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A LABORATORY CENTERED MOLECULAR BIOLOGY TEACHING MODULE TO FACILITATE LEARNING OF BIOLOGICAL SCIENCE

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MICHAEL JAMES BRUNDAGE

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Clarence Suelter
Howard Hagerman
Major professor

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A LABORATORY CENTERED MOLECULAR BIOLOGY TEACHING MODULE WHICH FACILITATES THE TEACHING OF BIOLOGICAL SCIENCE

By

Michael James Brundage

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ABSTRACT

A LABORATORY CENTERED MOLECULAR BIOLOGY TEACHING MODULE TO FACILITATE LEARNING OF BIOLOGICAL SCIENCE

By

Michael James Brundage

Students entering second year high school biology classes have diverse scientific backgrounds. Subject material including cytology, genetics, and physiology, necessitates an expanded knowledge base in molecular chemistry. To give all a somewhat equal starting point, a ten week molecular biology learning module initiates the class.

The module, and its laboratory activities, are designed to develop knowledge of: atoms and molecules, chemical reactions, bioenergetics, pH and buffers, carbohydrates, lipids, and proteins. Analytical techniques introduced include: Ouchterlony Double Diffusion, spectrophotometry, gel permeation chromatography, and gel electrophoresis. Judgement of the success of the module is based upon clinical interviews, pre and post test scores, classroom discussions, and laboratory behavior.

The motivational capacity of hands-on activities focuses student effort. This attention increases learning of the abstract lecture material. Students show increased dexterity with laboratory equipment during unstructured tasks. During the exit interviews, favorable attitudes toward science class are noted.

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STATEMENT OF THE PROBLEM

Will the introduction of a ten week molecular biology teaching module to a second year high school biology class (1) accomplish the stated objectives (see p. 7), and (2) will it facilitate future conceptual development in cytology, genetics, and physiology? Will fulfillment of the objectives be influenced by adding laboratory investigations into the module? To understand modern biology, students need a working knowledge of chemistry. This work describes an integrated approach for teaching molecular biology to second year high school biology students with inclusion of several laboratory exercises, and its success in student motivation. According to Bybee & Landes (1990), "The nature of the activities and approaches must be such that students have time to explore ideas, become acquainted with scientific or technologic concepts, and have the opportunity to apply the new concepts and evaluate their adequacy."

LITERATURE

Current literature suggests a trend toward increasing the involvement of high school science students in laboratory experiences or hands on activities. As stated by Okebukola (1985), "There has recently been a noticeable increase in published biology laboratory activities that depend heavily upon engaging the student in manipulative experiences to discover concepts rather than to verify them". Many of these materials contain complex procedures including the use of relatively modern research technologies. Though this may be a good idea, Gardner (1988) states that "While most educators agree that students should be exposed to the marvels of modern biology, teachers are concerned as to where such units will fit into an already overcrowded list of course objectives". To alleviate this problem, the exercises ought to be designed to facilitate achievement of the objectives already in place, and, when possible, should reinforce concepts and ideas previously covered. In addition, if they develop concepts deemed important enough to be newly introduced, information gleaned from the investigations ought to be supported by material covered later in the course.

Research about the format of laboratory exercises has led to the approbation of the Guided Inquiry laboratory approach. The Biological Sciences Curriculum Study, Biological Science: An Ecological Approach (1987) is a course plan which incorporates the Guided Inquiry method into investigations. It involves the formation of four sequential domains; introduction, materials, procedure, and discussion, each dealing with important segments of learning. The written introduction gives real world accounts of characteristics within the inquiry and explains its scientific goals. A materials list alerts the students to the exercise, equipment, and prior knowledge needed to operate it. The procedure is a series of carefully written steps which leads the student through the process. A key aspect of the Guided Inquiry procedure is the opportunity for students to engage in science processes. "Frequently included are more difficult skills, such as identifying variables, controlling for and manipulating variables and quantifying data" (Ingelsrud & Leonard, 1988). The discussion section is composed of questions which relate to the interpretation of the data and attempt to mold the student's concept of the area being studied. Laboratory investigations published in the science teaching journals; The Science Teacher, Natural Science, and The American Biology Teacher, as well as those found in the newer copyrighted texts and lab manuals, use the Guided Inquiry format. Personal and colleague participation in recent National Science Foundation funded teachers' workshops report requests for the Guided Inquiry format when developing or altering laboratory investigations.

CENTRAL QUESTIONS

Many American high school students, are not very interested in taking science classes. If this is not true, why must two years of science be a requirement for graduation by most Michigan school districts? Flannery (1988) states, "As every teacher knows, many students see science as difficult, complex and boring. Few, especially among nonscience majors, see it as interesting, illuminating and exciting". Perhaps a class in general biology and introductory chemistry are as far as most want to delve. Many reasons may be cited as the cause for the apparent apathy, but lifeless lectures, boring group activities, and non-realistic classroom discussions are among the reasons. The vast heterogeneity of topics covered during elementary and middle school science education may also play a role. If high school students could have a standard knowledge base in science prior to entering high school, their teachers would know where to begin.

Accordingly, if standards for graduation from high school were more explicit, teachers would know what to teach. With desire to teach for breadth rather than depth, teachers too often "present" materials to students once, with the attitude that those who are interested will learn the material while those who do not learn it are not studying hard enough. Repeated use of the same teaching materials and methods does little to resolve the issue. If we want students to become more excited about science, we must develop laboratory activities which incorporate new technologies and real life situations.

Robertson, (1989) has suggested that "conceptual understanding is associated with *connections* --connections between science concepts and everyday life and connections among the different science concepts in a discipline." To make the connections involves exploring "in place" classroom objectives, finding areas concerning students' problems, examining the texts and labs, interviewing pupils about their knowledge of and feelings for science classes, and then trying to make some reinforcing alterations. To begin this process, new laboratory exercises with introductions showing "real life" connections need to be acquired.

During the summers of 1987 and 1988, several modern molecular biology laboratory activities were developed by high school teachers attending workshops held on the campus of Michigan State University. Ten of these activities were chosen by teachers for their probable applicability within the present high school curriculum. The laboratory exercises were pre-tested by the teachers, to determine their feasibility in the high school science environment, and revised where needed. Some of these labs are incorporated into the molecular biology module. This is a report of student involvement with the module and subsequent assessments of their perceptions of biology and chemistry.

OBJECTIVES

Prior to the 1988/89 school year the second year program of biology in the Lapeer School District included studies in human anatomy and physiology. The predominant goal was "to develop the students' knowledge of human anatomy and physiology." The major laboratory exercises involved dissection of a preserved cat. Some molecular biology, cytology, and genetics were included in the initial phase of the course, but the depth of concern with these subjects was clearly inadequate. With the development and testing of laboratory exercises for a molecular biology module during the summers of 1987 and 1988, and the module's implementation during the school year of 1988-89, new aspects of cellular physiology were incorporated into the second revision of the class outline. The most recent schedule of subjects integrates technology and molecular biology with cytology, genetics, and physiology.

Appendix A is a list of terms used to help evaluate the success of the teaching module. The list includes the key terms and concepts to be understood and processed by the students, and it conveys the depth of study during the module. The order of the list is as presented to the students during an exit interview.

Two sets of objectives, one which guided the development and research of the laboratory exercises, and the other which was developed for teaching the module, were prepared and are listed below.

RESEARCH PROJECT OBJECTIVES

1. To develop successful inquiry approach laboratory exercises for biology and chemistry classes.
2. To introduce scientific technology to teachers.
3. To learn places where laboratory experiments and exercises can be integrated into established curricula.
4. To increase teacher competence in aspects of molecular biology.

TEACHING UNIT OBJECTIVES

1. To stimulate interest in molecular biology.
2. To prepare a knowledge base for further biological studies.
3. To introduce laboratory equipment and develop some dexterity with it.
4. To give practice with data collection, graphing, and interpretation.
5. To give practice at deductive reasoning.
6. To positively influence attitudes towards science classes
7. To correct and reinforce biological concepts
8. To cite examples of how science is connected to real world objects and systems.

Development of an understanding of the kinetic molecular theory of matter in the minds of biology students is a good starting point. Knowledge in this area facilitates the learning of many natural phenomena. Prerequisites to understanding cellular metabolism are reaction kinetics and chemical bonding. Since living material has a composition high in water, information about solutions, concentrations, ionization, polarity, and pH is essential. The concept of compartmentation of the cell, and movements of materials to and from these compartments, requires knowledge of the molecular organization of cell membranes. Knowing structure and function of carbohydrates, lipids, proteins, and nucleic acids is necessary if students are to deal adequately with genetics, cytology, and physiology. Few, if any, areas of biology can be well understood without some knowledge of biochemistry. Student objective two is to broaden the knowledge base of biochemistry.

Cognition, the result of learning experiences, can occur at various levels. Bybee & Landes, (1990) indicate "that learners actively construct a world view based on their observations and experiences." Student misconceptions derived during primary development of a perception can cause flaws with future thinking. Immature students may misinterpret information regardless of source. If teachers present biology as an inquiry rather than a series of facts, perhaps students would feel less defeated and would begin to see science more realistically. Investigative experiences concerning concept areas with which the students are to become familiar seem to enhance perception and attitude. In addition, connecting scientific concepts with real world situations can aid student comprehension. Throughout the teaching effort tied to this thesis, connections and analogies between the real world and concepts being studied are identified. (Table 1)

Table 1, Concepts and Real World Connections

CONCEPT BEING STUDIED	REAL WORLD CONNECTION
HEMOGLOBIN MOLECULE	SICKLE CELL ANEMIA
DISULFIDE BONDS	CURLED HAIR
pH	SHAMPOO/ACID RAIN
INDICATORS	URINALYSIS TESTS
PROTEIN DENATURATION	FRIED EGGS/MERINGUE
CARBOHYDRATES	NUTRITION
LIPIDS	NUTRITION
PROTEINS	NUTRITION
MEDIATED TRANSPORT	DRIVER/FAST FOOD WINDOWS
LIPIDS/EMULSIONS	VINEGAR AND OIL DRESSING
POLYMERIZATION	POP-BEADS
BETA- PLEATED SHEET	FOLDED PAPER FAN
CATALYST	SET UP FIGHT/BOY AND GIRLFRIEND
ENERGY TRANSFER	A DAM/TURBINE, GENERATOR
ANTENNA CHLOROPHYL	RADIO/TV ANTENNAE
HELIX	SLINKY
H-BONDING	ICE CRYSTALS/SURFACE TENSION
HYDROGENATED OIL	MARGARINE
BUTYRIC ACID	BUTTERMILK/BUTTERSCOTCH
HYDROPHOBIC	HYDROPHOBIA/CLAUSTROPHOBIA
CHOLESTEROL	GALL STONES/STROKE/BLOOD P.

The laboratory exercises, which were tested and rewritten during the summer research session in 1988, are presently being used in an attempt to increase interest and cognition in the four major content areas of the second year biology class. The laboratory exercises and their current arrangement in the module are listed in Table 2. Complete copies of the exercises are located at the Instructural Software Collection in the Michigan State University Library.

