in teaching agriculture.

This experiment is still underway. Each year a meeting of those who have used the material will be held to evaluate the content and procedure and to revise as necessary. Because this is a continuing process, no definite final results or conclusions are available. It could be observed that the project is achieving a good degree of success as far as fulfilling the intended purposes, but more important, a realization has been brought about of a need for correlating and consolidating the basic scientific aspects of agriculture and biology.

While the field of high school agriculture was the primary area of concern of the California study, much emphasis was placed on biology and the relationship of this science to agriculture. This was certainly necessary, for one purpose was to prove to state administrative and university educational officials a strong relationship which would justify high school agriculture as acceptable to fulfill college entrance requirements in science. In this attempt to point out a strong biological relationship and basis for agriculture, limited attention was given the development of principles of agricultural subject matter, many of which could be based on biology. The result was, as intended, biological principles basic to agriculture. The latter is the basic difference between the California study and the present study of the investigator. While the former deals with a biological base, the latter deals with the agricultural base and shows the biological relationship whenever and wherever possible within limitations of the study.

Experimental Work at Oregon State University

Early in 1961 the investigator, in cooperation with two teacher trainers, nine supervising teachers, and eight student and intern teachers, undertook the development of a unit of agricultural subject matter with the purpose of consolidating many facets of two subjects into a comprehensive unit of teaching material. The subjects chosen were soils and plant nutrition. One of the biological principles from the California study, plant nutrition, was selected as a basic principle upon which to build the unit. Each student and intern teacher, working with his respective supervising teacher and under the guidance of the teacher trainers and the investigator, began work on separate portions of the unit. The job of the investigator was to gather the eight unrelated contributions and review, edit, organize, and consolidate the materials into one basic unit dealing with soils and plant nutrition. As stated in the introduction to the unit, the

> primary purpose of this unit is to provide teachers of agriculture with content. It is hoped that a common core of instruction will develop. This infers that the content may be similar in every local department in the state, but the emphasis and adaptation will vary. Rather than standardizing the teaching, we would standardize the content (5, p. 1).

The first consolidation of material was not made available to other than those who had contributed to the project. Later in the year another graduate student in agricultural education joined the investigator and the teacher trainers in a critical analysis and series of revisions of the unit. Seven subject matter specialists, one from crop science, two from soil science, one from animal science, two from horticulture, and one from plant pathology, reviewed the material and made comments and suggestions. The unit was revised by the project leaders as a result of consideration by the subject matter specialists, then returned to the latter for additional comment and suggestion.

A third revision of the entire unit was made early in 1962. In May of that year a spring conference for supervising teachers was held to consider the principle approach to teaching. At this conference the unit on soils and plant nutrition was reviewed and commented upon by a group of 12 supervising teachers. A few minor revisions were made following this conference and a final revision of the material was distributed to the 12 teachers in June. The unit is now being used by these teachers in high school agriculture programs in various parts of the state. The results of the application of this unit will be the subject of another study which is basically related to the study of this investigator and part of a three year program which will be described under the "Procedures" section of this study.

The Biological Relationship

The need for a strong relationship between biology and the teaching of agricultural subjects was first pointed out in the California study. The need for this relationship is further pointed out by the following quotation:

> Agricultural sciences must increasingly be dependent upon biology. A continuing decline in rural population and the percentage of students enrolled in agricultural courses means that tomorrow's agricultural scientists will originate in high school biology classes. Already the farm manager is becoming more dependent upon biological scientists and technicians... The concept that agriculture is just farming must be changed. Enlightened citizens must view agriculture as an industry in which more than one-third of the U.S. labor force is employed in agricultural, business, chemical, technological and research endeavors (2, p. 25-27).

A soil science laboratory exercise workbook which was used as a reference source in preparing the soils and plant nutrition unit mentioned above is one of very few of its type showing an outward relationship between biology and agricultural subject matter on a practical, teachable basis (3).

While the biological relationship is not the focal point of this study, it does provide a basis from which to begin a serious consideration of principles in an area other than specific biology. That area is, of course, agricultural subject matter. In order to develop principles in agriculture with any degree of accuracy and meaningfulness, a starting point must be available with which to initially delimit the broad scope of subjects involved in the science of agriculture. Biology has been proved to be a feasible and meaningful basis through such work as the California study and other materials, and from this point the procedures which follow found their beginning.

CHAPTER III

PROCEDURE

Review of Background Work

Since the investigator has been involved in one way or another over a period of two and one-half years with the principle approach to organizing agricultural science subject matter, a brief review of the activities and steps involved over that period of time is in order.

The California study discussed in Chapter II was brought to the attention of the investigator during the fall quarter of 1960, for the material in the study related directly to several college courses in which he was enrolled. At that time the head of the Department of Agricultural Education outlined a general plan which was being considered for the development of subject matter content for vocational agriculture curriculum. This plan was to cover a period of several years, and would involve a number of persons including personnel and students in agricultural education, teachers of high school agriculture, college and university officials and subject matter specialists and curriculum specialists in several areas of study. Preliminary results of the California study on biological principles related to agriculture had created considerable interest among many of these groups. Curriculum specialists were especially concerned about a possible fresh approach to curriculum organization which was indicated by the apparent early success of the principle approach in California

The first indication of sincere interest in a program for Oregon similar to that conducted in California came about during the course of a class in agricultural education curriculum in which the investigator and several other upper division and graduate students were enrolled. Six professors of agricultural science were invited to the class to present principles basic to their particular areas of subject matter. The class heard from representatives of the soils, crop science, horticulture, poultry science, animal science, and agricultural economics departments. The most important observation of these meetings was that there was very little agreement among the visiting professors as to exactly what constitutes a principle. Some presented a series of facts, others dealt with generalizations and concepts, while two presented what could be considered true principles.

The purpose of these meetings was to point out to the students the considerable amount of specific material which could be reduced to principle form for purposes of organization of curriculum. The investigator and three other students undertook the development of statements of principle out of subject matter from the facts, laws, generalizations and concepts which had been presented in four cases out of the six.

While these early steps did not in and of themselves provide a great deal of subject matter information, a general understanding of the principle approach and procedure was beginning to develop.

Numerous professors in all areas of agricultural science indicated interest in the basic idea, for when called upon for help and advice, they tended to support the principle approach which was beginning to materialize.

The teaching unit on soils and plant nutrition described in Chapter II was the next major step toward the implementation of a long range program of subject matter development in agricultural science using the principle approach. Since the procedure involved in the development of that unit has been explained in some detail in Chapter II, nothing more will be said here. It is an important aspect of the background work upon which this study is based. Nearly 50 persons from all areas of agriculture were involved in the development of the soils and plant nutrition unit. Each of these people became acquainted with this approach to developing subject matter materials based on a single principle. The advantage of consolidation provided through the principle approach was sufficient to create considerable interest on the part of those involved in the steps which were to follow.

Each revision of the soils and plant nutrition unit added much to the meaningfulness of the content, demonstrations, and ideas contained in the unit. Each of the four revisions could be considered a separate step in the procedures which have resulted in the present study. A major point had been proved: it was possible to develop a teaching unit which contained sufficient content to present a number of previously unrelated materials as basically related subjects within the realm of a single basic principle of agricultural subject matter.

In May 1962 the soils and plant nutrition unit and the California study were the subject of a conference of supervising teachers and members of the curriculum committee of the Oregon Vocational Agriculture Teachers Association. The theme of the conference was "Subject Matter Content for Vocational Agriculture Curriculum." The specific purpose of the 1962 conference was to consider "The Biological Principles Upon Which Agriculture Is Based." Dr. S.S. Sutherland, project leader for the California study, served as conference leader, explaining the procedures which had resulted in the biological principles. Those participating in the conference were divided into four discussion groups to consider the areas of plant science, animal science, farm management and economics, and farm mechanics. The plant nutrition unit was the main subject of consideration by the group dealing with plant science. From this meeting came recommendations which resulted in a final revision of the unit.

