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ABSTRACT

The evaluation of a general college biology course taught by a combination of lectures, readings, small group discussions, and student-initiated activities, contains a list of the topics introduced in each of three semesters, the facilities available to students in conducting their individually designed research projects, audio-visual material available to staff and students for use in discussion groups, and vitae of the staff teaching the course. Positive and negative student and staff comments are reported. Statistically significant gains between the beginning and end of the course on the BSCS Comprehensive Examination, the Watson-Glaser Critical Thinking Appraisal, and n interest inventory are demonstrated. Correlations with average grade in the course and gains on each of the three test instruments used are reported for 17 student variables. Copies of term examination papers, a list of titles of student research reports, and a copy of the interest in biology inventory are appended. (AL)

Process-Centered General Biology*

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Oregon Education Coordinating Council,
Salem, Oregon.

Course Objectives

By instituting the Process-Centered approach to General Biology we had hoped to achieve a wider spectrum of the goals of introductory level biological science.

Through analysis and synthesis of reports from various sources, we arrived at the conclusion that scientists and professional educators are in general agreement on the objectives of a course in general biology, Murphy (6). Broadly stated our goals are:

(1) The communication of knowledge concerning the biotic environment of man and the communication of knowledge concerning man himself.

(2) The development of scientific attitudes appropriate to existence in our science-oriented society.

(3) The development of problem-solving abilities.

(4) The development of an interest in biology.

Study Objective

The goal of the current project was to conduct a thorough, statistically sound evaluation of the effectiveness of Process-Centered General Biology offered by the Department of General Science for the academic year 1970-1971. Effectiveness is judged on the basis of pre-test post-test gains in knowledge, critical thinking and interest in biology.

Process-Centered Course Description

The one hour lecture section of this course was devoted to the presentation of concepts and to the development of enquiry strategies rather than to the presentation of detailed information.

The themes of the course were

First Quarter - Environmental Biology
Second Quarter - Organismic Biology
Third Quarter - Cellular Biology

Assigned books for each quarter were related to the quarter's theme. Assigned books include Buchsbaum's Basic Ecology, Kormondy's Concepts of Ecology and Asimov's Wellsprings of Life. Titles for the winter quarters were Bold's The Plant Kingdom and Hanson's Animal Diversity. The text for the spring quarter was Swanson's The Cell.

For the purpose of arriving at grades the staff agreed upon the following arrangement:

(1) Lecture: Examination based on assigned books .25

(2) Small Group Discussion: Grade mutually decided upon by student and instructor .25

(3) Laboratory: Investigational activities and written papers .50

The grades were not based directly on lecture content because the lecture is designed primarily to inspire or incite students to greater efforts in reading, small group discussions and process centered laboratories.

In addition to the one hour lecture, students were expected to attend one small group discussion and one two-hour

session of laboratory per week. Except for absentees no student spent less than one hour per week in small group discussions and few students spent less than two hours in laboratory. Many spent from two to ten hours per week.

In Process-Centered laboratories and small group discussions stud t activities were spontaneous and were directed toward the solution of biological problems. Problems were defined tnrough student-student or teacher-student interaction. No laboratory manual was used and the instructor gave no specific directions as to how a particular problem was to be studied.

When an instructor poses general questions, students usually ask more specific questions which are directed at deriving clues regarding the general answer (observations as a student and as a teacher). Once the students ask these questions, they have defined biological problems which they can solve to some degree of satisfaction through "inductive methods". Through small group discussion, the students and the instructor decide which of the student questions can be effectively studied in the process-centered laboratory.

After feasible problems have been identified for study, students are asked to draw on their reading, lecture material and past observations to arrive at guesses (hypotheses) as to possible answers to their questions (biological problems). Once students make plausible guesses as to the answers to their questions, they then test the validity of their guesses. Since the students use specific facts which

they discover as a basis for acceptance, rejection, or refinement of their guesses, all students are using "inductive methods". Each student or student group designs his step by step attack of the problem (experimentation).

Through this process, students make use of scientific methods in arriving at the answers to biological problems. They derive their solutions directly from preserved and living biological specimens rather than accepting written or oral authority. These students study science as "enquiry" or "process". The "process" approach to the study of biology should contribute to the communication of knowledge of the biotic environment of man at the same time it leads to the development of scientific abilities through the use of "inductive methods". (Murphy, 5)

The following syllabus is intended to present a general outline of the topics which students might be exposed to during the course of "Process-Centered General Biology. The syllabus should be considered a suggested topical outline. The syllabus should not be considered chronological, except that general themes were presented by quarter.

Process-Centered Syllabus

FALL TERM: ENVIRONMENT

1. The nature of man - What is man? What is his role in the universe?

2. Environmental Balance - static or dynamic?
   A. Ecosystems - Accumulation of energy, cycling, transformation, storage, conversion and conservation. Photosynthesis, decomposition, herbivory, predation, symbiosis, parasitism.