Table 2, Laboratory Exercise Placement

NAME OF LAB	EQUIPMENT INTRODUCED	PLACEMENT
Ouchterlony Diffusion Using Salt Solutions	aspirator agarose gel micropipettes	Atoms and molecules
Introduction to Spectrophotometry	spectrophotometer	Bonding and reactions
Separation of Hemoglobin from Ammonium Sulfate Using Gel Permeation Chromotography	Sephadex gel chromotography columns pH indicator sticks indicator various pipette types/pi-pump spectrophotometer	Molecular mass
Biological Materials as pH Indicators	pH indicator sticks Pasteur pipettes	pH and buffers
General Effect of Salivary Amylase On Starch	indicators Pasteur pipettes spectrophotometer	Proteins and enzymes
Coagulation Temperature of Chicken Egg White	melting point tubes pH indicator sticks Pasteur pipettes	Enzymes and denaturation
Concentrations of Protein in Saliva Using Biuret Solution	indicator volumetric pipettes/pi-pumps spectrophotometer	Standard curve Concentration
Protein Digest By Papain and Bromelain	pH indicator sticks	Enzymes
Electrophoresis of Protein	electrophoresis apparatus pH indicator sticks agarose gel, stain/destain various pipette types	Buffers and protein

During the ten week module the time alloted for atomic and molecular theory of matter is about two weeks. Atomic and molecular theory of matter are taught through lecture, discussion and involve worksheets.

Beginning with the Bohr model of the atom, the students work through charge, number, and location of sub-atomic particles. The idea of atomic mass and molecular weight are next in the sequence; introduction of quantum numbers and electron configuration sum up the time used to study the atom. After this ionization, and ionic, covalent, and hydrogen bonding are discussed. The introductory Ouchterlony Double Difusion exercise is used to demonstrate ionization of salt compounds in solution, their ability to diffuse through a gel substrate, and their capacity to recombine with other ions. The Ouchterlony investigation facilitates understanding the concept of gel electrophoresis of proteins and gel permeation chromotography which are incorporated later in the module.

An introductory spectrophotometric laboratory exercise occurs during this section, and study of Beer's law reinforces the concept of the molecular nature of matter. Studies in molecular polarity strengthen knowledge of electrically charged particles. Combination, decomposition, and single/double replacement reactions are covered at this point and are of great importance to later understanding of metabolism. Gel permeation technology is discussed and an exercise in hemoglobin from ammonium sulfate separation follows.

Molecular and ionic kinetics is extremely important to understanding movement of molecules across membranes. Passive diffusion, facilitated diffusion, and various forms of mediated transport can only be accurately understood when one has a strong basic knowledge of the physical characteristics of matter.

Structure, bonding, bioenergetics including exergonic/endergonic reactions, free energy, coupling and energy transfer are needed ideas for conceptual development of cellular activity. The Walt Disney Studios produced film, Our Friend the Atom, is used in conclusion. Once these areas are understood shifting to the study of energy transfer within living systems occurs more readily.

The fact that chemical reactions occur in living cells, and that they only happen if the energy situation is favorable, appears to be new to the students. They do not seem to think of living organisms as "chemically active conglomerates" working in coordinated fashion. During first year biology classes, most teachers devote many hours to explanations describing energy relationships in living processes. They talk of the sun powering the whole system, producers harnessing the energy and making some of it available for the consumers. Discussions of photosynthesis and cellular respiration come afterwards, attempting to express the concept of energy transfer, but to little avail. This is because many students do not understand the comparative size and arrangements of molecules making up the cell organelles.

Many also lack a general knowledge of the characteristics of energy. For example, let us examine the following two sentences. "The electrons travel from cytochrome to cytochrome, giving up some of their energy to enzyme molecules called ATP synthetase. These molecules are found in the membrane surrounding the mitochondrial matrix and form ATP from ADP and phosphate." In order for an eleventh grade student to understand, one must insure the student has cognition of the molecular nature of the mitochondrion, and has some concept of free energy, coupling, and energy transfer. Perhaps chemistry and physics ought to be pre-requisites for biology.

Most high school biology laboratories will have: beakers, flasks, graduated cylinders, eye-droppers, dissecting tools, filter funnels, mortar and pestle, paper chromotography chambers, and microscopes. However, high school laboratories where molecular biology is taught require that the list be expanded to include: Pastuer, volumetric, and micropipettes, Pi-pumps, a centrifuge, Ouchterlony plates, spectrophotometers, gel permeation columns, thin layer chromotography plates, affinity chromotography columns, gel electrophoresis apparatus, and melting point tubes. Student comments when asked, " With which laboratory equipment, instruments, and processes have you developed some dexterity?", consistently choose use of the spectrophotometer and pipetting. Time restraints often interfere with the exercises involving use of electrophoresis equipment, thus various levels of proficiency with this apparatus occur.

STUDENT TRANSFORMATION

CLINICAL INTERVIEW

To help judge if the stated teaching objectives have been met, a clinical interview is held with each of twelve students over the two year study. The questions asked during the hour long discussions are listed in Appendix B. Students are selected to be interviewed according to their final class standing. Two students with highest and lowest percentage of accumulated points, as well as two students in the middle of the range, are chosen, and intensively interviewed at the end of each year.

The questionnaire is divided into two portions. The first is a covert attempt to see if the students know that a basic back -ground in molecular biology is necessary for understanding biological concepts. Answers to questions designed to test the hypothesis (see Appendix B, questions 4, 5, 7, 12, and16) confirm that they do. At the same time the questionnaire queries the students as to their feelings about the laboratory exercises.

The second part of the questionnaire is a list of terms and procedures with which the students ought to have become familiar during the course. All items on the list are introduced during the molecular biology module and many of them are actively used throughout the school year. During this section of the interview the student is asked to make an open statement about his or her understanding of each term. The interviewer, using subjective judgement, tallies the students' responses as excellent, good, or poor. (Table 3). The expected outcome would be that the ones scoring the highest on the pre-test would understand more. (See Tables 4 & 5)

However, the list is prepared so it can be used to determine if the lab exercises have a positive effect on learning and retention. Of the seventy-seven terms included in the list, twenty -one are involved with the laboratory exercises. Table 6 summarizes the number of times items associated with laboratory are well understood. Twenty-one of the seventy-seven terms (22%) show strong evidence of retention. (see table 3) Nine of these twenty-one (43%) were introduced during laboratory time and twelve of fifty-six (21%) during lectures. A Chi square test done with this data (which shows a less than 30% probability that the difference occurs due to chance) may be used as evidence that the exercises increase retention of terms.

Table 3. Student Interview: Vocabulary Item Analysis

(+) = excellent, (-) = good, (0)= poor

WORD	+	-	0	WORD	+	-	0	WORD	+	-	0
ABSORBANCE	12	0	0	HYDROPHILIC	12	0	0	AMPHIPATHIC	8	4	0
KINASE	10	2	0	CARBOXYLASE	10	2	0	PHOSPHORYLASE	6	6	0
TERTIARY	6	2	4	QUATERNARY	10	2	0	MERISM	10	2	0
DISSOCATION	6	4	2	POLAR	12	0	0	NON-POLAR	12	0	0
PERMEATION	8	2	2	SPECTROPHOTOMETER	10	2	0	ENDERGONIC	10	0	2
TRANSMITTANCE	8	2	2	EXERGONIC	10	0	2	COVALENT BOND	8	2	2
BUFFER	8	4	0	IONIC BOND	8	4	0	OLIGOSACCHARIDE	10	2	0
DISULFIDE BOND	10	2	0	KETOSE	6	2	4	TRIACYLGLYCEROL	4	6	2
ALDOSE	6	4	1	ALANINE	10	0	2	GLYCINE	6	0	6
PHOSPHOLIPID	6	2	4	HYDROGEN BOND	0	8	4	TRYPTOPHAN	6	0	6
CYSTEINE	6	0	6	METHIONINE	10	0	2	MELTING PT. TEMP.	6	2	4
PEPTIDE BOND	10	0	2	CATALYST	12	0	0	WAVELENGTH	12	0	0
LIGAND	8	2	2	NANOMETER	8	2	2	SEPHADEX	12	0	0
ELECTROPHORESIS	12	0	0	AGROSE	8	2	2	BEER'S LAW	8	0	4
PIPETTE	12	0	0	OUCHTERLONY	12	0	0	REDUCE	8	2	2
LAMBERT'S LAW	10	4	0	OXIDIZE	4	4	4	EMP. FORMULA	10	2	0
DALTONS	8	4	0	MOLE	4	8	0	COMB. REACTION	10	0	2
STRUCT. FORMULA	12	0	0	ELECTRON DOT FORM.	10	2	0	DBL. REPLACEMENT	12	0	0
FREE ENERGY	0	4	8	SINGLE REPLACEMENT	10	0	2	ANION	4	2	6
ASPIRATOR	2	0	10	CATION	4	2	6	EXTRAPOLATE	12	0	0
INTERPOLATE	12	0	0	PRECIPITAN LINE	8	0	4	PHOTOMETRY	2	2	8
LOGARITHM	6	6	0	EXTRACT	12	0	0	ALBUMIN	10	2	0
COOMASSIE BLUE	6	4	2	AMYLASE	10	2	0	INDICATOR	10	2	0
CENTRIFUGE	12	0	0	DESTAIN	8	0	4	PARAFILM	12	0	0
GLYCOLIPID	6	4	2	CENTRIFUGAL FRACT.	2	4	6	GLYCOSYLATION	4	0	8
DECANT	4	0	8	GLYCOPROTEIN	10	0	2				

Table 4, Percent Of Students Scoring Within Achievement Ranges With Total Word List

High achiever - "A" student, Medium achiever - "C" student, Low achiever - "E" student

STUDENT CATEGORY	STUDENT UNDERSTANDING OF ITEM		
	% EXCELLENT	% GOOD	% POOR
HIGH ACHIEVER	82	10	8
MEDIUM ACHIEVER	72	15	13
LOW ACHIEVER	53	19	28

Table 5, Percent Of Students Scoring Within Achievement Ranges With Laboratory Associated Terms

High achiever - "A" student, Medium achiever - "C" student, Low achiever - "E" student

STUDENT CATEGORY	STUDENT UNDERSTANDING OF ITEM		
	% EXCELLENT	% GOOD	% POOR
HIGH ACHIEVEMENT	98	0	2
MEDIUM ACHIEVEMENT	69	12	19
LOW ACHIEVEMENT	62	14	24

Table 6, Tallied Lab Word List From Interview

LIST ITEM	# OF STUDENTS UNDERSTANDING ITEM		
	EXCELLENT (+)	GOOD (-)	POOR (0)
TRANSMITTANCE	8	2	2
BUFFER	8	4	0
ELECTROPHORESIS	12	0	0
PIPETTE	12	0	0
LAMBERT'S LAW	10	2	0
ASPIRATOR	2	0	10
COOMASSIE BLUE	6	4	2
CENTRIFUGE	12	0	0
DECANT	4	0	8
SPECTROPHOTOMETER	10	2	0
OUCHTERLONY	12	0	0
PRICIPITIN LINE	8	0	4
EXTRACT	12	0	0
DESTAIN	8	0	4
ABSORBANCE	12	0	0
MELTING POINT TUBE	6	2	4
WAVELENGTH	12	0	0
SEPHADEX	12	0	0
BEER'S LAW	8	0	4
INDICATOR	10	2	0
PARAFILM	12	0	0

LITERATURE ANALYSIS

A textbook has not been chosen for the second year biology course. A multiple text approach was deemed most acceptable by the school district prior to inception of the class. Classroom sets of Jacob & Franconne (1982), and Vander et al (1980), were purchased as references. Lack of a textbook, and the fact that the class was originally organized to teach only human anatomy and physiology, forced production and distribution of copies of sections from Metcalfe's et al (1986) teacher's resource notebook. This material is used in conjunction with the beginning chapters of the classroom resource texts, Structure and Function of the Human Body and Human Physiology. These textbooks include basic explanations of: atoms, molecules, ions, polarity, solubility, concentration, and structural characteristics of carbohydrate, lipid, and protein molecules. The ten week molecular biology module allows expanded study of these areas and the addition of pH, buffers, catalysts, and reaction kinetics.