This conference was the first of a planned three year series of conferences dealing with the principle approach to curriculum development. In 1963 the conference will consider "The Agricultural Principles Upon Which High School Agriculture Is Based." The results of the study of the investigator will be the subject of consideration for those dealing with plant science. In 1964 the third planning conference will consider "The Curricular Principles Upon Which Community Programs of Agricultural Education Are Based."

The previous steps are considered background work directly related to the subject of this study. The results of this study will comprise but a small segment of a broad program aimed at developing a sound basis for curriculum development in agricultural education.

Committee of Subject Matter Specialists

Much valuable assistance was received from several professors of agricultural science in revising the soils and plant nutrition unit. The results were acceptable to teachers who now have and use the unit, for they recognize the value of organization of the content and the scientific accuracy of the statements. It was decided that persons with the same professional qualifications as those who contributed to the soils and plant nutrition unit would be an excellent source of help and advice in developing the subject matter principles of plant science which are the purpose of this study.

Purpose - The purpose of the committee of subject matter specialists was to assist the investigator in developing statements of principle which reflect consolidation, correlation, delimitation, and organization of agricultural subject matter in the area of plant science. The committee would also rule on the scientific accuracy of the statements of principle and any supporting material included in the results. Finally, the committee was to agree on the form in which the results would be presented.

Selection of committee members - The investigator, together with the head of the Department of Agricultural Education, met with the associate dean of the school of agriculture to discuss the proposed procedure of using a committee of subject matter specialists. The dean cooperated in suggesting professors who were best qualified to lend their professional abilities to the study, and also agreed to serve on the committee. The persons who agreed to represent their specialized fields of agricultural science included:

Wilbur T. Cooney, Associate Dean, School of Agriculture

Dr. J. Ritchie Cowan, Professor and Head of Department, Crop Science

Dr. Murray D. Dawson, Associate Professor, Soil Science

Dr. Ira W. Deep, Assistant Professor, Botany

Dr. William A. Frazier, Professor, Horticulture

Dr. William Furtick, Associate Professor, Agronomy

Organization of committee procedure - It was decided that the committee would work as a whole group rather than as individual members in carrying out its purpose. This facilitated an exchange of ideas among members of the group which was one of the most important factors in arriving at the final results. Prior to the reviews the investigator provided each committee member with a copy of the material which would be reviewed.

Reviews by Subject Matter Specialists

Three primary phases were involved in a progressive procedure toward developing the final results of committee consideration.

Each phase will be dealt with in the following brief descriptions, for this form of action research does not lend itself to statistical reporting. Much of the authenticity and validity of this study is supported by procedure.

Limiting the scope of principles - The initial phase of committee consideration concerned limitation of the scope of principles to the realm of agricultural subject matter. Results of this step included agreement on 18 basic statements of principle for the plant science area of agricultural subject matter.

Authenticating statements of principle - The second phase considered each statement separately in order to judge the form and scientific accuracy of the statement. In the process of authenticating statements of principle, the relationship of one principle to another and their logical order became apparent.

Consensus on form - The third phase of committee consideration involved the development of a general outline which placed the 18 statements of principle into one or more of four principle categories. These principle categories included: I. preliminary considerations and basic material; II. reproduction and genetics; III. growth; and IV. ecology. Within each of these categories could be found one or more of the 18 principles, the actual category depending upon the relationship and continuity of subject matter inherent in the principle. Some principles, now called sub-principles, appeared in more than one category, again depending upon relationship and continuity. A series of important facts were considered more meaningful as support and definitive material for each sub-principle than was a listing of definitions. Applicable definitions are appended to this study while a series of important facts are included within the results as support material for each sub-principle.

Revision - All aspects of the three phases of previously described procedure were considered by the investigator in revising the pertinent materials. Two copies of this revision were sent to each member of the committee for review. The glossary of definitions was completed and reviewed. Each member was asked to return one copy of the material with any comments or desired changes noted. It was understood that if this material was not returned, the subject matter specialist had accepted the revision. No copies of this revision were returned to the investigator.

Summary

The procedures involved in arriving at the results of this study have followed ten definite progressive steps:

1. Introduction to the principle approach through course work in agricultural science and education at Oregon State University.

2. Development of statements of principle in four subject matter areas of agricultural science from numerous unrelated facts, laws, generalizations and concepts as part of the course work in a

class in agricultural curriculum.

3. Organization and development of a core unit in soils and plant nutrition based on the principle approach.

4. Two revisions of the soils and plant nutrition unit based on suggestions and comments of several agricultural science subject matter specialists.

5. Revision of the same unit based on review and consideration by supervising teachers and curriculum committee members of a teachers' organization and distribution of the unit for teacher use.

6. Organization of a committee of subject matter specialists to assist the investigator in developing subject matter principles of plant science.

7. Limiting the scope of the principles basic to plant science, adding a new principle of soils to the study, and consolidating related statements of principle with the help of the above committee.

8. Authentication of the statements of principle by subject matter specialists by attention to scientific accuracy, form, wording and meaning, and consideration of the relationship of one principle or group of principles to another.

9. Arrival at a consensus on form for the results of the study by the committee which included agreement on four primary principle categories in plant science, decision on related sub-principles and relevant important facts which support each principle category, and the placing of important definitions in an appended functional glossary.

10. Final approval by the committee of subject matter specialists on the form and content of the subject matter principles basic to organizing and teaching fundamentals of plant science which comprise the following results of this study.

CHAPTER IV

RESULTS

Subject Matter Principles Basic to Organizing and Teaching Fundamentals of Plant Science

I. Preliminary Considerations and Basic Material

The principles of matter and energy, living versus non-living materials, animal versus plant life, and classification are all basic to the understanding and application of the specific subject matter principles of plant science. While no one of these principles by itself provides a basis for all the others, taken together they form a logical and substantial foundation upon which to build an understanding of specific principles and sub-principles of plant science.

A. MATTER AND ENERGY: All things living and non-living are either matter, energy, or a combination of matter and energy.

1. All matter is electrical in nature.
2. All matter is composed of small units called atoms.
    a. Atoms are composed of protons (positive)
       electrons (negative)
       neutrons (neutral)
    b. The above parts are the major parts of the atom, but each can be further subdivided.
3. Matter is normally found on earth in molecular form.

4. Matter can be transformed into energy (Einstein's Theory $E = MC^2$)

5. Matter can be measured by volume, weight and energy.

6. The radiant energy from the sun is the ultimate source of almost all energy.

7. Energy can be stored in matter.

8. Energy cannot be created or destroyed, but can be transformed into matter and matter into energy in an endless chain.

9. Chemical changes are accompanied by energy changes.

10. Electricity, heat and light are forms of energy.

11. Energy can be measured by its work calorie, B.T.U.

12. Energy is required by all living things by all activities of life.

13. Kinetic energy is the basis of diffusion.

B. LIVING VERSUS NON-LIVING: All living things are composed of protoplasm and carry on the life processes of reproduction, nutrition and response to environment.

Living matter

1. All known elements in protoplasm are found in non-living forms, but the complexity of the formula is unique to protoplasm.

2. Protoplasm is organized into structural and functional units called cells.

3. All living organisms behave as a unit whether they are made up of one or more cells.
4. The more complex an organism is in cellular structure and function, the greater the division of labor.
5. All living organisms come from existing living organisms. (reproduction)
6. Plants are capable of utilizing the energy from the sun through the oxidation of food within the body.
7. All living organisms come into the world with certain inherited capacities for responding to stimuli. (behaviour, irritability, responsiveness)
8. Increasing responsiveness to environment is associated with increasing complexity of the living organism.
9. All organisms must have energy in order to survive.