B. Environmental factors - Biogeochemical cycling, cycling of energy and water, evaporation, precipitation, erosion, deposition, biotic factors, trophic or food relations.

C. Communities - characteristics, succession, association, climax theory, maturity, complexity.

D. Niches

E. Populations - Nature of population growth, interaction of populations, regulation: space, intraspecies problem, non-living factors, interspecies relations, individuals.

F. Adaptation - diversity, evolution

WINTER TERM: ORGANISMIC

1. Internal Balance
   A. Energy Capture - Nutrition

   B. Obtaining Oxygen - Gas exchange

   C. Transport - Blood, heart, vascular elements

   D. Waste disposal

   E. Balance Mechanisms - Endocrine and nervous systems

   F. Perception of the Environment - Nervour system: Senses, Mechanism of nerve function, disruption and distortion of sensory impression - Alcohol and drugs

   G. Movement

   H. Imbalance of Man: Communicable disease, Immunity, Degenerative disease

2. Reproduction
   A. Introduction to Genetics
      1. Significance
      2. Asexual reproduction - main types
      3. Sexual reproduction - process and significance of meiosis

   B. Genetics

   C. Sexual reproduction, growth and development in Plants Life cycles emphasizing alternation of generations: thallus plants, bryophytes, ferns, flowering plants (seed formation, fruits)

D. Sexual reproduction in animals
   1. Development and importance of cross-fertilization
   2. External fertilization
   3. Evolution of internal fertilization for protection of egg and embryo - terrestrial forms
   4. Man - anatomy and physiology of reproductive system, embryology

SPRING TERM: CELLULAR

1. Origin of the universe
   A. Time theories of Origin (Big bang, Steady state) evidence to support these theories.

   B. Formation of: Galaxies, the Solar system, the earth, the elements

   C. The Changing Environment
      1. The Earth - Materials: rocks and rock types, elements, compounds, atomic theory, motion and measurement.
      2. History of Life - Records in strata (Paleontology), Time radioactive measures.

2. The Beginnings of Life
   A. Evidence and experimentation supporting formation of life.
      1. Energy sources
      2. Organic molecule formation
      3. Self duplication of molecules
      4. Miller-Urey experiments, AI Oparin, Coacervate Theory

   B. Formation of proto-cell
      1. Properties of new cells
      2. Cellular components; wall, mitochondria, etc.

3. Protoplasm
   A. Chemistry involved in physiological processes

   B. Physical aspects: diffusion, osmosis, dialysis

   C. Biological Aspects
      1. Mitosis
      2. Tissues - plant and animal
      3. Systems

   D. Metabolism
      1. Catobolism, Anabolism, Chemosynthesis, Photosynthesis
      2. Cellular respiration
      3. Cycles - Carbon, Nitrogen, Nutrient
         a. food chains
         b. "web of life"

E. Nutritive processes in living things
   1. Digestion and assimilation in plants
   2. Alimentation and assimilation in animals

Facilities and Equipment

This program was implemented in a three room complex. One of the three rooms contained the process-centered equipment. One of the rooms was designed to facilitate small group discussions; i.e., a round-table arrangement. The equipment that was available to the students was as diverse as the program itself. Student grade microscopes were supplemented with two phase-contrast microscopes. A spectrophotometer and autoclave were available as well as centrifuges, a Ph meter and a cryostatic microtome. Culture centers containing wide varieties of algae and invertebrates were available to the student. All of this equipment was complemented with the usual glassware, bunsen burners, hot plates, magnetic stirrers, etc. that are or should be found in a well equipped student laboratory.

The following description of facilities and equipment is more illustrative of the facilitative nature of our instructional complex:

Process-Centered Laboratory:

Student capacity: 15-24 seats

Flexible table arrangements adaptable to various projects

Gas and water

Subsidiary stockroom for storage of supplies from central stockroom

Research laboratory for student use, adjacent to teaching laboratory with equipment. e.g. spectronic 20, research microscope, algal culture unit, etc.

Small Group Discussion Room 2 OM.:

Student capacity: 15-24 seats

Flexible table arrangement

Books and periodicals current to topic

Bulletin board with current themes (designed by students in elementary or secondary education)

Audio-Tutorial Laboratory: (available as needed by individual students)

Student Capacity: 30 carrels

Two large demonstration tables, one equiped with a sink and gas.

Large stockroom used for laboratory preparation and storage

Two rooms used exclusively for storage.

Lecture Hall:

Small auditorium with sound system and large screen for use of overhead projector.

