Research Development at the High School Level

David D. Woodbridge

*Florida Institute of Technology, Melbourne, Florida*

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Cooperative College-School Science Program

The Cooperative College-School Science Program (CCSS) is part of the school system improvement program of the National Science Foundation. All programs sponsored by CCSS must be aimed at improving course content of a school system or school through some new innovation. Programs must be designed such that they are not limited just to the education of teachers or pupils. Because of this requirement, every CCSS program is coordinated closely with the County or District school system.

All types of science projects are encompassed by the CCSS Program. Most of the programs are a summer institute followed by occasional seminars with the high school teachers during the academic year. The programs run from Mathematics through Biological Sciences to Economics.

The History of Brevard County Cooperative College-School Science Program

The Cooperative College-School Science Program in Brevard County really started in the Fall of 1956 through the efforts of Dr. E. Frank Brown and Mr. Jerry Einem at Melbourne High School. It was at this time that a Science Club was formed to provide outstanding students with the opportunity to undertake individual research. A special class was formulated and directed by Mr. Einem. During the first week requirements for the course were explained. After this the students were turned loose on a stack of science books and journals to find topics of interest. Class time was provided for research in the library so that the student could better familiarize himself with the background of his project.

From the very beginning, the class was taught to operate under laboratory conditions. Each student was required to keep a ledger of accurate records of every step in his project. He not only had to record what he did and what were the results, but why he did it and how he evaluated it. Before the end of the year he was required to write a technical paper incorporating all the information that he had gathered in his ledger during the year.

A natural result of this activity in research was the development of outstanding science fairs at Melbourne High School. For many people the science fair was the reason for the research, however, for those truly interested in research the fair was merely an organism for the expression of their interests and an incentive to continue their work. For those whose primary research interest is only the science fair; when the fair is over the research stops.

Financial problems were severe during the early part of the program. Research requires much specialized equipment. There is always a continuing requirement for expendable supplies for any research program. In 1964, Dr. P. Frank Brown came to Florida Institute of Technology (then Brevard College) and asked the University to assist Melbourne High School with their research program. The first National Science Foundation Cooperative College-School Science Program Grant was a result of continued efforts of F.I.T. and Melbourne High School.

Philosophy & Objectives

Florida Institute of Technology believes that the senior high school years of a truly exceptional student should be enriched as much as possible. Students of this caliber who choose a scientific career should be given every opportunity to obtain as much additional training as possible, once they have mastered the fundamentals of the major science disciplines offered in the high school curriculum. This objective can only be obtained by training the high school teacher in research methods and approach.

To this end, F.I.T. has established a framework in conjunction with high schools in Brevard County, which is providing an opportunity for teachers to utilize the research experience of F.I.T. professors in developing their capabilities to direct their students activities. Under carefully supervised conditions, the teachers are afforded the environment of participating in research at a high academic level in laboratories which have adequate equipment for the program. It is furthermore the belief at the Florida Institute of Technology that teachers of students with such ability and training should gain immediate experience and appreciation for scientific research, as contrasted with project work for science fairs. This belief is shared by the high school administrators of Brevard County. As an example of this belief, high school teachers involved in the program have been willing to use time, not connected with their regular duties, to further their own scientific training and that of their students.
Present Program

While the Cooperative College-School Science Program started at Melbourne High School in the Fall of 1964, the following year it expanded to four other high schools; LaBelle High School, Stone High School, Satellite Beach High School, and Merritt Island High School. This last fall the program was further expanded to include Central Catholic High School.

The administrative structure of the program is as shown in Figure No. 1. Each of the final small boxes in this figure represents an individual teacher. On the average each teacher administers the work of 12 to 15 students.

The program is designed so that professors from F.I.T. act as constant consultants for the teachers and students of each of the individual projects. Florida Institute's role in the C.C.S. program is as shown in Figure No. 2. It is fulfilling all administrative links between the Brevard County School System and the National Science Foundation on the Cooperative College-School Science Program. Florida Institute of Technology has established biweekly seminars. These seminars were established to provide both teachers and students with the experience and training of presenting scientific papers before a technical organization. During the first part of the year, noted scientists from the area are presented as guest speakers. By the first of the calendar year the high school teachers themselves take over the running of the seminar and each high school group has an opportunity to present the various programs to the entire C.C.S. groups.