Non-living matter

1. Numerous non-living systems carry on processes similar to those of living organisms, making the dividing line between them very indistinct. However, living organisms are more complex and are capable of carrying on both constructive and destructive processes while non-living systems may not carry on both processes.

   Example

   Water continually alters its behavior in response to environment.

   a. Freezing causes water to grow through expansion.

b. Pressure can cause water to move.

c. Heat can cause water to change form.

d. Heavy water has ≠ charge added.

2. Organic material pertains to or derives from living organisms. While not classified specifically as living material, it often exhibits characteristics peculiar to living organisms.

C. ANIMAL VERSUS PLANT LIFE: The simpler the cellular structure and function of living organisms, the more difficult it is to distinguish between them as plants or animals.

Distinguishing Characteristics	Most Plants	Most Animals
1. Cell structure	Usually rigid cellulose wall surrounding membrane	No cellulose cell wall
2. Growth	Grow throughout life and usually localized	Grow to a definite size and usually generalized
3. Nutrition	Most can manufacture own with minimum dependency on other life	All dependent on outside sources of food. Ingest food
4. Locomotion	Most are stationary	Most are mobile
5. Response to stimuli	Less irritable and usually all living cells capable of response	More irritable and usually response restricted to specialized cells

D. CLASSIFICATION: The basis of classification of living organisms is the similarity of structure and function.

In general, the greater the similarity of any two organisms the closer the relationship.

1. There are approximately 2,000,000 different kinds of plants and animals in the world and more will be identified as time passes. It can readily be seen that a systematic approach must be used in classifying and categorizing these organisms.
2. All organisms in general are either members of the plant kingdom or of the animal kingdom. The separation is usually made on the basis of the presence or absence of chlorophyll and cellulose.
3. The philosophical basis for taxonomy is evolution. Modern scientific taxonomy seeks to group together organisms that appear to have evolved from a common ancestor.
4. Organisms may also be classified on the basis of utility, for example: meat producing animals, work animals, fiber crops, oil crops, vegetable crops, grain crops, etc. This method of classification is used for convenience and is not necessarily intended to follow any evolutionary grouping.
5. One of the principal advantages of classifying organisms on a scientific basis (rather than on a utilitarian or other artificial basis) is that it provides a series of categories under which one can

arrange all knowledge or organisms.

II. Reproduction and Genetics

Heredity and environment combine to different degrees to make possible life and growth. Heredity is responsible for its portion of these phenomena through reproduction and genetics.

A. REPRODUCTION: Living things, in order to survive, possess the ability to perpetuate their own kind from a part of themselves.

1. The higher forms of life reproduce sexually and are sex differentiated to some degree.
2. In general, the lower forms of life reproduce asexually and are not sex differentiated.
3. In general, reproduction is less complicated, more rapid, and more difficult to control in the lower forms of life.
4. Most higher plants depend upon carriers for pollination such as wind and insects. Many important agricultural plants do not depend on carriers but are self-pollinated; for example, wheat, barley and oats.
5. Many agricultural plants are able to reproduce both sexually and asexually.
6. Higher plants exhibit a definite alternation of generations. In plants of agricultural importance, the sporophyte is the large, conspicuous plant while

the gametophytes are inconspicuous and protected by sporophytic tissue.

B. GENETICS: All organisms resemble and differ from their parents with a degree of variation dependent upon the interaction and/or segregation of genes, environmental factors, and the occurrence of mutations.

1. Much of the physical basis of inheritance is to be found in the study of meiosis, the process by which gametes are formed. The remainder is to be found in a study of fertilization, the process in which unlike gametes unite to form a zygote.

2. There is usually at least one pair of genes responsible for the determination of the expressed variation of a particular trait. One gene of the pair is located on one of the homologous chromosomes and the other gene is located on the other homologue. Each chromosome bears many genes arranged in linear order upon it. The expressed variation of many traits is controlled by more than one pair of genes.

3. Meiosis accomplishes the formation of gametes. The duplication of chromosomes is inherent in this process. This means that genes are also duplicated. By means of the phenomenon of "crossing over" recombination of genes upon a given chromatid occurs.

III. Growth

Growth takes place over extended periods of time only when the rate of synthesis of protoplasm exceeds the rate of protoplasmic degradation. Growth in a broad sense is an increase in size and/or weight due to cell division and/or enlargement together with an increase in complexity of the organism.

A. PHOTOSYNTHESIS: All life on earth, both plant and animal, depends upon photosynthesis, the process by which plants transform radiant energy from the sun to chemical energy in food.

1. The production of sugar by the photosynthetic process takes place in two basic steps.

   a. The splitting of water into hydrogen and oxygen

   $$12H_2O + \text{light} \xrightarrow{\text{chlorophyll}} 24H + 6O_2$$

   b. The reaction of hydrogen with carbon dioxide to form sugar

   $$6CO_2 + 24H \xrightarrow{\text{enzymes}} C_6H_{12}O_6 + H_2O$$

2. The sources of CO_2 used in photosynthesis are the atmosphere and metabolic reactions which release CO_2 as a byproduct. The atmospheric CO_2 enters primarily via the stomates and is the major source of CO_2.

3. The source of the water involved in photosynthesis is the vascular tissue and ultimately the water in the soil or other medium surrounding the roots or the

entire plant (as in the case of aquatic plants).

4. Sugar formed in plants is converted to other carbohydrates, fats and proteins which are used in plant growth or stored.

5. Light is essential not only to the photosynthetic process, but also to the formation of chlorophyll (in higher plants).

B. SOILS: Soil is the only important medium in and upon which agricultural plants grow. It is a dynamic physical and biological system teeming with life and ever changing.

1. Certain physical properties of soils such as texture, structure and bulk density and water and air dynamics are subject to many laws and principles of pure physics.

2. The role of ionic exchange in soils is involved in processes related to the growth and development of plants.

3. Soil organic matter is both a process and a substance in its effect upon the soil's physical, chemical and biochemical properties.

4. The availability of both native and applied plant nutrients must be studied in terms of their chemistry and are influenced by numerous environmental conditions existing in the soil.

5. Soil formation, classification and survey are basic to

an understanding of sound land use.

6. Soil is a scarce resource capable of prolonged and high productivity or hastened exhaustion and impoverishment depending upon how it is managed.

C. PLANT NUTRITION: A plant's ability to attain maximum growth, development, and maintenance is directly related to the availability of all the essential nutrients, provided other environmental factors are favorable.

1. There are 16 presently known essential nutrients, of which 13 are derived from the soil and three from the atmosphere.

2. A nutrient (element) is considered essential if in its absence a plant will die. Those essential micronutrients (elements required in small amounts formerly called trace elements) are as vital to the plant as those macronutrients (elements required in large amounts) since the plant would not survive in their absence.

<u>Macronutrients</u>	<u>Micronutrients</u>
Carbon	Iron
Hydrogen	Zinc
Oxygen	Boron
Phosphorus	Copper
Potassium	Manganese
Nitrogen	Molybdenum
Sulfur	Chlorine
Calcium	
Magnesium	

3. All plants require all essential nutrients, the quantities of which will vary with the species of plant and the stage of its life cycle.

4. Plant nutrients are usually taken up out of the soil only after they have gone into solution.

C. ORGANIC CYCLES: All plant and animal life is dependent upon cycles in which quantities of certain essential food elements are kept in constant circulation (between plants, animals, soil, and air) and are used over and over. Some of the important cycles are carbon, nitrogen, oxygen, phosphorus, and hydrogen.

1. Life is associated with a continuous cycle of constructive and destructive changes that are kept in balance to the extent that life has existed for millions of years with little or perhaps no exhaustion of life sustaining materials.