Equipment used in Process-Centered Biology:

Binocular American Optical Research microscope

Stereoscopic dissecting microscopes

Compound microscopes

pH meter (Coleman)

Desk centrifuges

Spectronic 20

Algal Culture unit (automatic timer)

Single beam balances

Sterilizer

Dessicator

Air pumps

Aquaria

Hot plates

Animal cages

Autoclave

Forced air oven

Miscellaneous glassware

Chemicals

Drosophila culture facilities

Refrigerator - freezer

Process-Centered Laboratory supplies with standard student general biology equipment and supplies with adjacent research facilities

Nikon Binocular microscope

Green house

Cold room (walk in type) 8' X 6'

Audio-Tutorial Laboratory with 30 carrels and small culture center

8 Super 8 mm movie projectors

20 Pana-vue Kodachrome Slide viewers

Minimum collection of approximately 500 prepared glass slides ranging from tissues (plant and animal) to representatives of the plant and animal phyla.

A-V Department P.S.U.

The Audio-Visual Department at Portland State University has the following facilities and services which were used by our faculty and students:

1 Multi-purpose preview and listening room seating 25 students.

2 Preview rooms seating 20 students each.

1 Small group listening room seating 12 students.

6 Individual listening booths.

20 Listening carrels with a capability for reception of 10 separate programs. The carrels have the capacity for the use of filmstrip viewers and 8mm loop cartridges. Cassette-type players and recorders may also be used.

Student production laboratory area for production of slides and overhead transparencies.

1. Recording studio and related equipment for duplicating tapes and editing.

1 Production unit using high quality equipment of slides, overheads and 8mm films for faculty needs for original visual material. This unit is staffed by a graphics artist and two photographers.

C.C. Television capability is provided in the preview rooms, the multipurpose preview and listening room and in the student production laboratory area.

The normal inventory of A-V equipment is available for student use.

Resources

Appropriate bibliographic guides and tools may be consulted. Professional advice regarding use of materials is available.

Collections	Biology Holdings
600 films (both 16 & 8mm)	123
3,000 filmstrips	300
5,000 recordings	20
1,000 tape recordings	10
200 overhead transparencies	-
11,000 slides	515

Staff

Two professional librarians/media specialists
4 Clerical assistants (full-time)
2 Technicians (full-time)
30 Student assistants, (projectionists, lab assistants, technicians and clerical assistants)
1 Graphics Artist
2 Photographers

Films Available at Portland State University Audio-Visual Library (Partial list)

Algal Syngamy - Oogamy in Oedogonium. 4 min. Color 8mm. Iowa, 1965

Algal Syngamy - Zygote Formation in Pandorina. 4 min. Color 8mm. Iowa, 1965

Baboon Behavior, 31 min. Color. UC, 1961.
Compares their behavior and development with human behavior.

The Brain and Behavior. 29 min. Black and White. NET, 1963. Correlates: Electrical activity of brain and man's behavior.

Birth Control and the Law. 58 min. Black and White. CBS, 1962.

DNA: Molecule of Heredity. 16 min. Black and White. EBF, 1964.

Frog Anatomy. 17 min. Color. IU, 1969.

The Function of DNA and RNA in Protein Synthesis. 18 min

Human Heredity. 23 min. Color. Brown, 1956.
Discusses union of sperm and egg cell, Chromosomes, Genes, Heredity.

Life of the Molds. 21 min. Color MH, 1958.
Growth, reproduction, and environmental adaptions.

Mitosis of Chick Heart Fibroblasts Grown in Vitro. 15 min. Black and White. OSC, 1956.
Detailed study of cell division's four phases.

Photosynthetic Fixation of Carbon Dioxide. 2 films. 4 min. each. Color, Iowa, 1965.

Syngamy and Alternation of Generations in Allomyces - A water mold. 20 min. Black and White. PHASE, 1953.

World in a Marsh. 22 min. Color. MH, 1958.
Life in a marsh; its balance and survival of the fittest.

New Films not yet Catalogued

Cranial nerves

Darwin's Finches

Fresh Water Plankton

Partial List of filmstrips available at P.S.U. Audio-Visual Library. Students may use any filmstrip by requesting filmstrip and viewer. Filmstrips are to be viewed in Audio-Visual Library except when a student wishes to show filmstrip in a small group discussion as support for his hypothesis.