The inclusion of the new material demands the availability of more information. This is provided by the teacher through lectures and handouts (Appendix C). Sources for these materials include Albert et al (1983), the October 1985 issue of Scientific American, Srere and Estabrook (1978), Barrett et al (1986), Ferdinand 1976, Dickerson and Geis (1969), Lehninger (1970), and Stryer (1981) as well as others. Since many of these resources are current they are assumed "up to date" and correct.

Objectives two, seven, and eight of the module, enhancement of the knowledge base, correction and reinforcement of biological concepts, and real world connections are considerably influenced by the literature, lectures, and handouts. The other five teaching objectives are also impacted.

INSTRUCTION

DAILY CALENDER

The methods of instruction are varied and include lecture/demonstration, laboratory exercises, independent research, cooperative learning, films, monitoring tests, quizzes, worksheets, and reading assignments. To summarize the daily calender (see Appendix D), twenty five of the forty four days are used for lecturing and discussion, and thirteen days are spent in the lab. Six days are used in conjunction with either films, reviews, or tests.

LESSON PLANS

A complete compilation of the lesson plans used to teach this module are presented as Appendix E. The four sequences include subject material, instructions to the teacher, examples for use by the teacher, diagrams to be drawn on the board, questions to the students, when to hand out copied materials, and when the quizzes (Appendix F) and tests (Appendix G) are to be administered. The lesson plans, by no means, are all inclusive. In order to teach the material a working knowledge of biochemistry is required.

The labs which are incorporated into the module do not need exact placement, and therefore, are not positioned in the time frame. As is indicated earlier (Table 2), the labs are effective if placed within particular areas of study. A teacher wishing to implement the labs can rest assured that they are applicable to many areas of biology. It should be noted that the labs (Table 2) may involve the use of elaborate equipment, some of it is expensive (A new spectrophotometer, $1,200.00). Teachers wishing to incorporate any of these labs ought to become familiar with them prior to use in the classroom.

LABORATORY EXERCISES

Student objective three is to introduce laboratory equipment, and have students gain some dexterity with techniques necessary for its use. This segment of the module provides great impetus for influencing attitudes towards the scientific endeavor. Student excitement, enthusiasm, and debate over proper use of equipment is evident during lab periods. Lab reports, including data tables, graphs where appropriate, written interpretations, and conclusions, generally exhibit extensive effort.

The initial laboratory involves the use of Ouchterlony double diffusion to show how ions migrate through a colloidal phase of matter. It necessitates development of skilled use of an aspirator and micropipettes. Prior to the next laboratory exercise, a day is taken to discuss properties of light, and demonstrate how a spectrophotometer functions. The exercise itself involves an introduction to spectrophotometry, and with it successful student use of a spectrophotometer. "Biological Materials as pH Indicators" is a lab which involves the preparation of extracts from pigmented portions of plants, and tests to determine if they are good indicators of pH. Students use Pasteur pipettes, pH indicator paper, and spot plates. If a fair number of extracts (5-8) are prepared, data collection necessitates careful consideration. As in all the labs, interpretation of the data is necessary to answer the discussion questions at the end.

During the section on proteins five investigations ensue. Each introduces new equipment such as melting point tubes and gel electrophoresis apparatus, and demands student involvement. Reinforcement of techniques already initiated includes the use of Pipumps and various types of pipettes, pH indicator paper (a pH meter, if available), and spectrophotometers.

After the students have developed some functional skill with the apparatus, an open-ended assignment is given. The students are asked to develop a method for determining the number of pigments in plant leaves. They are allowed to gather their own leaves, prepare their analytical protocol, run the experiment, and do the research necessary to verify their conclusions. During the experimentation they use techniques such as thin layer chromotography, extraction, pipetting, and spectrophotometry. The most serious student effort, within the time frame of the module, occurs here.

EVALUATION

STATISTICS

Evaluation of academic achievement can be a difficult task. Some students perform best on objective tests, some on short answers, and others essay. Individuals can be sick or anxious when being evaluated. Because teachers are required to assign grades, we must make the best of a poor situation. Within the molecular biology module, numerous evaluation instruments are used to determine achievement. Positive student attitude and success on structured tasks, demonstrate a valid argument for the incorporation of modern molecular biology laboratory investigations into the teaching module. A carefully planned objective test, one which is dedicated to not only testing memorization and conceptual development, but also reasoning skills, may be able to measure realization of established goals. In conjunction, a well planned clinical interview can lend insight into intellectual development.

The developed pre and post objective type test (Appendix G) are one in the same. The test includes forty multiple choice items, and ten structural diagrams to be identified. The molecular diagrams are presented to the students from the blackboard, and vary, slightly, from pre to post test. Nine of the multiple choice items involve interpretation of presented data (questions 11-13, 16-18, 29-31). Of those, three (29-31) demand that students decide whether proffered conclusions are representative of the data. The Pre-Test is administered the first regular day of class, and the Post Test on the last day of the first quarter. After completion of the Pre-Test, students are informed that a similar test will occur at the conclusion of the module to check for improvement. On day fifteen a major test (see Appendix G) covering, roughly, the first third of the module occurs. Thirteen five point quizzes (Appendix F) are given throughout the module, and are used as monitoring devices.

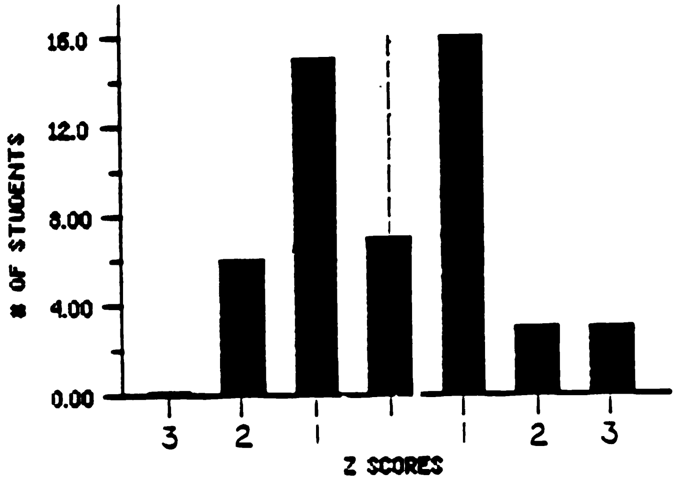
Analysis of the pre-test raw data indicates a significant lack of knowledge about molecular biology. The mean is14, and the standard deviation is 4.32. Standard Z scores (Figure 1) reveal 76% of the students score within one standard deviation while 94% are within two.

Appraisal of the post test raw data shows a mean 33.16, and the standard deviation as 5.58. Standardized post test data (Figure 2) indicates 72% of the students score within one standard deviation, and 96% score within two. A t-score of 19.13 indicates a significant change has occured. Post test data exhibit an average point increase of 38% over pre-test scores (Figures 3 & 4). The least individual achievement is indicated by an 18% increase (9 points), while the greatest improvement is 64% (32 points).

The correlation coefficient of two years of combined data for the pre and post test scores is .63. With a df of 48 the Null Hypothesis can be rejected with 99% certainty. A generalization claiming that the average 38% difference between the pre and post test scores may be due to the molecular biology teaching module can be made.

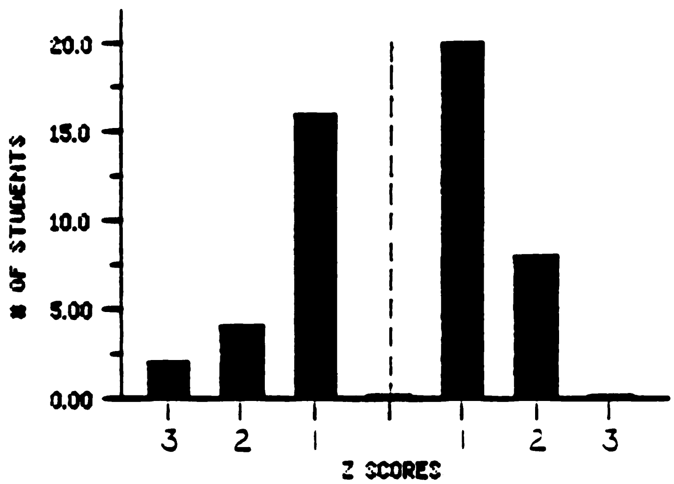
Most students put forth strong effort during this module and the increase in the mean score of the post test may signify this.

Those few students showing little gain can be classified as intelligent "problem children" who are placed into the class because of strong teacher discipline or those who pay little attention to counselors advice. The attempt to normalize student understanding of the chemical nature of living matter seems to be successful and this allows a more significant study of life processes for each.



mean score (14), standard deviation (4.32)

Figure 1, 1989 & 90 Pre-Test Z Scores



mean score (33.16), standard deviation (5.58)

Figure 2, 1989 & 90 Post Test Z scores

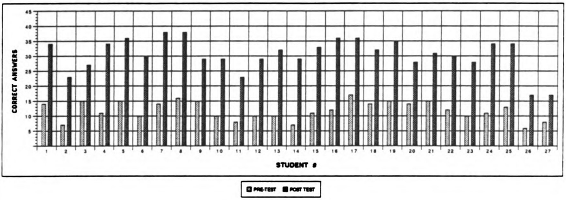


Figure 3, 1989 Pre/post Test Score Comparison

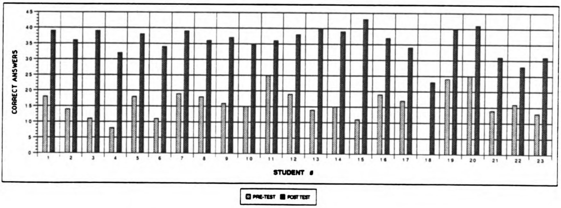


Figure 4, 1990 Pre/post Test Score Comparison

CONCLUSION

SUMMARY

The inclusion of this module into the initial phase of a second year biology class profoundly facilitates students' ability to understand cytology, genetics, and physiology. The expansion of their knowledge of molecular biology increases the depth to which the other subjects can be studied. The lab activities involve the students in situations resembling actual scientific research. This, in turn, motivates positive attitudes for science, and reinforces newly developed concepts.

STRENGTHS

Active participation is the major key in education. The laboratory activities, as measured by the Chi square test and pre/post test scores are evidence of its success. During lab time the usual preoccupation with "socialization" is at a minimum. Students are motivated by the challange of the endeavor, and this keeps their minds focused on what they are doing. At present, the molecular biology module includes much more lab time than do the other three modules making up the class. When asked for a comparison of preferred amounts of lab time, fifty percent of those students interviewed suggest more time be spent in the lab, and fifty percent feel the time devoted during the molecular biology module is about right.

Development of student realization that a background in molecular biology is necessary for understanding other biological concepts is another strength of the module. The cytology module involves the study of membrane structure and function. Without knowledge of phospholipids and proteins, and their inherent physical and chemical characteristics, accurate portrayal of mechanisms which move material through cell membranes is unlikely. One hundred percent of the students interviewed appreciate the importance of chemistry to cognizance of biological concepts.