2. All the elements used by living organisms follow a cycle but the most classic cycles are the nitrogen and carbon cycles.

3. The nitrogen cycle provides an element essential to protein synthesis and, after death, may result in the return of the nitrogen to the atmosphere. The nitrogen may be passed from organism to organism for extended periods of time before it is reduced to N_2 and returned to the atmosphere. Denitrification requires

anaerobic conditions.

a. Nitrogen cannot be used directly by higher plants and animals, but must be combined with other elements, usually O_2 or H. The nitrogen fixing organisms can use N_2 directly.

b. The amount of nitrogen in the soil affects the carbon cycle and vice versa.

4. The carbon cycle provides for carbohydrate formation by furnishing CO_2 for use on photosynthesis, for the subsequent breakdown of carbon containing compounds by micro and macroorganisms and the return of CO_2 to the atmosphere.

E. TRANSPIRATION: The aerial surfaces of all plants tend to lose water in the form of vapor (transpiration). Whenever the uptake of water by the roots is lower than the rate of transpiration, wilting will be initiated and the severity of damage, if any, will be dependent upon the kind of plant, the stage of growth, and the duration of time that the condition exists.

1. Transpiration is the loss of water by evaporation from the plant's surface. Water evaporating from the cell will tend to first fill the air in the intracellular spaces. The movement of this saturated air from the plant will be dependent upon the environmental conditions existing outside of the plant such as

humidity and temperature.

2. A continual shortage of water over an extended period of time can adversely affect the rate of photosynthesis and thus by a reduction in carbohydrate production, affect the metabolism of a plant.

3. The plant's structure such as exposed leaf area, the number of stomata present and location, the structure of the cuticle can affect the rate of transpiration passively. This is illustrated by contrasting corn which utilized 400 pounds of water in several weeks and a sunflower which utilized 150 pounds in its entire life of 140 days.

4. Transpiration occurs in association with the gas exchange in the aerial portion of the stem. The intracellular spaces connect to the outside of the plant via the stomata. In order for oxygen and carbon dioxide to be exchanged with the atmosphere, the cells themselves must also be exposed to the environment. It is as a consequence of this that transpiration takes place.

F. RESPIRATION: All organisms derive the energy required for the activities from the oxidation of simple foods within their protoplasm. The rate of energy release is dependent upon many internal and external factors.

1. In a sense, respiration is the reverse of photosynthesis

because CO_2 and H_2O are produced. The sequence of reactions involved is somewhat different however.

2. The synthesis and degradation of high energy phosphate compounds such as ATP (adenosine triphosphate) is intimately related to the process of respiration.

3. All living organisms require a source of energy for use in carrying out the activities of life.

G. DIFFUSION: All living organisms are dependent on the fact that, in general, materials tend to move from an area of high concentration to an area of low concentration.

1. The cell is under a constant state of change because of its metabolic activities. Consequently, there will always be variations in the concentrations of any particular substance. In general, these substances are obtained from the environment which is separated from the cell by the cell membrane.

2. When salts are present in excess in the soil, the osmotic concentration of the soil solution may exceed the osmotic concentration of the plant sap. When this occurs, water may move out of the plant and plasmolysis may occur.

H. GERMINATION OF SEEDS: Viable seeds will germinate when environmental conditions are favorable and the conditions of dormancy are satisfied.

1. The environmental factors affecting germination are

temperature, moisture, oxygen, and possibly light.

2. Different kinds of seeds have specific temperature ranges at which they will germinate. Temperature influences the metabolic rate and regulates to a great degree water intake. Water softens the seed coat, swells the embryo, increases the permeability of the seed to gases, activates the protoplasm, and acts as a solvent. Nutritive substances are to be found within the seed and are not taken from the environment. Soil is not a requirement for germination. Light may or may not affect germination; onions germinate better in the dark while blue grass will do better with increasing intensities of light.

I. GROWTH REGULATORS: All living things require specialized chemical substances (growth regulators, enzymes, vitamins) to regulate the life processes necessary for growth and development.

1. Hormones can and often do play dual roles in that they can both stimulate and inhibit a physiological response in the organisms depending upon the concentration. Generally medium does tend to stimulate growth and metabolism, but inhibits when at low or high levels of concentration.

2. Hormones are probably incapable of affecting or controlling a physiological response alone, but are

intimately involved with enzymes and vitamins in their actions.

3. Growth, leafing out, flowering, fruit production, germination, tropisms, and perhaps every activity associated with the living organism are governed at least in part by hormones.
4. Temperature, gravity and light affect the hormones which in turn produce specific growth effect or tropisms.

J. GROWTH: Growth takes place over extended periods of time only when the rate of synthesis of protoplasm exceeds the rate of protoplasmic degradation.

1. Growth is the result of a number of complex processes interacting with each other and requires certain organic compounds, inorganic compounds, ions, water, and chemical energy supplied by the oxidation of carbohydrates and lipids. The assimilation of the materials that make growth possible occurs within the organism.
2. Growth is manifested in the following ways, or by any combination of these:
   a. Increase in size of cells
   b. Increase in the number of cells
   c. The differentiation of cells

3. Growth is influenced by:

   a. Age of the cell, organ, or organism (Young cells grow faster than old)

   b. Health, which is influenced by nutrition, environment, parasites, et cetera

   c. Heredity

   d. Growth regulators

   e. Temperature

4. In many plants new leaves, branches, flowers, and roots are formed year after year. In plants, growth is localized in certain meristematic regions.

IV. Ecology

Environment, which is the counterpart of heredity in the phenomena of life and growth, is the sum total of the external factors (biological, physical, and chemical) that affect living organisms. In a changing environment, living organisms can survive only through adaptation and/or migration. The more severe the impact of environment, the greater will be the challenge to survive. Ecology is the science that deals with the inter/intra-relationships between living organisms and their environment.

A. SOILS: Soil is the only important medium in and upon which agricultural plants grow. It is a dynamic physical and biological system teeming with life and ever changing. See III B p. 32

death occurs. All living organisms have parasites that are capable of affecting their life processes to a degree which is dependent upon the susceptibility of the host, the environment, and the nature of the parasite.

1. Diseases are non-infectious or infectious.
2. Root rots, damping-off and vascular wilt diseases are caused by soil-borne bacteria and fungi which, having no very specific nutritional requirements, are "near" saprophytes. These diseases are controlled by soil conditioning, treatment of planting stock, sanitation, and sometimes by using resistant varieties.
3. Foliage diseases (leaf spots, blights, chlorotic spots and yellows diseases, mosaics, rusts, and mildews) are caused by airborne or vectored pathogens which have rather strict nutritional requirements and are usually found in nature only as parasites. These diseases are controlled by applying chemicals to the foliage and by using resistant varieties.

D. GERMINATION OF SEEDS: Viable seeds will germinate when environmental conditions are favorable and the conditions of dormancy are satisfied.

See III H p. 37

E. ORGANIC CYCLES: All plant and animal life is dependent upon cycles in which quantities of certain essential food elements are kept in constant circulation (between plants, animals, soil and air) and are used over and over. Some of the important cycles are carbon, nitrogen, oxygen, phosphorus, and hydrogen.

See III D p. 34

CHAPTER V

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Summary

The purpose of this study has been to develop a minimum number of subject matter principles basic to organizing and teaching fundamentals of plant science. A secondary purpose was that of assuring that any materials developed would reflect consolidation, delimitation, and scientifically accurate content which would encourage use of the material by teachers of agriculture.

Review of related literature and resource materials revealed a number of attempts at upgrading content in agricultural science by developing closer relationships to the science of biology. Certain of these references dealt with specific accomplishments in achieving such a relationship, while others considered the feasibility of developing entire units of instruction based on a single principle. The results in the case of a unit in soils and plant nutrition based on the principle of plant nutrition proved the first hypothesis of this study, at least in part.