Technical Research Projects

A few examples of Technical Research Projects carried out by the high school students will illustrate the latent capability and potential of this program. The following six projects are described here, as examples of projects carried out during the 1965-1966 school year.

1. The role of the Nucleus in the Biochemical Development of Enzymes
   John Iads

This project involved the study of alkaline phosphate activity in nucleate and anucleate sea urchin eggs during substrate induction and early development of enzymes in these events.

By using actinomycin-D it was found that substrate induction caused specific DNA transcription. m-RNA specific to the phosphatases is activated but not stabilized and soon denatures. Fertilization causes m-RNA transcription, but no DNA translation. Fertilization also causes m-RNA stabilization in both nucleate and anucleate eggs.

Experiments with actinomycin-D on the sexual hormone mechanism of Achlya bisexualis demonstrate that this relatively simple organism such as this phycomycete mold, hormones act as effector substances at the genetic level. The possibility that actinomycin-D is acting as solely a growth inhibitor is ruled out by experiments with dinitrophenol, which showed that in spite of a growth inhibition, female reproductive organs can still be formed.

The importance of work on a simple hormone mechanism like that of Achlya is that any clues to hormone action which may be revealed here might well apply in a basic understanding of the more complicated systems of Metaphyta and Metazoa. In addition, Achlya's evolutionary position is of value in this type of work. As one of the simplest Protists, Achlya lies near the base of organism evolution, and is thereby a possible link to the origin of higher groups of animals and plants.

Preliminary work on the inductive reproductive system of Achlya bisexualis paves the way for a study of the actual genetic pathway of the hormone action through the use of radioactive labeling (uridine tracers) and extractions for m-RNA. One possibility is that the successive inductions by the four sex hormones in Achlya are due to sequential gene activations, much like the puffing patterns caused by cedysone, the Daphnia molting hormone. In any case, the processes of cytodifferentiation and morphogenesis induced by a hormone require immediate genetic messages in order to fulfill their developmental functions.

2. The Effects of a Cholinesterase Inhibitor on Operant Behavior
   Thomas Humble

This project was directed at studying the alternations and levels of acetylcholine in animals. Eserine, a cholinesterase inhibitor, was injected in albino female rats and an increase in "skinner box scores" was observed. The mechanism involved is one of increased neural stimulation which is brought on by the inhibition of cholinesterase and the proposal that behavioral changes follow increased nerve stimulation from the sensory organs to the nerve center.

The data presented indicated a significant alternation in operant behavior of rats after eserine was injected. Inhibition of cholinesterase by eserine results in an accumulation of acetylcholine at the lenticular, prolonging depolarization and prohibiting regularization. This state remains until available cholinesterase molecules can break down the accumulated acetylcholine and render the hormone biologically inactive. It has been proposed that an intense neural stimulation would result in an increase in the
number of neurons discharging into the cortex. A second proposal further states that a behavioral change can follow an abnormal functioning of neurons discharging into the cortex.

3. The Effects of Melatonin on the Reproductive Systems of Mice
   Victor Kane

   The purpose of this experiment is to determine the effects of melatonin on the various organs of the reproductive system. Melatonin is a hormone produced in the pineal gland of all mammals and fishes thus far examined. Although the precursors of melatonin are found throughout the body, the enzyme 
   N-acetyltransferase necessary for the final step in melatonin production has been found only in the pineal gland. Therefore, the pineal is the sole source of melatonin in the body.

   Three separate but related experiments have been completed in order to further the hypothesis. The experimental data collected shows significantly that melatonin injections in female mice can cause increases in uterine weight and decreases in ovarian weight. The data also shows that this effect is not confined exclusively to the female sex, but rather that melatonin injections also cause a significant decrease in testicle weight of male mice. It can further be hypothesized that the pineal-melatonin system in the body is able to recognize environmental factors, specifically lighting variations, and transfer them into influences on the reproductive system.

   Furthermore, since melatonin production was shown to be directly related to N-acetyltransferase activity and since N-acetyltransferase activity can be regulated by light through the action of the photo-receptor cells in the pineal, it is possible that in the pineal-melatonin system lies the answer to the question of how environment factors affect the reproductive system. This hypothesis is supported by the work of Axerod and Turtman on experiments in which lighting conditions were found to have an effect on ovarian weight and incidence of estrous. Also this hypothesis would offer an explanation, and could also be supported by the phenomenon of photo-periodism which has puzzled scientists for years.