WEAKNESSES

The most "glaring" weakness of the module involves time restraints put upon the lab activities. Even though the labs are designed to be completed in an hour, or multiples of hours, they run over. Students rush to complete some sections, leading to frustration. Most teachers comply with requests for "ten minutes" of their class time, but this puts a burden on them as well as their pupils. Students quickly realize that prior reading of the lab protocol, and prompt initiation of it, facilitates completion of the lab on time. A alternative might be to schedule two hour blocks of laboratory time into the day once or twice a week.

SUGGESTIONS

A high school level text, which includes all the material covered in the molecular biology module, would be of great value. Providing current reading information for the students becomes tedious and time consuming. Martini (1989) is the Lapeer School District's newly adopted text for the Biology II classes. It includes more of the chemistry information than previously used classroom reference texts, but is still incomplete. A short textbook, written at tenth grade reading level, would be superior.

The positive influence of a knowledge base in molecular biology, and the stimulation of student appetite through the use of labs involving modern research techniques, are fueling the development and alteration in other subject areas. Modules being affected include cytology and genetics. The genetics module embodies a new electrophoresis lab, and the cytology module entails labs involving electrophoresis, tissue culture, thin layer chromotography, and measurement of rates of cellular respiration. As time and money permit, new labs shall continue to be added. Perhaps the realization that cognizance of concepts and techniques in the field of chemistry are a prerequisite to comprehension of biology will alter the order in which the two subjects are presented.

APPENDICES

APPENDIX A

MOLECULAR BIOLOGY ITEM LIST

MOLECULAR BIOLOGY ITEM LIST

ABSORBANCE	HYDROPHILIC	AMPHIPATHIC
KINASE	CARBOXYLASE	PHOSPHORYLASE
TERTIARY	QUATERNARY	MERISM
DISSOCATION	POLAR	NON-POLAR
PERMEATION	SPECTROPHOTOMETER	ENDERGONIC
TRANSMITTANCE	EXERGONIC	COVALENT BOND
BUFFER	IONIC BOND	OLIGOSACCHARIDE
DISULFIDE BOND	KETOSE	TRIACYLGLYCEROL
ALDOSE	ALANINE	GLYCINE
PHOSPHOLIPID	HYDROGEN BOND	TRYPTOPHAN
CYSTEINE	METHIONINE	MELTING PT. TEMP.
PEPTIDE BOND	CATALYST	WAVELENGTH
LIGAND	NANOMETER	SEPHADEX
ELECTROPHORESIS	AGROSE	BEER'S LAW
PIPETTE	OUCHTERLONY	REDUCE
LAMBERT'S LAW	OXIDIZE	EMP. FORMULA
DALTONS	MOLE	COMB. REACTION
STRUCT. FORMULA	ELECTRON DOT FORM.	DBL. REPLACEMENT
FREE ENERGY	SINGLE REPLACEMENT	ANION
ASPIRATOR	CATION	EXTRAPOLATE
INTERPOLATE	PRECIPITAN LINE	PHOTOMETRY
LOGARITHM	EXTRACT	ALBUMIN
COOMASSIE BLUE	AMYLASE	INDICATOR
CENTRIFUGE	DESTAIN	PARAFILM
GLYCOLIPID	CENTRIFUGAL FRACT.	GLYCOSYLATION
DECANT	GLYCOPROTEIN	

APPENDIX B

CLINICAL INTERVIEW

CLINICAL INTERVIEW

1. Which of the four areas of study this year was most interesting?
   A. Molecular biology
   B. Human genetics/Bioethics
   C. Cytology
   D. Human anatomy & physiology

2. Which of the four areas was the most enjoyable/fun?

3. Tell me something you remember from each major unit. Make the comment about something you think is important.

   A.
   B.
   C.
   D.

4. In what sequence do you feel the four major areas should be studied, to best facilitate understanding how organisms work?

5. Sequence the levels of organization in the living world with the simplest first. Explain what you can about how these levels are influence other levels.

6. Arrange the levels in the order you know them with best first.

7. Explain why you need to understand molecular biology in order to understand:

   genetics-

   cytology-

   A and P-

8. Which specific areas of each major subject is least understood by you? (Show them the outlines of each module.)

9. Which laboratory experiences seemed most valuable to your understanding of the area being studied?

10. Name and explain some cellular level functions of specific molecules.

11. How many methods of molecular transport can you name and describe? Describe them.

12. Tell me your concept of the Cell theory. Which area of those studied would necessarily have to be known to best understand this theory?

13. Which component of the Cell theory do you understand best? Least?

14. Give an example of a homeostatic mechanism in a living organism.

15. Give an example of a specific metabolism and explain it simply.

16. Which area(s) of study need(s) to be understood to better comprehend this mechanism and metabolism?

17. Give some examples of how comprehension in each of the four areas studied may be important in your every day life.

    molecular biology-

    genetics-

    cytology-

    A and P-

18. With which laboratory instrument/equipment/process have you developed some dexterity?

19. Is an hour sufficient lab time to complete most investigations? If not, which ones seem to long? Where might the problem lie?

20. Would you enjoy more or less laboratory work?

APPENDIX C

EXAMPLES OF HANDOUTS

EXAMPLES OF HANDOUTS

OXIDATION-REDUCTION AND IONIC BONDING

1. Does the following equation represent an oxidation or a reduction of an atom of potassium? Prepare a sentence which explains your choice.

   K + bond energy yields K^+ + e^- ________________

   ____

2. Does the following equation represent the result of an oxidation or reduction? Prepare a sentence which explains your choice.

   Br^- ________________

   ____

3. In the following equation, which element has been oxidized and which has been reduced? Prepare a sentence which explains your choice.

   Mg + Br2 yields MgBr2 OXIDIZED________________
   REDUCED________________

   ____

4. Diagram an electron dot formula for the following atoms.

   DOT FORMULA

   Be atomic # 4
   atomic mass 9.0122

   Al atomic # 13
   atomic mass 26.9815

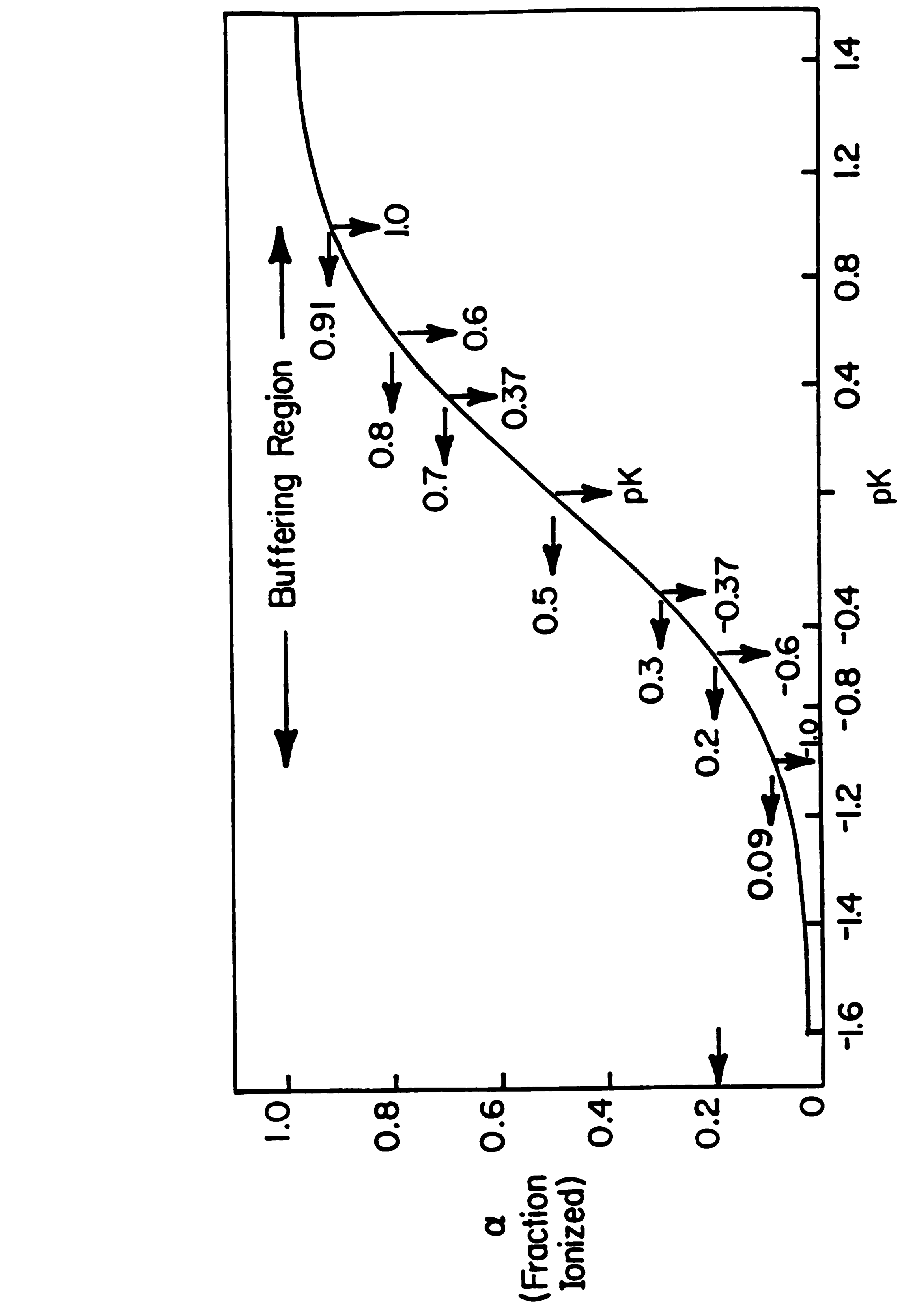
   O atomic # 8
   atomic mass 15.9994

5. Using electron dot formulas, prepare an equation which illustrates ionic bonding between Li (Lithium) and O (Oxygen). Prepare a sentence which explains the equation and why it is correct.

   EQUATION-

   ____

6. Do the same as above for Mg (Magnesium) and Br (Bromine). Use the back of the sheet for your answers.



Buffering Region
α (Fraction Ionized)
1.0
0.8
0.6
0.4
0.2
0
pK
-1.6
-1.4
-1.2
-0.8
-0.4
0.4
0.8
1.2
1.4
0.91
1.0
0.6
0.37
0.8
0.7
pK
0.5
-0.37
0.3
-0.6
0.2
-1.0
0.09

BOND ENERGY

Using the terms exergonic and endergonic, label the following reactions.

A. 1 mole Na + 119 kcal <u>yields</u> 1 mole Na^{+} + 1 mole e^{-}

____

B. 1 mole of Cl + 1 mole e^{-} <u>yields</u> 1 mole of Cl^{-} + 83 kcal

____

C. 1 mole Na + 1 mole Cl <u>yields</u> 1 mole $Na^{+}Cl^{-}$ + 153 kcal

____

D. 1/2 mole of H_2 + 52 kcal <u>yields</u> 1 mole H

____

E. 1 mole Mg + energy <u>yields</u> 1 mole Mg^{++} + 2 moles e^{-}

____

F. 1 mole Mg^{++} + 2 moles Br^{-} <u>yields</u> 1 mole $Mg^{++}Br^{-}{}_2$ + 587 kcal

____

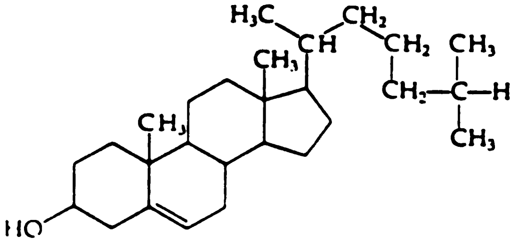
Complete each sentence with your own words.