116 Life in Ponds, Lakes and Streams
117 Small Freshwater Animals, Insect
118 Fresh Water Shellfish, Amphibians
119 Fresh Water Turtles and Fish
120 Keeping an Aquarium
121 Plants and Strange Animals of the Sea
122 Shellfish of the Seashore
168 Understanding Snakes
190 Creatures of the Sea
628 Birds of the Countryside
632 Birds of the Sea and Shore
902 The American Buffalo
905 Coyotes and Other Prairie Animals
925 Life and Death of the African Plain
928 Elephants in Africa
932 Arctic Foxes and Wolves
934 Birds of the Northland
1339 Land of Tropical Forests
1643 Symbiosis: Strange Partners
1695 Zoo Snakes and their Relatives
1889 Learning About Mammals

1888 Learning about Birds

1897 Snakes

1907 Birds of Prey; Primitive Water Birds

Birds and Animals

1974 Snails and Slugs

1978 Arachnids, Centipedes and Millipedes

1980 Primitive Cartilage Fish

1981 Primitive Bony Fish

1988 Carnivores

2110 The Snail and its Relatives

2267 What is a Vertebrate?

Botany

1586 The Plant Kingdom

1587 Life Cycle of a Plant

1588 Roots of Plants

1589 Stems of Plants

1590 Leaves of Plants

1951 Flowers and Fruit

1853 The Parts of a Plant

1991 Bacteria

1993 Algae

1995 Bryophytes

1996 Gymnosperms

1997 Monocotyledons

1998 Dicotyledons

1340 Mammals of the Tropical Forests

1713 What is Conservation?

1714 Saving Our Soil

1715 Enough Water for Everyone

1716 Improving our Grasslands

1717 Using Our Forests Wisely

1718 Giving our Wildlife a Chance

1719 Using our Minerals Wisely

116 Life in Ponds, Lakes and Streams

117 Small Fresh Water Animals and Insects

1869 Insects: What They Are

1870 Insects: Their Life Cycles

1884 What is an Insect?

1885 The Life Cycles of Insects

2185 Beetles and Their Life Cycles

2187 Dragonflies and Damselflies

Personnel

Personnel for the Process-Centered General Biology course included:

1. Glenn W. Murphy, Associate Professor .5 FTE devoted to teaching and directorship of the course.

2. Ellen Benedict, Instructor 1.0 FTE devoted to instruction in laboratories and small group discussions.

3. Arthur Lowell, Teaching Assistant .33 FTE devoted to instruction in laboratories and small group discussions.

4. Mike Uhtoff, Teaching Assistant .22 FTE devoted to instruction in laboratories and small group discussions.

5. Sally Lind, Instructor .25 FTE devoted to instruction in laboratory and small group discussions.

6. Stanley C. Poitras, Undergraduate student assistant. Devoted 15 hours per week to preparation of solutions and instruction in use of equipment.

7. Assorted other undergraduate assistants who devoted part time as needed.

The following resume's provide some indication of the quality of the academic staff associated with the course.

6. Stanley C. Poitras, Undergraduate student assistant. Devoted 15 hours per week to preparation of solutions and instruction in use of equipment.

7. Assorted other undergraduate assistants who devoted part time as needed.

The following resume's provide some indication of the quality of the academic staff associated with the course.

I. Dr. Glenn W. Murphy, Associate Professor General Science

A. Experience:

Murphy, Glenn Wayne (1940) Associate Professor (1969)

Education

B.A.	University of Kentucky	1962
M.A.	University of Kentucky	1963
Ed. D.	University of Kentucky	1967

Previous Experience

1959-61	Elementary teacher, Liberty Kentucky
1961-61	Research Assistant in Botany and Ecology, Kentucky
1962-62	Teaching Assistant, Summer Institute, Kentucky
1962-63	Science teacher, Hustonville, Kentucky
1964-69	Assistant professor, Biology and Education, Virginia Commonwealth University
1969-	Associate Professor, General Science, Portland State
1970-71	Acting Head, General Science, Portland State

Research and Interest Fields

Biological Systematics, Curricular Development

Course Responsibility

General Biology, Field and Laboratory Techniques, Methods of Teaching Science

Publications

High School Students as "Accomplished" Field Botanists. American Biology Teacher. Vol. 30, No. 7:545-547, September 1968. Glenn W. Murphy, Dianna S. McKinney and Junius Woodard.

The River and its Tributaries: Our Laboratory. American Biology Teacher. March, 1968.

Content Versus Process Centered Biology Laboratories, Part I: Foundations of Biology Education. Science Education. February, 1968.

Content Versus Process Centered Biology Laboratories, Part II: The Development of Knowledge, Scientific Attitudes, Problem-Solving Ability and Interest in Biology. Science Education. February, 1968.

For Cell Study: The Use of Nitella sp. American Biology Teacher. October, 1967.

Algae, a Simple Tool for Teaching Scientific Methods. The Science Teacher. May, 1966.

For Culturing Algae: A Modification in the Use of Bristol's Solution. American Biology Teacher. February, 1966.

General Science - Increasing Student Motivation. The Science Teacher. October, 1965

The Theory of Expectancy Applied to Laboratory Sickness. American Biology Teacher. September, 1965.

Fishes of the Green River Basin in Casey and Lincoln Counties, Kentucky. Transactions of the Kentucky Academy of Science. Auguest, 1965.

Fishes of Green River. 1964. The Casey Press. A booklet written and published especially for high shcool students.