Procedures involved in carrying out the purposes of the study included the engagement of a committee of subject matter specialists, professors of agricultural science subjects, to assist the investigator in his study. This committee reviewed, edited and consolidated 18 basic principles of plant science based on a study conducted in California dealing with biological principles related to agriculture. The latter work was used as a primary resource unit. In addition to authenticating the scientific accuracy of the statements of principle, the committee judged form, wording, and the relationship of one principle or group of principles to another. It agreed on the final organization and content of the framework of principles.

Limitation of the scope of principles by the committee resulted in a much condensed framework of four categories of principles basic to plant science fundamentals. The four categories, each denoted by roman numeral, are supported by several sub-principles of biologically related subject matter. Each of the sub-principles is, in turn, supported by a number of important facts which are intended to lend clarification to the meaning of the statement of principle. The four categories have been placed in a progressive relationship to each other beginning with fundamentals, and progressing through process to product and the ecological effects which influence that product.

Conclusions

The following conclusions are made by the investigator based on the results of this study:

1. The procedures used in carrying out this study are valuable for the purposes of consolidating and upgrading content in agricultural subject matter.

2. The soils and plant nutrition unit based on the principle approach, one of ten procedures of this study, has been proved to be useable on the high school level.

3. Consolidating fragmented knowledge into whole units of instruction is advantageous in teaching.

4. Students benefit when subject matter specialists synthesize subject matter into basic, related principles.

Recommendations

The following recommendations based on the results of this study are:

1. Companion research to this study be carried out in the agricultural subject matter areas of animal science, agricultural economics and farm management, and farm mechanics.

2. The procedure employing the use of a committee of subject matter specialists of university level implemented in this study be given serious consideration as a valuable means of arriving at accurate and meaningful statements of principle in the subject matter areas noted above.

3. That follow-up work on the results of this study be undertaken to prove the value of the principle approach to curriculum organization by applying these results to the organization of

teaching material in plant science in agriculture.

4. That in the activity recommended above, applications to agriculture, examples, and demonstrations of specific and general nature be an integral part of the procedures used in proving the value of the principle approach, specifically the plant science principles proposed by this study.

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APPENDIX

FUNCTIONAL GLOSSARY OF DEFINITIONS

The following glossary provides definitions of terms related to the subject matter principles which comprise the results of this study:

CLASSIFICATION

1. Taxonomy: The science that deals with the classification and naming of organisms
2. Classification: The placing of an organism or group of organisms in groups or categories according to a particular plan or scheme.
3. Nomenclature: That aspect of taxonomy that deals with assigning the proper name to an organism according to some system
4. Dichotomous key: A key arranged in such a way that at each step in the process of "keying out" only two choices of diagnostic characteristics are available
5. Binomial: The name given to a species consisting of the name of the genus to which the species belongs, plus the name of the species
6. Variety: A sub-division of species, the members of which have more characteristics in common than with members of other similar sub-divisions of the same species
7. Species: Generally a grouping of very similar organisms that are interfertile
8. Genus: A group of related species
9. Family: A group of related genera
10. Order: A group of related families
11. Class: A group of related orders
12. Phylum: A group of related classes
13. Kingdom: A group of related phyla

REPRODUCTION

1. Angiosperm: Flowering plant

2. Reproduction: The process by which living organisms give rise to others of their own kind

3. Asexual reproduction: Any reproductive process which does not involve the union of gametes

4. Fertilization: The union of unlike gametes

5. Pollination: The transfer of pollen from a microsporangium of a plant to a stigma or ovule of a plant

6. Cross pollination: Transfer of pollen from two microsporangia of one plant to the stigma or ovule of another plant. The pollen producing plant must be of different genetic constitution than the egg producing plant

7. Self pollination: Transfer of pollen from the microsporangium of a plant to a stigma or ovule on the same plant

8. Monoecious: Microsporangia and megasporangia are borne on the same plant

9. Dioecious: Microsporangia are borne on one plant and megasporangia are borne on a separate plant

10. Mitosis: The division of a nucleus into two daughter nuclei each of which has the same number of chromosomes as the mother (parent) nucleus. (Characteristic of all higher living organisms)

11. Meiosis: Nuclear division in which four daughter cells or nuclei are formed, each of which possesses one-half as many chromosomes as the mother cell. This process occurs in all sexually reproducing plants

12. Cell division: The division of the extranuclear portion of the protoplast. This phenomenon is separate from mitosis. Cell division may follow mitosis very closely, it may be delayed for a time, or it may not occur at all depending on species and nature of the tissue involved

13. Alternation of generations: The alternation of a multicellular diploid generation with a multicellular haploid generation. (Characteristic of most sexually reproducing plants; not characteristic of mammals)

14. Diploid: Having the 2n number of chromosomes

15. Haploid: Having the n number of chromosomes. (Characteristic of the gamete-forming plant and of the gametes of both plants and animals)

16. Megasporangia: A structure that bears megaspores. In angiosperms the ovules are the megasporangia

17. Megaspore: A spore which gives rise to the female gametophytes

18. Microsporangia: A structure that bears microspores. In angiosperms they are located in the anthers of the stamens and are often called pollen sacs

19. Microspore: A spore which gives rise to the male gametophyte. In angiosperms the microspore is the pollen grain

20. Gametophyte: A plant that produces gametes. In angiosperms the female gametophyte is represented by the embryo sac and the male gametophyte is represented by the germinated pollen grain

21. Stigma: The receptive portion of the style upon which pollen grains germinate

22. Style: The upper portion of the ovary

23. Ovary: The structure which encloses the ovules

24. Ovules: The structures which give rise to megaspores

GENETICS

1. Allele: An alternative form of a gene

2. Chromatid: The half chromosome formed during meiosis and mitosis

3. Chromosome: One of the nuclear bodies which bear the genes

4. Dominance: The ability of one gene to mask the effect of its alternative gene (allele) when the two genes occur together in a hybrid so as to determine the expression of the trait for which the pair of genes is responsible. The allele which does not manifest itself is then said to be recessive

5. Gamete: Cells produced in meiosis

6. Gene: A hereditary determiner located on a chromosome

7. Genetics: The branch of biology dealing with the study of heredity and variation

8. Genotype: The genetic constitution of an individual

9. Heredity: The tendency of an organism to resemble its parents

10. Heterozygous: The condition of having the two members of a given pair of genes unlike. (Example: if tall is dominant (T) and short is recessive (t) the genotype (Tt) would be heterozygous)

11. Homologous chromosomes: Chromosomes that pair at meiosis

12. Homozygous: The condition of having the two members of a given gene pair exactly alike. Example: TT or tt

13. Incomplete dominance: When one gene is able to only partly obscure the effects of its allele

14. Kinetochore (centromere): The region of chromosomes to which the spindle fiber is attached and the point of union of sister chromatids

15. Locus: The position on the chromosome where a gene is carried

16. Mutation: A heritable alternation in a gene or chromosome

17. Phenotype: The external, visible appearance of an organism or the physical expression of a particular genotype

18. Recombination: Formation of new combinations of genes resulting from the union of gametes of genetically unlike parents

19. Segregation: Separation of homologous chromosomes at meiosis and the consequent separation of gene pairs leading to the possibility of recombination in the zygote

20. Sex chromosomes: Chromosomes carrying the genes responsible for sex differences. In man the "X" and "Y" chromosomes

21. Zygote: The cell resulting from the union of gametes

PHOTOSYNTHESIS

1. Photosynthesis: The process by which simple sugar is produced from water and carbon dioxide in certain plant cells in the presence of chlorophyll with light as the source of energy