An exergonic reaction is one which
____.

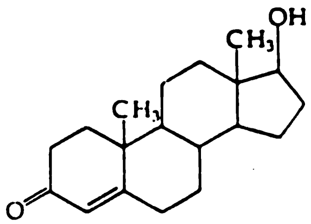
An endergonic reaction is one which
_______________________________________.

If we react two compounds in a beaker, and the beaker is warm after the reaction is complete, the reaction was ______________________.

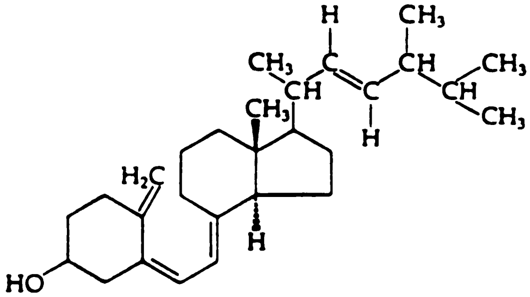
If we react two compounds in a test tube, and when the reaction is complete the test tube feels cold, the reaction was
_____________________.



Cholesterol



Testosterone
(a male hormone)



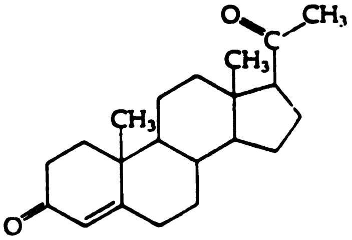
Vitamin D_2

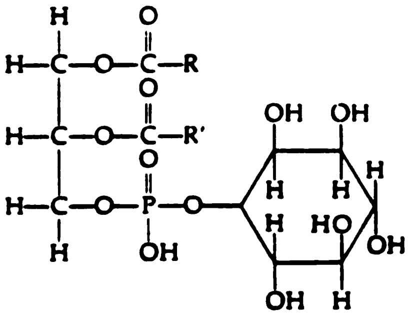
Figure 3-5. Three common steroids.

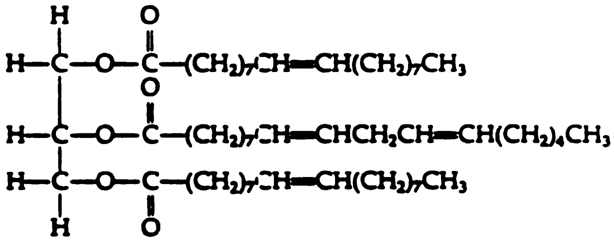
Questions

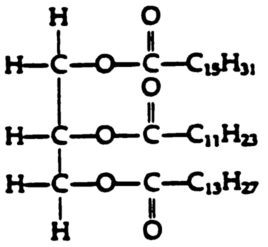
Identify each of the following substances as: A. neutral lipids, B. phospholipids, C. steroids, or D. waxes.

1. $CH_3(CH_2)_{24}-\overset{\displaystyle O}{\overset{\|}{C}}-O-(CH_2)_{31}CH_3$

2. 

3. 

4. 

5. 

APPENDIX D

DAILY CALENDER

DAILY CALENDAR

Day 1
Discussion of section of school rules, introduction to teacher, subject material to be covered, location of equipmrnt

Day 2
Pre-test

Day 3
Atomic structure, periodic chart, sub-atomic particles, symbols of elements, ions, molecules

Day 4
(Quiz 1) Ionic bonding, moles, bond energy, quantum theory, electron dot formula, empirical formula

Day 5
Movie: Our Friend The Atom, Walt Disney Studios

Day 6
(Quiz 2) Lab-Ouchterlony Diffusion Using Salt Solutions (set-up and preface)

Day 7
Ouchterlony lab/Discussion of lab results

Day 8
Covalent bonding, diatomic molecules, structural formula, nuclear fusion, valence, endergonic/exergonic

Day 9
(Quiz 3) Lab equipment, spectrophotometry, graphing

Day 10
Lab-Introduction To Spectrophotometry

Day 11
(Quiz 4) Discussion of lab, hydrogen/disulfide bonding, charge polarity, general reactions types, free energy

Day 12
(Quiz 5) pH/buffers, introduction of pH lab

Day 13
Lab-Biological Materials As pH Indicators

Day 14
(Quiz 6) Discussion of lab,

Day 15
Test

Day 16
Introduction of organic molecules/structural vs functional, carbohydrates

Day 17
(Quiz 7) Carbohydrates

Day 18
Carbohydrates

Day 19
Carbohydrates

Day 20
(Quiz 8) Proteins

Day 21
(Quiz 9) Proteins

Day 22
Movie-Sickle Cell Anemia (N.I.H)

Day 23
Discussion of movie, review

Day 24
Protein, introduction of next lab

Day 25
Lab-General Effect Of Salivary Amylase On Starch

Day 26
(Quiz 10) Discussion of lab, introduction of next lab

Day 27
Lab-Coagulation Temperature of Chicken Egg White

Day 28
Enzymes, catalysts, denaturation

Day 29
Environmental effects on enzymes, metabolism, ligands

Day 30
(Quiz 11) Standard curves/concentration vs transmission, introduction of lab

Day 31
Determining Concentrations of Proteins In Saliva Using Biuret Solution

Day 32
Discussion of lab, Introduction of next lab/set-up lab

Day 33
Lab-Protein Digest By Papain And Bromelain

Day 34
Discussion of lab, lipids

Day 35
(Quiz 12) Lipids

Day 36
Lipids

Day 37
Electrophoresis discussion

Day 38
Preparing buffers, pK, sigmoid curve

Day 39
(Quiz 13) Introduction to next lab, preparation of buffers

Day 40
Lab-Electrophoresis of Proteins

Day 41
Discussion of lab, review for test

Day 42
Test

Day 43
Review for major test

Day 44
Post-test

APPENDIX E

DETAILED LESSON PLANS

DETAILED LESSON PLANS

LESSON PLANS: ATOMS, MOLECULES, REACTIONS, ENERGY, pH AND BUFFERS -

Hand out periodic chart to each student

Discuss chart, atoms, sub-atomic particles, how to determine the numbers of each, Bohr model, energy levels and quanta.

They must know symbols for major elements found in living organisms: O, C, N, H, P, S, Na, K, Mg, Ca, Cl, Mn, Fe, Co, Cu, Zn

5 most abundant in universe: H, He, C, N, O
H, C, N, O = 99% total mass of most organisms

Define atom; smallest chemical unit of a substance that is capable of stable independent existence.

- Ionic Bonding

Discuss compounds and molecules

Demonstrate ionic bonding of Na and Cl on the board
show ionization of Na and Cl, explain how they become ions.

	(mole)		(mole)	(mole)
1st	1 mass Na atoms + 119 kcal	yields	1 mass Na ions +	1 mass e
2nd	1 mass Cl atoms + 1 mass e	yields	1 mass Cl ions +	83 kcal
3rd	1 mass Na ions + 1 mass Cl ions	yields	1 mass NaCl +	189 kcal

Discuss energy situation; 189 kcal + 83 kcal - 119 kcal =
total gain of 153 kcal/mass (mole)

Work other examples. For instance Mg + Br or Li + O

Explain oxidized(lose electrons) and reduced(gained electrons)
Work on developing concept by asking about what an oxidizing or reducing agent will do to an atom.

Explain cations (+) and anions (-)

-Covalent Bonding
No transfer of electrons, shared instead
Diatomic atoms; H, O, N, Fl, Cl
Example

H + H yields H2
Electron dot formula H:H
Structural formula H-H
Empirical formula H_2

2 masses H atoms yields 1 mass H_2 molecules + 104 kcal
and
1 mass H2 molecules + 104 kcal yields 2 masses H atoms

Have them explain the difference in their own written words.

104 kcal = BOND ENERGY (Amt. of energy necessary to break one mass of H2 into two masses of hydrogen atoms.)

Example; Cl + Cl
electron dot formula
structural formula Cl-Cl
empirical formula Cl2

1 mass Cl2 + 58 kcal yields 2 masses Cl atoms
Ask what bond energy is.

Example; O + O
electron dot formula
structural formula O=O
empirical formula O2

Bond energy = 119 kcal/mole

Example; N + N
electron dot formula
structural formula N=N
empirical formula N2

Bond energy = 226 kcal/mole

-Covalent bonds between unlike atoms
H + Cl
Name- hydrogen chloride or hydrochloric acid
electron dot formula
structural formula H-Cl
empirical formula HCl
one electron from each atom is shared with the other atom.
1 mass HCl + 103 kcal yields 1 mass H atoms + 1 mass Cl atoms

Bond energy/ mole = 103 kcal

-Water molecules
electron dot formula
structural formula

empirical formula H2O

1 mass H2O + 222 kcal yields 2 masses H atoms + 1 mass O atoms

Ask the bond energy of O-H

Ask students to correctly combine in correct proportions:

1 N + H

1 C + H

1 C + Cl

-Hydrogen Bonds

A weak chemical bond betwen a hydrogen atom in a molecule and a very electronegative atom in a second molecule.

Electronegativity; The measure of a tendency of an atom in a molecule to attract shared electrons.

O and N are highly electronegative when sharing electrons with H.

(2 extra - charges) _ side

electrons are drawn closer to O than H

(2 protons/+ charges) + side

Discuss polar molecules

H bonding when ice crystals form.

-Disulfide Bonding

certain situations

-Reactions

Combination A + X yields AX

Na + Cl yields NaCl
$Li + O_2$ yields LiO_2 Review electron exchange and ask
Mg + O yields MgO which kind of bonds are formed (ionic)

$C + O_2$ yields CO_2
$H_2 + O$ yields H_2O Review electron sharing and ask
$C + H_4$ yields CH_4 what kind of bonds are formed (covalent)

Decomposition AX yields A + X
HgO + energy yields Hg + O (Let former chem students
PbO + energy yields Pb + O know the equations are
NaCl + energy yields Na + Cl not balanced, but we just
want to see examples of
decomposition reactions)

Single Replacement reactions AX + B yields AB + X
Cl + KBr yields KCl + Br
Br + KI yields KBr + I
Cl + NaI yields NaCl + I

Double Replacement reactions AX + BY yields AY + BX
$Al_2(SO_4)_3 + Ca(OH)_2$ yields $Al(OH)_3 + CaSO_4$
Explain how radicals sort of act like atoms.
They have electrons to share.

Bioenergetics

Exergonic-any process which liberates energy as it proceeds.
(show example)

Endergonic-any process which absorbs energy as it proceeds.
(show example)

Biologically speaking-photosynthesis

$6CO_2 + 6H_20$ + sunlight yields $C_6H_{12}O_6 + 6H_20$

Ask students whether it is exergonic or (endergonic). Why is sunlight necessary?

$6C + 9O_2 + 6H_2$ yields $6CO_2 + 6H_2O$ + energy

$6C + 9O_2 + 6H_2$ yields $C_6H_{12}O_6 + 6O_2$ + less energy than above

GRAPH

don't write in
right away

Therefore: $C_6H_{12}O_6$ + $6O_2$ yields $6CO_2$ + $6H_2O$ (+ energy)

Ask students, "How could we reverse the reaction? What would be necessary?"

Have them diagram it going the other way. Make sure they include the energy involved. Ask where the energy comes from.

Free Energy = F   Change in Free Energy = delta F

We now know that the absorption of light energy provides the necessary F to run the photosynthetic reactions.

Give examples now and discuss F.