A Preliminary Survey of the Flora of Casey County, Kentucky. Castanea. Vol. 25, No. 2:118-131, June, 1970.

Content Centered vs. Process Centered Biology Laboratories Part IV: The Relationship of High School Achievement ot Success. Science Education. Vol. 54, No. 1:41-44, January-March, 1970.

Content Centered vs. Process Centered Biology Laboratories, Part III: The Relationship of Student Values to Success. Science Education. Vol. 54, No. 1:37-40, January-March 1970.

II. Ellen Benedict, Instructor, General Science

A. Experience

Benedict, Ellen M. (1931) Instructor (1969)

Education

B.S. Portland State 1965
M.S. Portland State 1969

Previous Experience

1966-1969 Graduate Assistant in Biology, Portland State
1969- Instructor in General Science, Portland State

Research and Interest Fields

Soil arthropods

Course Responsibility

General Biology

Publications

A systematic and ecological study of the genus Pseudotyrannochthonius in the Pacific Northwest. Proceedings of the Oregon Academy of Sciences, Biology Section. With D.R. Malcolm.

An unusual aggregation of the newt Taricha granulosa granulosa. Copeia. 1970 (1): 176-178. With M. Coates and C.L. Stephens.

Some pseudotrannochthoniine false scorpions from western North America (Chelonethida: Chthoniidae). J. of N.Y. Ent. Soc. 1970, 78(1):38-51. With D.R. Malcolm.

Professional Organizations

Oregon Academy of Science, Oregon Entomological Society, California Academy of Sciences, American Association for the Advancement of Science, Oregon Society of Marine Biology, Centre International de Documentation Arachnologique, Portland Zoological Society

III. Sally K. Lind, Instructor, General Science

A. Experience

Lind, Sally K.

Education

B.S. Oregon State University 1959
M.S. Portland State University 1970

Previous Experience

1959-63 Teacher, Denver Public Schools
1965-69 Substitute Teacher, Beaverton Schools
1969-70 Graduate Teaching Assistant, Portland State
1970-71 Instructor, Portland State

Research and Interest Fields

Special methods of education of economically disadvantaged students

Course Responsibility

New Careers contract class, Health Science; Audio-Tutorial Biology, Process-Centered Biology, Operation Plus Core Curriculum.

Professional Organizations

Phi Kappa Phi, Phi Sigma

Honors

Mortar Board

Course Evaluation

Cost analysis:

When considering alternative approaches to instruction administrators and instructors alike consider comparative cost a primary determining factor. Therefore a cost analysis (Table 1) is presented at the outset of the present project evaluation.

Table 1 presents a breakdown of instructional costs directly attributable to three approaches to General Biology as offered by the General Science Department. For Audio-Tutorial and Process-Centered Biology the cost estimates are fairly accurate. The cost estimates for the Traditional approach are deflated in that the Traditional instructors relied heavily on Audio-Tutorial and Process-Centered supplies, services and equipment.

After adjustments are made for "Traditional " use of Audio-Tutorial supplies and equipment it appears that the two approaches would cost approximately the same per student credit hour (roughly $20.00 per student credit hour). It should also be noted that the cost of Audio-Tutorial includes the initial purchase of thirty student carrels, a large expenditure which will not be necessary in future operation of the course.

Process-Centered General Biology is clearly more costly than the other two approaches. The cost of roughly $30.00 per student credit hour is approximately 150 per cent of the cost of the Audio-Tutorial and Traditional courses. The

inflated cost is clearly a result of the course structure. The structure demands a small student: instructor ratio and also requires that students be able to order supplies as needed for their research projects.

Any decision to implement Process-Centered Biology requires recognition of merits which outweigh consideration of the added cost.

Table 1

Comparative Instructional Costs

Academic Year 1970-1971

Cost Category	Total Cost			Cost per Student Credit Hours		
	A-T	P-C	Trad.	A-T	P-C	Trad.
Services & Supplies						
90-050-0490	645.21	1,087.04	72.06			
90-260-4119	3,846.78					
90-260-8101		1,339.29				
Total	4,491.99	2,426.33	72.06			
Equipment						
90-050-0490	160.00	160.00				
90-260-4119	15,071.91					
90-260-8101		745.00				
Total	15,231.91	905.00				
Student Wages						
90-260-4119	733.38					
90-050-5302		323.52				
Total	733.38	328.52				

Cost Category Continued	Total Cost A-T	Total Cost P-C	Total Cost Trad.	Cost per student Credit Hours A-T	Cost per student Credit Hours P-C	Cost per student Credit Hours Trad.
Faculty Salaries						
90-050-0490	$ 27,787.00	19,486.00	5,832.00			
90-260-4119	7,654.00					
Total	35,441.00	19,486.00	5,832.00			
TOTAL	55,898.00	23,146.00	5,904.00	20.34	29.56	17.42

Enrollment Trends

When holding power of a course is considered an index of effectiveness, Audio-Tutorial and Process-Centered Biology are equally effective while both are more successful than Traditional Biology. Based on Fall Quarter enrollment (see Table 2) the Audio-Tutorial course had a retention of 88% Winter Quarter and 86% Spring Term. Process-Centered Biology had a retention of 88% for the Winter Quarter and 86% for the Spring Quarter. The Traditional course had a retention of 81% Winter Quarter and 54% for Spring Quarter.