4. The Effects of Wavelengths on the Temperature of Plants
   Diane Baccus

   The purpose of this project was to measure the effect of specific wavelengths of light on the temperature of plants.

   This was done by inserting thermocouples in the thick leaves of certain plants, and comparing the results with a thermocouple encased in a charcoal-paraffin mixture.

   Thermocouples are very accurate, sensitive, small thermometers made by welding two wires of different metals together. The response of the thermocouple was measured by a galvanometer and graphed as a function of time.

   The graphs show that the heating rate of the plant is less than that of the charcoal paraffin. The slope of the graph of the heating rate of the plant is less than the slope of the graph of the heating rate of the charcoal paraffin in all cases.

   It is known that different colors of light or different wavelengths affect the rate and type of growth of plants. It has also been proven that many plants grow better and mature sooner if the light which falls on them is alternated with periods of darkness. The melatonin and absorbed by the plant is probably closely tied to the reason for these phenomena.

   The experimenter measured the temperature of plants and the effect different wavelengths or colors of light had on the plant temperature, while attempting to qualify the energy emitted and absorbed.

   A qualitative analysis of the data indicated that the rate of heat absorption by the charcoal-paraffin reference thermocouple decreased from white light through red, green, then blue, and that the rate of heat energy generated by the plant for each wavelength decreased from white light, green, blue and then red light.

5. Magnetic Effects on the Decomposition of H₂ O₂
   Victor Kane

   To measure the rate of a chemical reaction, it is necessary to measure one of the products of the net reaction. The number of atoms or molecules in this product in any given interval of time must be proportional to the number destroyed in the same interval.

   "In chemical statistics one is concerned with the equilibrium state of matter; in chemical dynamics one is concerned with the mechanism and velocity whereby that state is attained. Chemical thermodynamics tells one how far a tilde go; chemical kinetics how fast."

   To compare different reaction rates the rate constants (the concern of kinetics) of the reactions must be computed.

   With few exceptions the mechanisms and kinetic laws of the changes considered were first established by investigation of reactions in solution. Two principles are used in formulating kinetic laws. The first
is that the instantaneous rate of a chemical change is proportional to the concentrations of the reactants raised to integral powers. The second is that in a sequence of changes differing widely in velocity, the net rate is determined by the slowest step in the sequence.

There exist essentially three types of orders of reactions. Any particular reaction is classified as to its dependence upon the different numbers of molecules within the reaction. A reaction of the first order is dependent upon only one reactant, a second order reaction upon the probability of two molecules colliding and reacting, and a third order reaction upon three. When the rate of change of concentration is proportional to the concentration of a single reactant, the reaction is said to be of the first order. It can be seen that one must limit experiments to this order when attempting to determine a physicochemical effect so as to rule out the possibilities for explaining the effect may be limited to the breakdown of a single molecule. In a further limitation of scope, one must consider the type of effect expected and choose those molecules which will most likely yield a hypothesis. Since the effect of magnetism was desired, the magnetic properties of the reactants had to be considered. Magnetic susceptibility is a comparison of the paramagnetic and diamagnetic properties of elements and compounds. A paramagnetic substance is attracted to the poles, while a diamagnetic substance is repelled. In the customary system of units (cgs) an attracted substance is positive and a repelled one negative. It was noted that the oxygen gas molecule, \( \text{O}_2 \), has a magnetic susceptibility of \(+3449 \times 10^{-6} \) cgs units and is common in many oxidizing agents. Therefore, it was desirable to use a reaction which involved oxygen in some step of the rate mechanics.

Hydrogen peroxide is a common oxidizing agent; it is used for bleaching and as a disinfectant. Its decomposition, catalyzed by potassium iodide, \( \text{KI} \), yields oxygen, which is easily measured. The peroxide molecule is also slowly decomposed by light. The complete reaction is:

\[
2 \text{H}_2 \text{O}_2 \rightarrow 2 \text{H}_2 \text{O} + 1/2 \text{O}_2
\]

By using this first order decomposition, it is hypothesized that because of the presence of a compound, \( \text{O}_2 \), which is highly affected by magnetism, there should exist an appreciable difference in the reaction rates obtained in the presence of magnetism and those completed without this external agent.