A. Water flows downhill if given a chance to. Can the F in the water do work? How did the water get up high enough to flow downhill?

B. Weights fall unimpeded. Can the F given off do work? How did the weights get high enough to fall?

PULLEY AND WEIGHT DRAWING

Which side of pulley gains F and which loses F?

Same idea for chemical reactions.

Acetyl Coenzyme A + CO_2 + 4.5 kcal/mole yields malonyl CoA

Ask students, is F added to make it happen or is it given off when it happens? (added) Is this (endergonic) or exergonic

Ask students, where does 4.5 kcal come from?
answer, from an exergonic reaction
-which is-

ATP + H_2O yields ADP + P + H ions + 8.9 kcal/mole

Ask students, is F added to make it happen or given off?
(given off) Is this reaction endergonic or (exergonic)?

Have students explain in their own written words how these two reactions are connected to one and other.

If necessary go back to ionic and covalent bonding.

Coupling

A Acetyl CoA + CO_2 + 4.5 kcal/mass yields malonyl CoA

and (HPO3)

B ATP + H_2O yields 8.9kcal/mass + ADP + P + H+

These reactions are not connected to each other in any way.

i.e. Draw pulley with one weight unattached.

We must couple the 30# weight to the 25# weight by the rope. Similarly, we must couple reaction A from above to reaction B if the reaction is to occur.
The rope is Acetyl coenzyme A carboxylase denoted as E. Biotin is a cofactor bound to E

E-biotin + CO_2 + ATP + H_2O yields

(P)

E-biotinCO_2 + ADP + HPO_3 + H + 4.2 kcal/M

then

E-biotinCO_2 + AcetylCoA yields

E-biotin + malonylCoA + 0.2 kcal/M

The net result of these reactions is:

AcetylCoA + CO_2 + ATP + H_2O yields

Malonyl CoA + ADP + HPO_3 + H+ + 4.4 kcal/M

Talk briefly about catalyst (enzyme) function in metabolisms.
(DESCRIBE JOHN'S DEMONSTRATION OF CATALYSTS AND USE IT NEXT YEAR)

pH and Buffers

LESSON PLANS: CARBOHYDRATES

- Functions; energy source for cells, carbon source, storage, cell structure
- empirical formula $(CH_2O)n$

-aldehydes or ketones that have two or more hydroxyl (OH) groups

aldehyde if: ketone if:

SIMPLE MONOSACCHARIDES

-simplest monosaccharides with n=3 are trioses $C_3H_6O_3$

glyceraldehyde dihydroxyacetone

Ask which is ketone and which is aldehyde.

Because they are sugars we call them aldOSE and ketOSE depending on the group present.

Monosaccharides with 4,5,6,and 7 carbons (n) are called:

tetroses, pentoses, hexoses, heptoses

Two common hexoses:

GLUCOSE FRUCTOSE

Ask why they are monosaccharides. Ask which is an aldose and which is a ketose.

Then ask why. (group recognition)

In solution these two hexoses are not open-chain structures. They cyclize and form rings.

HAVE STUDENTS BUILD MODELS FROM KITS. THEN WORK THROUGH THE FORMATION OF THE RING STRUCTURE AS DRAWN BELOW.

Because of the ring form the molecule will either be called a pyranose or furanose. This particular one is called (GLUCOPYRANOSE). Similarly the following is the formation of a furanose. This particular one is called (FRUCTOFURANOSE)

-Horwath projections are diagrams of the previous but with the C for the carbon atoms of the rings left out.

-Numbering of carbon atoms in hexoses

glucose galactose fructose

DISACCHARIDES

-are formed by dehydration synthesis reaction. (diagram 1-4, 1-6 bonding)
HAVE STUDENTS BUILD MODELS WITH KITS. TWO MONOSACCHARIDES FIRST. WHEN THEY COMBINE THE TWO DEFINE THE BONDS DESIRED. (1-4, 1-6)

-can be broken apart by hydrolytic reaction.

sucrose = glucose + fructose
lactose = glucose + galactose

maltose = glucose + glucose
HAVE STUDENTS BREAK THE BONDS. (ASK WHERE ENERGY AND ATOMS COMES FROM)

- sweetness of di and monosaccharides vary. Fructose very sweet. Lactose least sweet.

-In humans, glucose is the most commonly transported sugar.

STORAGE AND STRUCTURAL CARBOHYDRATES

-called poly, and oligosaccharides

-most carbo's are stored in living systems as polysaccharides of large mass.
These are long chains (polymers) of monosaccharides. Glucose is the most common primary unit.
i.e. starch, glycogen, cellulose, lignin
-All three are composed of glucose units but have different properties due to linkage.

HAVE STUDENTS BUILD DEFINED MONOSACCHARIDE. GET WITH PARTNER AND FORM A DISACCHARIDE. GET WITH ANOTHER GROUP AND FORM OLIGOSACCHARIDE. GET WITH ANOTHER GROUP AND FORM POLYSACCHARIDE. WITH SMALL GROUPS HAVE THEM IDENTIFY THE 1-4, 1-6 BONDING POINTS. (ASK ABOUT THE LEFT- OVER WATER MOLECULES.)

Starch- storage form in plants.
Digestive tracts of animals secrete enzymes which can hydrolize starch into glucose units. These can then enter the bloodstream.

Glycogen- main storage carbo of animal cells. (liver-blood/muscle-respiration)
very large molecules sometimes 500,000 glucose units.

Cellulose- major structural unit of plant cell walls.
wood = 50% cotton = 98%
largely unbranched chains which form hydrogen bonds between adjacent chains. (sometimes 100 - 200 chains together in a fiber. The many H bonds between make the chains resistant to dissolving in water.

-The orientation of the glucose units determines which enzymes can fit into the bonded regions. Enzymes in animals can't fit into those points on cellulose or lignin, but can on starch and glycogen.

-Some animals (rumenants-cattle, horses, sheep, deer) possess bacteria and protozoa in their digestive tracts. These organisms secrete enzymes which can break the bonds in the polysaccharide, and use the monosaccharides as food. As the microorganisms' populations increase they, and some of the monosaccharides, serve as nutrients for the animal.

-Anecdote
termite/cockroach eat cellulose, protozoans in their dig. tracts eat cellulose, bacteria in the protozoa digest the cellulose.

chitin (exoskeleton of arthropods) is a structural polysaccharide. Difficult to hydrolize. Few animals possess the enzymes to do so.

PROTEINS LESSON PLANS:

- Macromolecules (large) many functions
  - Structural support, bone, cartilage, hair
  - Enzyme catalysts, all enzymes are proteins, growth and cell functions
  - Transport/storage, Transferrin/Fe, Hemoglobin/O_2, Ferritin/stores Fe
  - Movement, muscle fibers/actin and myosin
  - Immunity, immunoglobulins
  - Hormonal regulation, Thyroxine (released as thyroglobin), insulin
  - Sensory perception, receptor proteins for light, neurotransmitters

-The functional diversity is due to practically unlimited potential for structural variation.

-Composed of combinations of twenty structurally different alpha amino acids.
Amino Acids-an organic acid which possess an AMINO GROUP (NH_3^-)

-and a CARBOXYL GROUP. ($COOH^-$)

-General structural formula:

alpha carbon is the one to which the carboxyl group is attached.

-If the amino group is attached to the alpha carbon it is an ALPHA Amino Acid.

HAVE STUDENTS FORM MODELS OF SIMPLE AMINO ACIDS. IMPRESS UPON THEM THAT THE STRUCTURAL DIFFERENCES BETWEEN AA'S IS THEIR R GROUP.

HAVE THEM FORM GLYCINE AND ALANINE.

Each amino acid is identified by its side chain (R group). It is attached to the alpha carbon.

The size, shape, charge, H-bonding capacity, and chemical reactivity of an amino acid is mostly dependent upon its R-group.

Side chains vary in complexity.

glycineleucine-

tryptophan-

Have the students refer to the handout which describes the various R-groups and the polarity of the amino acids.

-Variability of proteins:

a small protein might contain 100 amino acids.
2^{100} combinations are possible in that case.

sizes range from 50 to several hundred amino acids.

complex organnisms have several thousand different kinds of proteins.

arrangement of AA's gives each protein its own structural properties.

The properties allow it to carry out its specific function.

-Peptide Bond

covalent bond between carboxyl group of one AA and the amino group of the neighboring AA.

dehydration synthesis (Remind them that the bond can therefore be broken by hydrolysis.)

Dipeptide - 2 AA's linked, Tripeptide - 3 AA's linked, etc.

Handout diagrams of polypeptides.

always a free amino group at one terminus and a free carboxyl at the other.
free AA is the N-terminal, free carboxyl is the C-terminal.
free N-terminal is considered the beginning of the molecule.
when writing sequence, begin with this end.

HAVE THEM WRITE THE SEQUENCE OF PART OF THE POLYPEPTIDE DIAGRAM.

Three-D structure of proteins: (Use howard Hughes Foundation booklets)

4 levels-primary, secondary, tertiary, quaternary
(USING THE RIBBED RIBBON ANALOGY DESCRIBE THE 4 LEVELS)

primary-sequence of amino acids as determined by the DNA.
secondary-alpha helix and beta pleated sheets due to bonding between AA's
tertiary-bending and folding usually due to disulfide bonds and/or

hydrophobicity.
quaternary-merism of the bended and folded molecules

Breifly discuss sequence errors and how they might effect the shape and therefore function of a protein.

Show N.I.H. movie on Sickle Cell Anemia (2 days)

LIPIDS:

-Insoluble in water, soluble in organic solvents (i.e. acetone, benzene)
demonstrate vegatable oil with water and with several solvents

-they are non-polar (water is polar - reinforce that like likes like)

-three major categories: fats/oils-----------storage compounds
phosphoglycerides---- components of cell memb.
steroids----------- components of memb., vitamins, hormones

Fats and Oils

Fats- solid at room temp. and produced by animals. (lard, butter)
Oils- liquid at room temp. and produced by plants. (corn, olive oil)

chemical group called <u>esters</u> - compounds formed by reaction between an alcohol and an acid.

complete hydrolysis of one molecule of fat or oil yields glycerol, which is an alcohol, and from one to three long chain molecules called fatty acids.

HAVE STUDENTS MAKE A GLYCEROL MODEL WITH KITS

glycerol has three OH^- groups so three fatty acids can be joined to it through the dehydration synthetic reaction.

mono, di, tri acylglycerol depends on how many fatty acid molecules react with the glycerol molecule.

HAVE STUDENTS MAKE MODELS OF MONOACYLGLYCEROL. (H_2O ?)
HAVE THE ACID GROUP BE 13 - 14 C'S LONG.

triacylglycerols accumulate in the fat cells.

fatty acids - long zigzag chains of C's, usually with two H's per C, and always with a carboxyl (carboxylic acid) group at one end of the chain.

usually they are drawn as follows;

butyric acid (main component of buttermilk.)

HAVE STUDENTS MAKE A MODEL OF BUTYTIC ACID.

saturated/unsaturated fatty acids (double bonds)

more than one set of double bonds - polyunsaturated
ASK STUDENTS WHY THE WORD POLY IS USED.

animal fats (solid) - saturated (no double bonds)
plant oils (liquid) - unsaturated (double bonds)

if plant oils are hydrogenated (break double bonds and add H's) they become solids. (i.e. margarine & peanut butter) we call these hydrogenated vegatable oils.