Table 2

Enrollments

	Audio-Tutorial		Process-Centered		Traditional	
	Enrollment	Student Credit Hours	Enrollment	Student Credit Hours	Enrollment	Student Credit Hours
Fall	333	999	95	285	48	144
Winter	295	885	82	249	39	117
Spring	288	864	82	249	26	78
TOTAL	916	2748	261	783	113	339

Student Reactions

Depending upon the reader's philosophical stance, the success or failure of Process-Centered General Biology may be assessed by analyzing the following condensed list of student statements regarding the positive and negative features of the course.

The following responses were given in the Process-Centered lecture of November 11, 1970 to the questions:

"What are the most positive features of Process-Centered Biology?"

Freedom, being allowed to study what you want at your own speed. The more personal teacher-student relationship helps.

Advantage of hearing and learning things which are of interest to another student. There is an understandable communication when your ideas are being exchanged between people of your own level.

Independent-study biology supports the progressive idea that the aim of education should be to teach students how to think, rather that what to think.

More emphasis put on individual learning and less on grades.

I like having one major project in which I can become completely involved rather than ten smaller experiments which I usually don't understand anyway.

The material is much more relevant than the usual biological material of fact after fact.

By exploring fields of interest we can learn and not just memorize statements and can apply or fit them into our lives.

You don't have to take everything for fact, you can follow it through yourself and find out if it is negative or positive.

Individual projects wipe out competition and encourage scientific development.

The small group discussions are very positive features of Process-Centered Biology. One has the chance to compare and share with others in the class the things he has found or expects to find with his experiment.

If you get interested in something you can pursue it without feeling quilty of letting the text down.

I feel that I am a person as a student and not just a number.

I don't feel as lost as I have in previous science courses, and not so scared of science now.

The student by experimentation gets to observe and record the results of an important experiment which is pertinent to the environmental problems which now threaten us.

"What are the most negative features of Process-Centered Biology?"

The labs are great but I feel the lectures lack factural (sic) material.

Some un-motivated people are not compelled to get busy.

I'm confused to exactly know what we should be doing to obtain a grade.

The most negative feature is class at a particular time.

A full picture of biology may not be presented to the students.

Signed up for the lecture teacher but twice a week get someone else.

Having been educated in a "do this first, then that" type structure, the freedom and responsibility offered by the Process-Centered Biology requires a "little bit" of adjustment.

Lack of homework on study assignments.

The negative aspects of this independent study is that it is contradictory that this is being initiated on a college level whereas in the previous 12 or 13 years of education it was only discussed therefore it causes a "spoon-fed education backlash."

Faculty Evaluation

Near the end of the year, the General Science Faculty who are involved in the General Biology course were asked to respond to the same questions the students had answerd in November. Evaluations by those who responded to the request were as follows.

I. What do you consider to be the most positive aspect of Process-Centered Biology?

A. "highest potential for turning even the "worst" students on to something."

"students become involved with their life, they look at the world in terms of questions rather than answers.

B. students become aware of scientific process.

areas extend outside of hard biology, thus approaching an integrated program.

encouragement of level 2, 3, & 4, thinking

fields of study open, encourages inquiry

requires independent consultation with resources outside of lecture and immediate texts

curriculum proceeds from areas of simplest learning to areas of more complex learning, which is a logical learning process

instructors have a 1 to 1 relationship with students

development of secondary, peripheral objectives

experimentation encouraged

student loses inhibition concerning sensitive areas of inquiry

students develope sense of responsibility for own progress

C. both fall and winter term I was involved in lecture and lab and small group discussion in regular P-C programs. I feel that this program has many positive aspects including:

1. The pathway is open for students to launch into projects of their own choosing.
2. A give and take of learning is possible and provided for in small group discussion provided the group has learned that each has something important to contribute to the knowledge of the group - and not just the instructor. To establish this cooperative attitude is the main task of each instructor.

D. "the most positive aspect, in my opinion, is that of creating scientific thinking in regards to method of learning."

E. the most positive aspect, without a doubt, is the personal involvement of those students capable of, and willing to, become personally responsible for their own learning.