The results obtained show a ten to fifteen per cent decrease in the rate constant of the decomposition of hydrogen peroxide with the presence of a strong magnetic field. This indicates that both steps of the reaction share in determining the ultimate reaction rate, and not just the first as had been previously thought.

6. A Study of Acne and some of its Contributing Factors

Cora Shedrick

Acne is a skin disorder which occurs in the upper areas of the body where there is hair growth. It can be caused by a lack of yeast in the body or by unbalanced hormones. Several contributing factors are chocolate, sweets, oily skin, cola beverages, citrus fruits, before, during, and after menstruation, nervous tension, unhappiness, and hot weather. Many treatments have been established: examples are the estrogenic treatment and use of antibiotics.

The objectives of this study were to:

1. To obtain information on the skin disorder for additional research.
2. To obtain information on some of the most dominant contributing factors and the effects they produce.

Oily skin, which appeared high as a contributing factor in the study, is due to the over secretion or rapid secretion of the sebaceous gland. If the oily substance is not removed often enough it builds up, plugs the hair follicle, and causes an elevation in the skin.

Nervous tension and the effect during the menstrual cycle can be attributed to increases in body temperature, the increased temperature of the body thus activating the secretion of sebum.

The results of this project indicate that the causes of acne are dependent only upon the individual's skin condition, but the contributing factor can accelerate the degree to which the individual has acne. Of course, the contributing factors may have different effects on various individuals because susceptibility to acne varies greatly.

This year all six high schools are participating in a unified research program besides carrying on their individual research programs. This unified program is a study of the pollution in tributaries in the Indian River. Each high school has a particular tributary or part of a tributary in which they perform a time-history analysis of the bacterial count and chemical conditions of the stream. The particular areas studied by each high school are listed in Figure No. 3. Each high school has established a set of self-made rain gauges in the area of their measurements. These rain gauges are read at 5:00 p.m. every
night. Thus, the students have a micro structure of the rainfall in the drainage area near to their measurement points. Every Monday each high school measures the same four locations on their respective tributaries. Besides obtaining samples of the water from which both bacteriological and chemical analysis are obtained, water and air temperatures and the wind velocity are measured. In this way, the students obtain a time history of both the bacteriological and chemical conditions of the tributary and the physical parameters involved in the flow into the Indian River.

In this manner, data is obtained. Now the remaining question arises. What does a research individual do with the data so that he obtains information of value from the data? The answer to this question is "Plot it." Time plots will be made of the following parameters at each location:

A. The bacterial level,
B. The chemical analysis,
C. The average rainfall in the drainage area,
D. The water level,
E. The wind direction and velocity, and
F. Temperature of the air.

When each of these variables are plotted against the same time scale, correlations between the variables can be observed.

When each of the high schools has obtained approximately six months of simultaneous data, a general work-shop will be for the cross-correlation of the data obtained from the various tributaries. A time varying record of the flow of pollution into the Indian River will result from the work-shop.

Results of this group project and of each of the individual projects that are being carried on at the high schools will be a technical paper. These papers will be published by F.I.T. in the annual journal of Brevard County High School Technical Reports. The first of these annual reports was published in the summer of 1965 as a result of the research work performed at Melbourne High School under the direction of Mr. Jerry Eisen, Mr. Robert Richmond and Mr. John Hessner. This original report only presented short resumes of the work performed by the students. The first full annual journal was published in the fall of 1966. This journal was composed of some 44 papers written by 68 students from the high schools of south Brevard. A number of these papers demonstrated research work equivalent to that performed on many Master's Thesis.
Figure 1.
FIT

ADMINISTRATION

SCIENTIFIC CONSULTANTS

SEMINARS

WORK SHOP

TECHNICAL REPORT

Figure 2.
Central Catholic High — Turkey Creek
Stone High — Crain Creek
Melbourne High — Eau Gallie River
Eau Gallie High — Elbow Creek
Satellite Beach High — Mouth of Banana River
Merritt Island High — Upper Banana River & Sites Creek

Figure 3.