HAVE STUDENTS MAKE MODELS OF STERIC ACID. GIVE THEM ONLY THE EMPIRICAL FORMULA. ($C_{18}H_{35}OH$)

HAVE STUDENTS MAKE MODELS OF OLEIC ACID. GIVE THEM ONLY THE EMPIRICAL FORMULA. ($C_{18}H_{33}OH$)

ASK STUDENTS WHERE OLEIC ACID MIGHT BE FOUND. (OLEO)
ASK THEM WHICH OF THE ABOVE IS SATURATED. SHOW THEM WHERE THE DOUBLE BOND GOES, AND HAVE THEM CORRECT THEIR MODELS.

- Lipids are a good energy source

complete oxidation (burning) of fats/oils releases twice as much energy (calories/gram) as do carbohydrates and proteins.

more water is produced when oxidized. (i.e. animals in hibernation/estivation need this water)

animals (fat) store as much energy as plants (starch) in half the mass.
ASK THE STUDENTS WHY THIS MAY BE BENEFICIAL TO THE ANIMAL'S SURVIVAL.
in mobile organisms (animals) less mass means more kilometers/gram of fuel. (similarity to automobiles)

-Phosphoglycerides

same as triacylglycerols except a phosphoric acid is substituted for a fatty acid, and an additional group is added to the phosphate.

the additional group attached to the phosphate provides a region of strong polarity.

oleic acid (C_{18}) saturated

palmitic acid (C_{16}) unsaturated

long chain portions are non-polar and therefore will not mix with water. ASK STUDENTS WHY. HINT: LIKE LIKES ?

additional group on phosphoglycerides is polar and will not mix with non-polar molecules. (THIS IS IMPORTANT WHEN DESCRIBING CELL MEMBRANE STRUCTURE, SO MAKE SURE THEY KNOW IT!)

long chains of phosphoglyceride molecules don't like to be around water (BECAUSE ITS POLAR) and thus are said to be hydrophobic. USE THE TERM PHOBIA WITH HYDROPHOBIA AND CLAUSTROPHOBIA.

additional group portion of phosphoglyceride molecules like water (ASK WHY) and are attracted to it. They are called hydrophilic.

polar region

non-polar region

ASK STUDENTS TO DIAGRAM THE ARRANGEMENT OF PHOSPHOLIPID MOLECULES SITTING ON THE SURFACE OF WATER IN A BEAKER.

ASK STUDENTS TO DIAGRAM THE MOLECULAR ARRANGEMENT OF THE SPHERICAL BUBLES WHICH FORM WHEN OIL AND WATER ARE EMULSIFIED. (SUSPENSION/MICELLES)

-Steroids

four interconnected carbon rings (i.e. cholesterol, estradiol, testost.)

HAND OUT DRAWINGS

no relationship to fats/pils or phosphoglycerides. the reason they are classified as lipids is because they are soluble in organic solvents but not in water. (ASK STUDENTS IF THEY ARE POLAR OR NON-POLAR)

cholesterol is one of the most abundant, it is found in the cellular membranes of all animals.

i.e. it is a major component of Schwann cells which wrap around axons of nerve cells and act as insulators.

it is a chemical precursor of important animal hormones (i.e. testosterone)

a 132# human normally has 1/2# of chlosterol

chlosterol tends to settle out of solution when present in high concentrations. sometimes precipitates from bile, forming gall stones in the gall bladder.

fatty / hardened

accumulates in walls of arterioles (athero-sclerosis) which contributes to; high blood pressure, stroke, and heart attacks EXPLAIN WHY IF TIME PERMITS

APPENDIX F

QUIZZES

DAILY QUIZZES

QUIZ #1

1. The smallest piece of an element which retains the properties of the element is a(n) ____(ATOM)____.
2. An __(ION)__ will have either more or less electrons than it does protons.
3. The four main energy levels are K, L, M, and N. What is the maximum number of electrons one would expect to find in the L level? __(EIGHT)__
4. The symbol for the element potassium is ____(K)____.
5. An atom which has an atomic number of 80 and an atomic mass of 200.59 Daltons will contain ____(121)____ neutrons.

QUIZ #2

1. Ionic compounds often __(DISSOCIATE)__ when placed in a solution of polar molecules.
2. An atom which strongly attracts electrons is said to be a(n) ___(OXIDIZING) agent.
3. If energy must be provided to form an ion, the formed ion has what charge? ___(POSITIVE)___
4. An atom which has the atomic number 13 has its electrons in which main energy levels?

ENERGY LEVEL	NUMBER OF ELECTRONS
K	__(2)__
L	__(8)__
M	__(3)__
N	__(0)__

5. If an atom loses electrons we say it has been __(OXIDIZED)__.

QUIZ #3

USING YOUR PERIODIC CHART, ANSWER THE FOLLOWING QUESTIONS.

1. If energy is necessary for a reaction to occur, the reaction is said to termed ______(ENDERGONIC)____.
2. How many electrons are there in the outside energy level of an atom with the atomic number of 15 ? _____(5)_____
3. Diagram an electron dot formula for an atom of magnesium.
4. Diagram, with an electron dot formula, a molecule of carbon dioxide.
5. Draw a structural formula for a molecule of carbon dioxide.

QUIZ #4

1. Succinctly, and in your own words, explain Lambert's Law.
   (The depth of a colored solution determines the amount of light transmitted from it.)
2. Briefly, and in your own words, explain Beer's Law.
   (The number of pigment molecules in a solution determines the amount of light transmitted from it.)
3. What can spectrophotometers be used for?
   (Determining which pigment molecules are in a solution and measuring the relative amounts of them present.)
4. What is meant when we say we read transmittance from the Spec. 20?
   (The meter gives us a relative measurement of the amount of light with a particular wavelength which has passed through the cuvette and sample.
5. What is meant when we say we read absorbance from the Spec. 20?
   (The meter gives us a relative measurement of the amount of light with a particular wavelength which has been "trapped" by the pigment molecules.)

QUIZ #5

1. Using the beet juice graph, determine the wavelength of light which is least absorbed. (670 nm) (close is good)
2. If we used paper chromotography on some beet juice, what should we see if ou data is correct?

   (We should see two pigment lines, one red and one blue.)
3. Using the beet juice graph, determine the wavelength at which the greatest amount of light was absorbed. (400 nm)
4. Using our data, and the fact that light at the wavelength of 680 nm seems to be transmitted most from the beet juice, we should see the color (RED) when looking at the beet juice.
5. Using the graph of absorbance as a function of %T, interpolate the value of "Y" if the %T is 31. (either 5 or 50) (close is good)

QUIZ #6

LABEL EACH OF THE FOLLOWING CHEMICAL EQUATIONS AS TO TYPE.

1. H_2O + SO_3 yields H_2SO_4

   (COMBINATION)
2. Ca + $2H_2O$ yields $Ca(OH)_2$ + H_2

   (SINGLE REPLACEMENT)
3. Cl_2 + 2NaI yields 2NaCl + I_2

   (SINGLE REPLACEMENT)
4. H_2SO_4 yields H_2O + SO_3

   (DECOMPOSITION)
5. AB + CD yields AC + BD

   (DOUBLE REPLACEMENT)

QUIZ #7

1. How many carbon atoms in a heptose? ____(7)____
2. A carbohydrate must have more than two ____HYDROXYL____ groups.
3. What is the correct general empirical formula for monosaccharides?
   ____$(CH_2O)n$____
4. Which of the following is not a function of carbohydrates?
   a. REGULATION OF CHEMICAL PROCESSES WITHIN CELLS
   b. structural component of cells
   c. an energy source for cells
   d. a carbon source for cells
5. What is the chemical structure which indicates an aldehyde?

QUIZ #8

1. Which of the following does not belong to the group?
   a. lactose b. (FRUCTOSE) c. maltose d. sucrose
2. Which three letters at the end of a molecule's name idicate that the molecule is a protein? ____(ASE)____
3. What affect can pH have on protein molecules?
   ____(pH CAN AFFECT THE SHAPE OF MOLECULES)____
4. Which of the hexoses has a five-sided ring?
   ____(FRUCTOSE)____
5. The process of breaking molecules apart by the addition of water is termed ____(HYDROLYSIS)____

QUIZ #9

1. List three functions of proteins.
   a. ENZYME CATALYSTS
   b. HORMONAL REGULATION
   c. SENSORY RECEPTION

   OTHER POSSIBLE ANSWERS; TRANSPORT/STORAGE, MOVEMENT, IMMUNITY, STRUCTURAL/SUPPORT
2. ____(POLYMERS)____ of amino acids are called proteins.
3. The amino and carboxyl groups of amino acids are usually attached to the ____(ALPHA CARBON)____.
4. Diagram the structure of a carboxyl group.

5. The least complex residue of amino acids is ____(-H)____.

QUIZ #10

1. The empirical formula NH_2 represents a(n) ____(AMINO)____ group.
2. Diagram the structural formula of glycine.
3. Circle the carboxyl group. (only that group, no other atoms.)
4. Structurally diagram a dipeptide using the letter "R" for residue.
5. Circle the carbon in the peptide bond. (Only the bond carbon)

QUIZ #11

1. Enzymes are ____(CATALYSTS)____ because the influence the rate of reactions.
2. Which of the following will NOT influence the rate of enzyme activity?
   a. the number of substrate molecules
   b. the number of enzyme molecules
   c. (THE PRESENCE OF OTHER ENZYMES)
   d. the pH of the environment
3. Metabolic paths can and do occur without enzymes but the process is ____(SLOW)____.
4. ____(ANABOLIC)____ metabolisms build larger structures.
5. Another name for a prosthetic group would be ____(COFACTOR)____.

QUIZ # 12

1. The major cellular function of phosphoglycerides is; (STRUCTURE OF CELL MEMBRANES).
2. A fatty acid with several double bonds is a(n)____(POLYUNSATURATED)____ fatty acid.
3. Glycerol is a three carbon ____(ALCOHOL)____.
4. Structurally diagram a diacylglycerol molecule.
5. Fatty acids are bonded to glycerol by a ____(DEHYDRATION SYNTHESIS)____ reaction.

QUIZ #13

1. Gel electrophoresis separates molecules because of their ___(CHARGE)___.
2. Mixtures between weak acid and salt of that acid are called ___(BUFFERS)___.

3. A solution with a pH of 5 would be represented by which of the following concentrations of H+, in moles/liter?

   a. .5 b. 1 x 10 5th c. (.00005) d. 5=
4. The negative of which of the following is the largest number?

   a. 1 x 10 3rd b. (1 x 10 -3rd) c. 1 x 10 6th d. 1 x 10 -2

5. The symbol representing the pH value when one half the buffer is dissociated is ___(pK)___.

APPENDIX G

TESTS

MOLECULAR BIOLOGY PRE/POST TEST

MOLECULAR BIOLOGY PRE-TEST

CHOOSE THE BEST ANSWER (50 POINTS)

1. SUBSTANCES WHICH DISSOCIATE IN POLAR SOLVENTS ARE,
   A. HYDROGEN BONDED B. SULFIDE BONDED
   C. IONIC BONDED D. COVALENT BONDED

2. A SOLUTION WHICH HAS A HYDROGEN ION CONCENTRATION OF (1×10^{-7}) PER LITER HAS A pH OF;
   A. 7 B. 10 C. -7 D. 1

3. A SOLUTION WITH A pH OF (1×10^{-5}) HYDROGEN IONS PER LITER WOULD BE CONSIDERED;
   A. ACIDIC B. ALKALINE (BASIC) C. NEUTRAL

4. AN ATOM OF THE ELEMENT IRON HAS AN ATOMIC NUMBER OF 26 AND AN ATOMIC MASS OF OF 55.847 DALTONS. DETERMINE THE NUMBER OF NEUTRONS IN AN ATOM OF THIS SUBSTANCE.
   A. 26 B. 30 C. 56 D. 82

5. IF AN ATOM HAS AN ATOMIC NUMBER OF 13, IT WILL HAVE HOW MANY ELECTRONS IN THE M ENERGY LEVEL?
   A. 13 B. 10 C. 8 D. 3

6. THE CHEMICAL SYMBOL FOR PHOSPHORUS IS;
   A. P B. Ph C. Po D. Ps

7. IN THE EQUATION $Mg + Br_2$, WHICH ELEMENT HAS GAINED ELECTRONS?
   A. THE ONE WHICH HAS BEEN REDUCED. B. THE ONE WHICH HAS BEEN OXIDIZED
   C. THEY BOTH HAVE D. NEITHER HAVE

8. WHICH OF THE FOLLOWING IS EXERGONIC?
   A. Na ATOMS + 119 KCAL YIELDS 1 MOLE Na^+ + 1 MOLE e .
   B. Cl ATOMS + ELECTRONS YIELDS 1 MOLE OF Cl^- + 83 KCAL.
   C. BOTH ONE AND TWO ARE EXERGONIC.
   D. NEITHER ONE NOR TWO ARE EXERNONIC.