II. What do you consider to be the most negative aspect of Process-Centered Biology?

A. "lack of some central theme for all students"

B. requires energy and time that few students have available solely for this course

students usually too dependent on grades and precise requirements

process is too long term for a 1 year course

process to easily reverts to practices not consistent with P-C philosophy

staff uncomfortable with lack of level 1 learning

uncertainity as to what tests should evaluate

impossible to evaluate those aspects of learning the P-C approach is designed to facilitate

C. I feel that attendance at small group discussion is essential and a mechanism needs to be devised that will promote this activity.

procrastination is a human quality that becomes very apparent in non-structured situations. I'm trying to think of a way to get people involved in study earlier than they have been in the past leaving them time at the end of the project to draw some conclusions

I feel that P-C is not a panacea for all college students and I would hope that techniques be contemplated to determine ways to separate those who would learn more from a more highly structured approach.

D. "any negative aspect may involve continuation of learning on the student's part in a narrow area. My belief is that beginning students should be presented with a wide variety of opportunities (through content) etc. develop new areas of interest through awareness.

E. the most negative aspects are the kind of "con" job an instructor gets, intended to convey the impression work has been done and learning achieved where in fact neither has been the case, and the inability of many to tackle a problem independently.

Grade Distribution

If it is first admitted that course grades reflect many things in addition to knowledge, then analysis of grade distribution may reveal a number of things regarding the success of a course.

For Process-Centered Biology, grades represent a consensus of the judgments of the staff to arrive at grades per quarter, course activities were weighted as follows:

Lecture Examination	25%
Laboratory	50%
Small Group Discussion	25%

While scores on final examinations may represent a somewhat objective basis for grading, evaluation of laboratory activity and small group discussion participation are admittedly highly subjective.

The three final examinations (Appendix I) were quite different. The fall term examination was an in-class essay type. For winter quarter students were handed examination directions one week in advance of the testing date. The spring term examination was an in-class objective test (multiple choice). Term examinations were graded by the entire academic staff assigned to Process-Centered General Biology.

Laboratory instructors evaluated students on the basis of project reports (see Appendix II for listing of student research topics) and observed laboratory activity. Criteria

for grading included evidence of knowledge, scientific attitude and problem solving ability as judged by the instructor.

Grades for small group discussion were based on a subjective evaluation of student participation and contribution. The composite grades are presented in Table 3:

Table 3

	AB	P,C	W	I
Fall	41	20	9	25
Winter	43	6	15	20
Spring	39	15	16	12
Year Totals	123	41	40	57

An analysis of the total Process-Centered grade distribution indicates that 47% of the students demonstrated either good or excellent performance in the course. Students who did average (?) work represented only 16% of the total. Another 15% withdrew from the course or were given grades of withdrawal in lieu of F. At the end of the year, 22% of the grades assigned were incompletes (I).

Considering that 47% of the students were highly successful while another 37% received either an I (I's also include A and B potentials) or a W, one must conclude that the Process-Centered approach mitigates against mediocre performance. Either the student does very well or he is unsuccessful.

The grade distribution indicates a need for counseling some students into the course while conseling others into sections of General Biology which utilize alternative approaches. (See correlates of success, p.).

Objective Evaluation of Process-Centered Effectiveness

A more objective evaluation of Process-Centered Biology is based on tests of the significance of pre test-post test gains on the BSCS Comprehensive Examination (appendix IIIB). the Watson-Glaser test of Critical Thinking (appendix III A). and Interest Inventory developed by the project director (appendix IIIC). These instruments are purported to measure (1) biological content and processes, (2) development of critical thinking and (3) development of interest in biology, respectively.

Inspection of Table 4 reveals that pretest-post test gains were significant for all three instruments. Gains on the BSCS examination and gains in interest in biology were significant at the .01 level. Gains in critical thinking were significant at the .05 level. These levels of significance support the conclusion that Process-Centered Biology was an effective instructional program.

Table 4

Significance of Gains on BSCS, Watson Glaser and Interest Inventory

Instrument	MeanD	N	SD_D	SE_{MD}	t	Level of significance
BSCS	2.69	39	5.33	.85	3.16	.01
Watson-Glaser	3.42	38	9.66	1.56	2.19	.05
Interest Inventory	1.50	38	2.40	.389	3.85	.01

Correlates of Success in Process-Centered General Biology

In addition to assessing the effectiveness of Process-Centered teaching we conducted an analysis of the correlates of success in the course. Correlation coefficients were computed for (1) grade in course, (2) BSCS gains (3) Watson-Glaser gains, and (4) interest gains versus the following possible correlates:

STAT = student status; Freshman, Sophmore, Junior, Senior, Graduate
SEX = male or female
MAR = married or single
BRTH = date of birth
SATV = scholastic aptitude verbal score
SATM = scholastic aptitude mathematical score
HSGP = high school grade point average
CURG = current university grade point average
CURH = current number of hours student is enrolled for
TOTG = cumulative grade point average
TOTH = total number of quarter hours to date
MMAJ = major at matriculation
CMAJ = current major
PRE I= pretest score on Interest Inventory
PRE B= pretest score on BSCS Comprehensive examination
PRE W= Pretest score on Watson-Glaser Critical Thinking Appraisal
CGPA = students three term average grade in the course

For measures of effectiveness the following symbols were used.