2. Enzymes: Organic catalysts produced by living organisms

3. Catalyst: A substance which modifies the rate of a chemical change without itself being used up in the process

SOILS

1. Aeration soil: The process by which air and other gases in the soil are renewed. The rate of soil aeration depends largely on the size and number of soil pores and on the amount of water clogging the pores. A soil with many large pores open to permit rapid aeration is said to be well aerated, while a poorly aerated soil either has few large pores or has most of those present blocked by water

2. Air-dry: State of dryness after prolonged exposure to air, or any exposure sufficient to bring a material into moisture equilibrium with the air. Moisture content at air dryness is indefinite since it depends on relative humidity

3. Bulk density, soil: Mass per unit bulk volume of soil that has been dried to constant weight at 105°C. Symbol - D_b

4. Bulk specific gravity: The ratio of the mass of a dry bulk volume of oven-dried (105°C.) soil to the mass of

an equal volume of water

5. Consistence: (1) Resistance to deformation of material. (2) The degree of cohesion or adhesion of the soil mass or its resistance to deformation or rupture. Separate terms used for describing these properties at three moisture contents follow:
consistence when dry - loose, slightly hard, hard, very hard, and extremely hard
consistence when moist - loose, very friable, friable, firm, very firm, and extremely firm
consistence when wet (stickiness) - nonsticky, slightly sticky, sticky, and very sticky
consistence when wet (plasticity) - nonplastic, slightly plastic, plastic, and very plastic

6. Darcy's law: (1) Historical: The volume of water passing downward through a sand filter bed in unit time is proportional to the area of the bed and to the difference in hydraulic head, and is inversely proportional to the thickness of the bed. (2) Generalization for other fluids: The rate of viscous flow of homogeneous fluids through isotropic porous media is proportional to, and in the direction of, the driving force

7. Evapotranspiration: The sum of water removed by vegetation and that lost by evaporation for a particular area during a specified time

8. Field capacity (field moisture capacity): Amount of water remaining in a well drained soil when the velocity of downward flow into unsaturated soil has become small. It is expressed as a percentage of weight of oven-dry soil

9. Friability: The ease of crumbling of soils (Note: coherence would determine crushing strength)

10. Hydraulic head: The elevation with respect to a standard datum at which water stands in a riser or manometer connected to the point in question in the soil. This will include gravitational head, pressure head, and velocity head if the terminal opening of the sensing element is pointed upstream. For nonturbulent flow of water in soil, the velocity head is negligible. In unsaturated soil, a porous cup must be used for establishing hydraulic contact between the soil water and water in the manometer. Dimensionally, hydraulic

head is a length (h - L)

11. Hygroscopic water: Water adsorbed to the surface of soil particles when in equilibrium with an atmosphere of 98% humidity

12. Moisture equivalent: Percentage of water retained in a soil sample 1 cm. thick after it has been saturated and subjected to a centrifugal force 1,000 times gravity for 30 minutes

13. Particle density: The average density of the soil particles not including fluid space. Particle density is usually expressed in grams per cubic centimeter and is sometimes referred to as "real density or grain density"

14. Percolation (soil water): A qualitative term applying to the downward movement of water through soil. Especially the downward flow of water in saturated or nearly saturated soil at hydraulic gradients of the order of one or less

15. Permeability: Refers to the readiness with which air, water, or plant roots penetrate into or pass through soil's pores. The portion of the soil being discussed should be designated, e.g., "the permeability of the A horizon"

16. Physical properties: Soil properties related to or caused by the forces and operations of physics

17. Porosity: The fraction of the total soil volume not occupied by solid particles

18. Saturate: (1) To fill all the voids between soil particles with liquid, (2) To form the most concentrated solution possible under a given set of physical conditions in the presence of an excess of the substance

19. Soil air: The combination of gases occurring in the gaseous phase in soil

20. Soil separates: Mineral particles, less than 2mm. in equivalent diameter ranging between specified sized limits. The names and sizes of separates recognized in the United States are: very coarse sand (2.0-1.0mm.) coarse sand (1.0-0.5mm.), medium sand (0.5-0.25mm.),

silt (0.05-0.002mm.), and clay (<0.002mm.)

21. Soil-texture: The relative proportions of the various soil separates in a soil material. The proportions of sand, silt, and clay in different soil-texture classes vary with the soil-texture class. The sands, loamy sands, and sandy loams are further subdivided on the basis of the proportions of the various sand separates. All these textural soil class names are modified by the addition of suitable adjectives to the name where coarse fragments are also present in the soil material

a. Loamy sands: Loamy coarse sand - 25% or more very coarse and coarse sand and less than 50% any other one grade of sand; Loamy sand - 25% or more very coarse, coarse, and medium and less than 50% fine or very fine sand; Loamy fine sand - 50% or more fine sand (or) less than 25% very coarse, coarse, and medium sand and less than 50% very fine sand; Loamy very fine sand - 50% or more very fine sand

b. Sands: Coarse sand - 25% or more very coarse and coarse sand, and less than 50% of any other material or sand separate; Sand - 25% or more of very coarse, coarse, and medium sand, and less than 50% of fine or very fine sand; Fine sand - 50% or more of fine sand or less than 25% very coarse, coarse, and medium sand and less than 50% very fine sand; Very fine sand - 50% or more very fine sand

c. Sandy loam: Coarse sandy loam - 25% or more very coarse and coarse sand and less than 50% of any other one grade of sand

22. Tilth: The physical conditions of soil relative to its response to tillage machinery and its mechanical impedance to root penetration

23. Wilting point: Same as permanent wilting percentage as defined in standard plant physiology texts

24. Adsorption complex: The group of substances in soil which are capable of sorbing materials. The organic matter and colloidal clay form the greater part of the adsorption complex; the materials in silt and sand size exhibit adsorption, but to a greatly reduced extent in most soil material

25. Base saturation: The extent to which a material is saturated with exchangeable cations or other than

hydrogen expressed as a percentage of the cation-exchange capacity

26. Buffer compounds, soil: The clay, organic matter, and such compounds as carbonates and phosphates which enable the soil to resist appreciable change in pH value

27. Deflocculate: To separate the individual parts of compound particles by chemical means; more specifically, to disperse particles of colloidal dimensions from a flocculated condition

28. Exchangeable cation percentage: Indicates the degree of saturation of the soil exchange complex with a cation and is defined as follows:

$$ECP = \frac{\text{Exchangeable cation (me. per 100 g. soil)}}{\text{Cation-exchange capacity (me. per 100 g.)}} \times 100$$

29. Ion: Acids, bases and salts (electrolytes) when dissolved in certain solvents are more or less dissociated into electrically charged units called ions. Some electrolytes dissociate into ions when fused. Positive ions are atoms which have lost valence electrons; negative ions are those to which additional electrons have been added. Positively charged ions are called cations; negatively charged ions are called anions

30. Lime requirement: The number of pounds of limestone or other specified liming material required to raise the pH of one acre (six inches to 2,000,000 pounds) of an acid soil to any desired value under field conditions

31. Soil solution: The aqueous solution existing in equilibrium with a soil at a particular moisture tension and whose chemical composition is determined not only by soluble electrolytes and nonelectrolytes, but also by direct dissociation of ions on the surfaces of the soil colloids

32. Aerobic: Living or active only in the presence of molecular oxygen. Pertaining to or induced by aerobic organisms, as aerobic decomposition

33. Ammonification: Production of ammonia as a result of the biological decomposition of organic nitrogen compounds

34. Anaerobic: Living or active in the absence of molecular oxygen

35. Biological interchange: The interchange of elements between organic and inorganic states in a soil or other substate through the agency of biological activity. It results from biological decomposition of organic compounds and the liberation of inorganic materials on one hand (mineralization) and the utilization of inorganic materials in the synthesis of microbial tissue on the other (immobilization). Both processes commonly proceed continuously in normal soils

36. Carbon cycle: The sequence of transformation undergone by carbon utilized by organisms wherein it is used by one organism, later liberated upon the death and decomposition of the organism and returned to its original state to be re-used by another organism.