9. THE EQUATION $Cl_2 + 2 KI$ YIELDS $2 KCl + I_2$ IS;
   A. COMBINATION B. DECOMPOSITION
   C. SINGLE REPLACEMENT D. DOUBLE REPLACEMENT

10. AN ATOM WHICH HAS BEEN OXIDIZED WOULD BE CALLED A(N);
    A. CATION B. ANION C. POSITIVE D. NONE OF THESE

THE NEXT THREE QUESTIONS INVOLVE THE FOLLOWING DATA RECORDED FROM SPECTROPHOTOMETRIC READINGS. THE FIRST ROW IS WAVELENGTHS, THE SECOND ROW IS PERCENT TRANSMISSION.

400	420	440	460	480	500	520	540	560	580	600	620	640
.22	.22	.22	.25	.28	.28	.30	.35	.40	.52	.68	.75	.40

11. The wavelength of light most greatly absorbed is;
    a. 400   b. 480   c. 600   d. 640

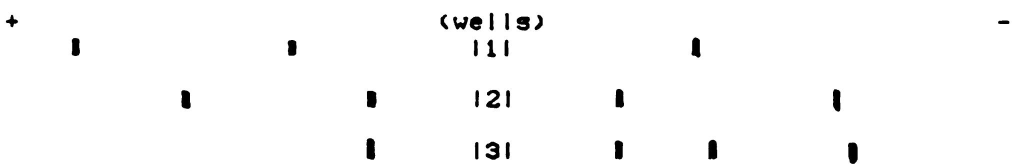
12. The number of different colors our eyes would see when looking at the cuvette which gave the above readings would be;
    a. 1   b. 2   c. 3   d. 4

13. These/this color(s) would be;
    a. blue   b. yellow and blue   c. yellow   d. green

14. Which of the following data supports Beer's law?
    a. Twice the thickness of solution causes twice the absorbance.
    b. Twice the thickness of solution causes half the absorbance.
    c. Twice the number of absorbing molecules causes twice the abs.
    d. Twice the number of absorbing molecules causes half the abs.

15. Observation of precipitans are important in the analytical technique called;
    a. gel permeation chromotograohy
    b. Ouchterlony diffusion
    c. spectrophotometry
    d. electrophoresis

THE DATA IN THE FOLLOWING DIAGRAM OF AN ELECTROPHORETIC GEL SHOULD BE USED TO ANSWER THE NEXT THREE QUESTIONS.



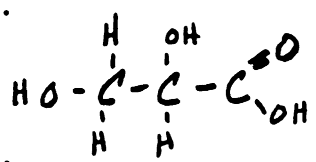
16. Which well(s) contained the protein mixture with the greatest number of different proteins?
    a. 1   b. 1 and 2   c. 3   d. 2 and 3

17. Which well(s) contained the smallest protein?
    a. 1   b. 1 and 2   c. 3   d. 2 and 3

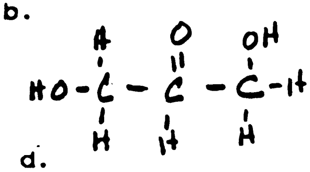
18. Which well(s) contained the greatest number of positively charged proteins?
    a. 1   b. 1 and 2   c. 3   d. 2 and 3

19. Which of the following is an aldehyde?

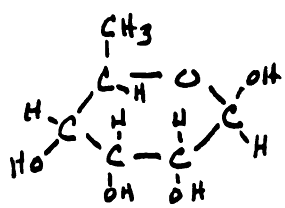
a.



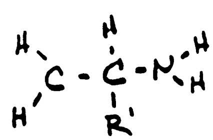
b.



c.



d.



20. Which of the following are the correct monosaccharide pairs for the disaccharide lactose?
    a. glucose-glucose b. glucose-fructose
    c. galactose-fructose d. glucose-galactose

21. Which of the following is the storage polysaccharide(s) in plants?
    a. starch b. glycogen
    c. glycogen and cellulose d. starch and cellulose

22. A simple sugar consists of
    a. a hydroxyaldehyde b. either a or d
    c. an acid and ketone d. a hydroxyketone

23. The protein molecule's tertiary structural characteristics are due to;
    a. the arrangement of amino acids.
    b. various monomers fitting together.
    c. hydrogen bonding forming the alpha helix or beta pleated sheet.
    d. bending and folding due to sulfide bonds and hydrophobicity.

24. Which of the following is NOT attached to the alpha carbon of alpha amino acids?
    a. H b. OH c. $COOH^-$ d. NH_2

25. Which of the following has a ring structure for the residue?
    a. glycine b. alanine c. glutamic acid d. tryptophan

26. A peptide bond forms between;
    a. the hydrogen of an amino group and the oxygen of a carboxyl.
    b. the alpha carbons of amino acids.
    c. between the nitrogen of an amino group and the alpha carbon.
    d. between the nitrogen of an amino group and the carbon of a carboxyl group.

27. The peptide bond is considered which of the following?
    a. ionic b. sulfide c. covalent d. hydrogen

28. If the molecular weight of a molecule of hemoglobin is 64,000 daltons, and the average amino acid has a mass of 120, how many amino acid molecules would there be in one alpha globin molecule?
    a. 574 b. 142 c. 284 d. 120

THE NEXT THREE QUESTIONS INVOLVE THE FOLLOWING DATA.

SAMPLE	pH OF SAMPLE	DENATURATION TEMP. (^{O}C)		
		TRIAL 1	TRIAL 2	TRIAL 3
EGG WHITE AND WATER	7.5	72	72	69
EGG WHITE AND BAKING SODA	10.5	84	85	84
EGG WHITE AND TARTAR	6.0	69	70	70
EGG WHITE AND SUGAR	8.0	72	72	72

Key: A. statement acceptable based on the data.
     B. statement disproved by the data.
     C. statement too broad a generalization.
     D. no data on the statement.

29. The temperature at which the protein in egg white denatures is directly proportional to the pH of the egg white sample.

30. Egg yolk probably has the same direct proportion as the egg white.

31. The lower the pH of the egg white mixture the lower the temperature will be when the protein denatures.

32. Complete hydrolysis of one molecule of triacylglycerol will yield;
   a. one molecule of glycerol and three fatty acid molecules.
   b. one molecule of glycerol and from 1 to 3 molecules of fatty acid.
   c. one molecule of glycerol and three molecules of acyl.
   d. one molecule of glycerol, one molecule of phosphate, and two molecules of fatty acid.

33. Most lipids are;
   a. polar b. non-polar c. neutral

34. Which of the following are common components of cell membranes?
   a. triacylglycerol molecules b. phosphoglycerides
   c. cholesterol molecules d. both a and c

35. What must be done to plant oils to make them into margarine?
   a. They must be chilled. b. they must be hydrogenated.
   c. they must be mixed with animal fat. d. they must be coiled.

36. The molecular formula of oleic acid ($C_{18}H_{32}OH$) is;
   a. saturated b. unsaturated c. polyunsaturated

37. Lipid molecules are;
   a. polar b. hydrophobic c. hydrophilic d. a and c

38. Which of the following contain ring structures?
   a. neutral lipids b. phospholipids c. waxes d. steroids

39. Which of the following is a carbohydrate?
   a. chitin b. glycerol c. valine d. insulin

40. Which of the following is a protein?
   a. chitin b. glycerol c. valine d. insulin

QUESTIONS 41-50 INVOLVE NAMING THE STRUCTURAL DIAGRAMS ON THE BOARD.

41. 42. 43. 44.

45. 46. 47. 48.

49. 50.

BIOLOGY II TEST
PROTEINS AND LIPIDS

FILL IN THE BLANKS WITH THE BEST ANSWER. (20 POINTS)

1. That which makes one amino acid different from another is the _______________.

2. The beginning of a polymer of amino acids is the ___________ terminal.

3. The bonds which connect one amino acid to another would be called a _________bond.

4. Bending and folding of polypeptides is due in part to _______ bonding.

5. Merism is the _________________ level of protein structure.

6. The sequence of amino acids in a protein is primarily determined by ______________

7. Gel _____________________ is a means of seperating protein by charge or mass.

8. Proteins are formed on cell organelles called ______________.

9. Hemoglobin serves the function of ______________.

10. _________ Daltons is the average mass of an amino acid.

11. Higher than normal temperatures often cause proteins to _________________.

12. One of the amino acids containing sulfur is ________________

13. The R group, carboxyl group, and amino group are all attached to the _______ carbon.

14. Proteins treated with SDS would seperate in an electrical field by ___________.

15. The three types of lipids are; fats and oils, phospholipids, and _______________.

16. Fats and oils are for the storage of ____________.

17. ____________ form from acids and alcohols chemically combining.

18. The alcohol found in diacylglycerol is ________________.

19. A fatty acid with a bend in the carbon chain is called________

20. The lipid _________________ is important in the formation of testosterone.

MULTIPLE CHOICE: (10 POINTS)

21. Which of the following is not an amino acid?
A. alanine B. glycine C. adenine D. glutamic acid

22. Hemoglobin is a;
A. monomer B. dimer C. trimer D. tetramer

23. Which of the following is not a fatty acid ?
A. stearic acid B. oleic acid
C. butyric acid D. glutamic acid

24. Diacylglycerol is partially soluble in polar as well as non-pola solvents and is said to be;
A. amphipathic B. hydrophobic C. hydrophilic D. insoluble

25. Which of the following is solid at room temperature?
A. peanut oil B. sunflower oil
C. corn oil D. hydrogenated olive oil

26. Which of the following is not a function of proteins?
A. carrier of materials in the molecular form.
B. formation of particular cell structures.
C. energy storage.
D. regulation of hormonal functions.

27. Which of the following is not a secondary determiner of protein structure?
A. beta pleated sheets. B. disulfide bonding C. alpha helix

28. Which of the following is the most common molecule in cell membranes?
A. triacylglycerols B. diacylglycerols
C. carrier proteins D. phospholipids

29. Equal amounts of which of the following could generate the most energy?
A. carbohydrates B. proteins C. lipids

30. Which of the following regulates the production of the others?
A. carbohydrates B. proteins C. lipids

31-40 Name each molecular structure drawn on the board.

REFERENCES

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