36. Cation-exchange capacity: The sum total exchangeable cations adsorbed by a soil expressed in milliequivalents per 100 grams of soil. Measured values of cation-exchange capacity depend somewhat on the method used for determination.

38. Compost: (1) Organic residues, or a mixture of organic residues and soil which have been piled, moistened and allowed to undergo biological decomposition. (2) Mineral fertilizers are sometimes added. Often called artificial or synthetic manure when produced primarily from plant residues

39. Immobilization: The conversion of an element from inorganic to organic combination in microbial or plant tissues. This has the effect of rendering unavailable (and usually not readily soluble) an element that previously was directly available to plants

40. Nitrogen cycle: The sequences of transformation undergone by nitrogen wherein it is used by one organism, later liberated upon the death and decomposition of the organism and is converted by biological means to its original state of oxidation to be re-used by another organism

41. Nitrogen fixation: The conversion of elemental nitrogen to organic combinations or to forms readily utilized in biological processes by nitrogen-fixing microorganisms.

When brought about by bacteria in the root nodules of leguminous plants it is spoken of as symbiotic; if by free-living microorganisms acting independently, it is referred to as nonsymbiotic fixation

42. Soil organic matter: The organic fraction of the soil. Includes plant and animal residues at various stages of decomposition, cells and tissues of soil organisms, and substances synthesized by the soil population. Commonly determined as those organic materials which accompany the soil when put through a 2mm. sieve

43. Fertilizer: Any organic or inorganic material of natural or synthetic origin which is added to a soil in an attempt to provide plant nutrients

44. pH (soil): The negative logarithm of the hydrogen-ion activity of a soil. The degree of acidity (or alkalinity) of a soil as determined by means of a glass quinhydrone or other suitable electrode or indicator at a specified moisture content or soil to water ratio, and expressed in terms of the pH scale

45. Reaction, soil: The degree of acidity or alkalinity of a soil, usually expressed in terms of pH value. Descriptive terms commonly used are as follows: extremely acid, below 4.5; very strongly acid, 4.5 to 5.0; strongly acid, 5.1 to 5.5; medium acid, 5.6 to 6.0; slightly acid, 6.1 to 6.5; neutral, 6.6 to 7.3; mildly alkaline, 7.4 to 7.8; moderately alkaline, 7.9 to 8.4; strongly alkaline, 8.5 to 9.0; very strongly alkaline, 9.1 and higher

46. ABC soil: A soil with a distinctly developed profile including an A, B, and C horizon

47. AC soil: A soil having a profile containing only A and C horizons and no clearly developed B horizon

48. BC soil: A soil with a profile having no A horizon

49. Classification: The assignment of objects or units to groups within a system of categories distinguished by their properties. In the classification of soils the fundamental unit is a soil type. Similar soil types are grouped to form a series. Series are grouped into families, families into great soil groups, these into suborders, and suborders into orders, of which there are three; the Zonal, Azonal and Intrazonal

50. Concretion: Hardened, local concentrations of certain chemical compounds as calcium carbonate or iron oxides in the form of indurated grains or nodules of various sizes, shapes, and color

51. Diatomaceous earth: A geological deposit derived chiefly from the remains of diatoms

52. Humic-Gley soils: Includes Wiesenboden and those soils formerly grouped with Half-Bog soils that have a thin muck or peat A_o horizon and an A_1 horizon. Developed in wet meadows and forested swamps

53. Loess: A fine-grained aeolian deposit dominantly of silt-sized particles

54. Metamorphic rocks: Rocks derived from pre-existing rocks by mineralogical, chemical, and structural alternations due to geological processes originating within the earth. Igneous and sedimentary rocks may be changed to metamorphic rock or one metamorphic rock may be changed into another metamorphic rock

55. Mottled zone: Layer that is marked with spots or blotches of different color or shades of color. The pattern of mottling and the size, abundance, and color contrast of the mottles may vary considerably and should be specified in soil description

56. Physical weathering: The breakdown of rock and mineral soil into smaller fragments by physical forces, as by frost action

57. Prairie soils: A zonal group of soils having a dark colored granular A_1 horizon six inches or more thick, resting on brown, yellowish-brown, or graying-brown subsoil frequently mottled, commonly having a blocky structure and usually higher in silicate clay content than the adjoining horizons. The organic matter in the surface horizon decreases gradually with depth and has a C/N ratio of approximately 11.2. The exchange complex contains less exchangeable H than other cations. They are usually developed under grass vegetation in a humid to semi-humid temperate climate

58. Regolith: The unconsolidated mantle of weathered rock and soil material on the earth's surface; loose earth materials above solid rock. This is approximately equivalent to the term "soil" as used by many engineers

59. Rendzina soils: (1)(U.S.) An intrazonal group of soils with brown or black friable surface horizons underlain by light gray to pale yellow calcareous material; developed from soft, highly calcareous parent material under grass vegetation or mixed grasses and forest in humid and semi-arid climates. (2)(Europe) A group of calcareous soils with dark gray to nearly white surface horizons that are usually stony and that grade into partially disintegrated limestone at shallow depths. These would be called Lithosols in the United States

60. Sedimentary rock: A rock largely composed of sediments more or less consolidated. The chief sedimentary rocks are sandstones, shales, limestones, and conglomerates

61. Soil association: (1) A group of defined and named taxonomic soil units occurring together in an individual and characteristic pattern over a geographic region, comparable to plant associations in many ways. (2) A mapping unit used on general soil maps composed of two or more defined taxonomic units, geographically associated, but the scale and purpose of the map does not permit or require the delineation of the individual soils. A soil association is described in terms of the taxonomic units included, their relative proportions, and their pattern of association if one exists in the area. Sometimes called "natural land type"

62. Soil classification: Study of soils and their interrelationships, description of their properties, naming, and grouping them systematically. The taxonomic units are frequently regrouped for various purposes such as drainage requirements, crop adaptations, highway construction or forestry purposes

63. Soil horizon: A layer of soil or soil material approximately parallel to the land surface and differing from adjacent genetically related layers in properties such as color, structure, texture, consistence, biological and chemical characteristics

64. Soil map (detailed): A soil map on which the boundaries between all soil types that are significant to potential use (generally field-management systems) are shown. The scale of the map depends upon the purpose to be served, the intensity of land use, the pattern of soils,

and the scale of other cartographic materials available. Traverses are usually made at one-quarter mile or more frequent intervals. Commonly a scale of four inches = one mile (1:15,840) is now used for field mapping in the United States

65. Soil map (generalized): Small scale maps made to bring out the contrasts within large areas by generalization of more detailed maps. They vary from soil association maps of a county, on a scale of one inch = one mile (1:63,360) to maps of larger regions showing associations dominated by one or more great soil groups

66. Soil monolith: A vertical section taken out of a soil profile and mounted for display or study

67. Soil morphology: (1) The constitution of the soil body as expressed in the kinds, thicknesses, and arrangement of the horizons in the profile, and in the texture, structure, consistence, porosity, and color of each horizon. (2) The properties of the soil body or any of its parts

68. Soil survey: The systematic examination, description, classification, and mapping of soils in an area. Soil surveys are classified according to the kind and intensity of field examinations

69. Tundra soils: A zonal group of soils having dark-brown highly organic surface horizons over grayish or brownish horizons which rest on cold or even frozen substrata; developed under shrubs and mosses in cold, semiarid to humid climates, e.g. in artic regions

70. Erosion: (1) The wearing away of the land surface by running water, wind, or other geological agents, including such processes as gravitational creep. (2) All processes by which earthly materials or rocks are loosened and moved from place to place. (3) Detachment and movement of soil or rock material by water, wind, ice or gravity

71. Productivity: Soil productivity is the capacity of a soil in its natural environment for producing a specified plant or sequence of plants under a specified system of management. In the definition of productivity the specifications are necessary since no soil can produce all crops with equal success nor can a single system of management produce the same effects on all

soils. Productivity emphasizes the capacity of soil to produce crops and should be measured in terms of unit yields

72. Site: (1) An area considered as to its ecological factors with reference to capacity to produce vegetation; the combination of biotic, climatic, and soil conditions of an area. (2) An area sufficiently uniform in soil, climate and natural biotic conditions to produce a particular climax vegetation

73. Soil improvement: The processes for, or the results of, making the soil more productive for growing plants by fertilization, drainage, addition of organic matter, irrigation and the like

74. Soil management groups: Groups of taxonomic soil units with similar adaptations or management requirements for one or more specific purposes such as adapted crops or crop rotations, drainage practices, fertilization, forestry, highway engineering, et cetera

PLANT NUTRITION

1. Nutrition: The means by which elements are absorbed, translocated, and utilized

2. Nutrition: The sum total of the processes involved in obtaining food or raw material for manufacture of food and the synthesis, translocation and utilization of food materials

3. Diffusion: The fact that in general, materials tend to move from an area of high concentration to an area of low concentration

ORGANIC CYCLES

1. Cycle: A series of changes which result in the re-establishment of the original condition

2. Assimilation: That process whereby foods are utilized in the building of protoplasm and cell walls

3. Ammonification: The release of nitrogen from decaying organic compounds in the form of ammonia (NH_3) through

the activities of microorganisms

4. Nitrification: The conversion (oxidation) of ammonia to nitrate

5. Denitrification: The conversion of nitrate to gaseous nitrogen (N_2)

6. Nitrogen fixation: The reaction of atmospheric nitrogen with other elements to form chemical compounds containing nitrogen

7. Respiration: A series of chemical reactions in which carbohydrates, fats, and proteins are broken down by the living protoplasm and energy is released for use by the organism. (Proteins are normally respired only under conditions of carbohydrate shortage)

8. Aerobic respiration: Respiration that requires the presence of molecular (free) oxygen

9. Anaerobic respiration: Respiration that does not require the presence of molecular oxygen

10. Symbiosis: An association of two different kinds of organisms involving benefit to both

TRANSPIRATION

1. Transpiration: The loss of water vapor by the aerial portion of the plant to the atmosphere

2. Turgor pressure: (turgor meaning swelling) A distension or pressure created by the protoplasm against the cell wall caused by the accumulation of fluids (normally water)

3. Wilting point: The time at which the available soil moisture is less than what is required by the plant. It is at this time wilting is initiated and turgor pressure is decreased with the cells becoming flaccid

4. Temporary wilting point: Wilting is initiated during this condition. However it may be rectified by adjustments in the atmosphere which will reduce the transpiration rate (increased humidity or decreased temperature)

5. Permanent wilting point: The wilting of a plant that cannot be corrected by adjustments in the atmosphere, but only by the addition of soil moisture (if the condition has not been prolonged)

6. Field capacity: The amount of water a soil will hold against gravity when allowed to drain freely

7. Humidity: The moisture or dampness contained within the air. It is generally reported in terms of relative humidity which is the ratio of water vapor in the air as contrasted to the amount the air is capable of holding at a given temperature

RESPIRATION

1. Respiration: The oxidation of foods and consequent release of energy within the organism; the methods by which oxygen is made available to the organism and the removal of gaseous waste products from that organism

DIFFUSION

1. Diffusion: The movement of substances (molecules, particles) from a more concentrated area to a less concentrated area. This process will tend to continue until the two concentrations have become equalized

2. Osmosis: The movement of water through a selectively permeable membrane from the direction of the side containing the lesser concentration of substances other than water to the side with the greater concentration of these substances. This process continues until both sides have the same relative concentration of water. Osmosis is diffusion of water

GERMINATION OF SEEDS

1. Germination: An increase in the metabolic rate which is evidenced by renewed growth which gives rise to the specialization and differentiation of cells with the ultimate rupture of the seed coat and the emergence of the seedling

2. Dormancy: A period during which seeds will not germinate even though environmental conditions may be favorable. The development of the seed is curtailed by such devices as an immature embryo, a seed coat which prevents the adsorption of water or oxygen or both, or resists the swelling or growth of the embryo by virtue of its thickness and chemical changes or auxins. This phenomena naturally carries the seed through periods of unfavorable environmental conditions

3. Rest period: A stage reached in the development of a seed after it reaches maturity and a cessation of activity is noted. There is an absence of further cell division or growth during this period. It might be noted that even if a thick seed coat were removed, development would not be enhanced

4. Seed viability: The ability of a seed to sprout after conditions of rest and dormancy have been fulfilled and the environmental conditions are correct

GROWTH REGULATORS

1. Regulators: Organic compounds, either synthetic or naturally occurring, small amounts of which are capable of stimulating or inhibiting growth, development, and differentiation

2. Enzyme: The organic substance produced within a plant or animal which is capable of inducing or accelerating a chemical reaction; an organic catalyst

3. Vitamin: A group of organic substances contributing to the formation of enzymes at a cellular level or reacting with enzymes to cause a reaction normally synthesized by plants

4. Natural plant hormones (auxins): Substances, generally produced in regions of active plant growth such as the root or shoot apical meristem of plants and which cause changes in other parts of the plant. Examples: gibberellin and indoleacetic acid

5. Tropism: A plant's response to an environmental stimulus such as light, temperature, et cetera, whether it is positive or negative. The environmental stimulus affects the concentration of auxins present which in turn initiates a response in the plant. This simple behavior

or reaction of the plant is a tropism.

6. Differentiation: Growth does not involve the mere duplication of identical cells, but rather the formation of different kinds of cells by the process of differentiation

GROWTH

1. Growth: An increase in size and/or weight due to cell division and/or cell enlargement together with an increase in complexity of the organism

2. Differentiation: An aspect of growth which refers to physiological and morphological change occurring in a cell, tissue, organ, or organism during development from a meristematic or juvenile to a mature or adult state. It is usually associated with an increase in specialization

3. Assimilation: The transformation of food into protoplasm

4. Metabolism: The synthesis and degradation of organic material in the living protoplasm

5. Meristematic cells: Cells which are capable of active cell division and differentiation into specialized tissue

RESPONSE TO STIMULI

1. Irritability: Property of living protoplasm to receive stimuli and to react to them through increasing the chances of survival

2. Stimuli: Environmental factors which elicit a response in an organism

3. Response: positive response - move toward
   negative response - move away

4. Adaptation: The adjustment of the organism by physiological and/or structural changes and the alteration of the life cycle; and of the species by natural selection to the changing environment

PLANT DISEASES

1. Disease: A malfunction of any life process of an organism caused by a continuous irritation
   Non-infectious diseases caused by nutritional disorder, smog
   Infectious diseases caused by viruses, bacteria, fungi, nematodes, insects, and mites

2. Injury: A sudden irritation of short duration and generally a physical trauma

3. Pathogen: A parasite or a virus that causes disease

4. Host: The organism that is affected by the pathogen

5. Vector: That which transmits the pathogen to the host

6. Obligate parasite: An organism obliged to live on living tissue

7. Facultative parasite: An organism that lives primarily on non-living matter (saprophyte) but may parasitize living tissue. (There is a range of organisms capable of living between these two extremes)

8. Homeostasis: The process by which the organism maintains optimum conditions within itself