CGPA = students three term average grade in the course

DEL I= pre-test - post-test gain on Interest Inventory

DEL B= pre-test - post -test gain on BSCS Comprehensive Examination

DEL W= pre-test - post -test gain on Watson Glaser Critical Thinking appraisal

In terms of course grades, success may be predicted on the basis of enrollment status, marital status, total quarter hours completed and pre test scores on the Watson-Glaser Critical Thinking appraisal (see Table 5). The higher the enrollment status the more likely the student is to succeed. Concomitantly, the greater number of hours he has completed the more success he is likely to enjoy. Married students are more successful than single students. Finally, students who have high initial critical thinking scores are more successful with Process-Centered General Biology.

Marital status and initial critical thinking scores may also be used to predict success in terms of gains on the BSCS Comprehensive examination.

These correlates should enable some selective placement of students in the Process-Centered course.

Table 5

Correlates of Success in Process-Centered General Biology

	CGPA		Del B		Del W		Del I	
	r	l	r	l	r	l	r	l
STAT	0.46	.01	0.17		-0.06		-0.03	
SEX	-0.02		0.12		-0.15		0.08	
MAR	0.30	.05	0.45	.01	-0.004		0.005	
BRTH	-0.27		0.01		0.05		-0.08	
SATV	0.23		0.13		0.10		0.09	
SATM	0.24		0.11		0.12		0.06	
HSGP	0.21		0.12		0.12		0.04	
CURG	0.07		-0.13		-0.14		0.07	
CURH	0.12		-0.14		0.09		-0.09	
TOTG	0.02		-0.19		0.03		0.08	
TOTH	0.39	.01	0.23		-0.08		0.07	
MMAJ	0.05		-0.13		-0.07		-0.006	
CMAJ	0.07		-0.11		-0.09		0.002	
PREI	0.18		0.16		0.31	.05	-0.11	
PREB	0.23		0.15		-0.02		0.14	
PREW	0.42	.01	0.36	.05	-0.10		0.26	
CGPA	1.00		0.28		0.008		0.23	

l= level of significance

df = 43-2 = 41

Conclusions, Implications and Recommentations

In most respects the Process-Centered General Biology project has been a successful venture in educational experimentation as well as in instruction.

In terms of instructional effectiveness the Process-Centered approach proved to be a successful treatment with most students. Since we have identified some correlates of success in Process-Centered Biology we should be able to counsel students who are likely to be unsuccessful with the approach out of this type program. Of course it is possible that students who were unsuccessful with Process-Centered Biology might also be unsuccessful with other approaches.

In terms of subjective and objective evaluations conducted in conjunction with the instructional program, the project was a success. The majority of the students received from average to excellent marks for the course. Also there were statistically significant gains in knowledge of biology, development of critical thinking, and development of interest in biology.

While the information regarding the effectiveness of the Process-Centered General Biology and correlates of success meets the initial objectives of the project, other results of the project are also worth noting. Process-Centered General Biology was offered as one of three alternatives to the course. The other alternatives were Audio-Tutorial and Traditional General Biology. Gains on pretest-posttest examinations for each of these courses enabled a comparative study of the effectiveness

of the three approaches. Results of the comparative study should provide significant information to the field of biology education. The comparative study should serve as basis for papers to be presented at the national conventions of The National Association of Biology Teachers and The National Association for Research in Science Teaching. Articles will also be submitted to the Journal of Research and Science Teaching, The American Biology Teacher and Science Education.

The operation of Process-Centered General Biology within the Department of General Science has prompted considerable student and faculty discussion of the merits and the liabilities of this educational philosophy. The Process-Centered philosophy now permeates Physical Science (G.S. 104, 105, 106) as well as General Biology.

During the academic year 1971-1972 the General Biology staff will offer a program titled Integrated Strategies Approach to Biology for Nonscience Majors. A proposal for evaluating the "Integrated Strategies" has been submitted to the regional office of the United States Office of Education. The program incorporates the more positive facets of Audio-Tutorial and Process-Centered General Biology.

Finally the Process-Centered philosophy will now serve as one of the focal points for the development of Integrated Science I and Integrated Science II, two new courses which our department will introduce within the next year or two. The successful operation of the present project (even with the negative points noted under faculty and student comments) has provided an in-road for this philosophy.

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Appendix I

Final Lecture Examinations

G.S. 101, 102 and 103

General Science 101

Murphy, Benedict, Lowell and Lind

Process-Centered
General Biology: Environmental
Final Examination

We have decided that it would be far more appropriate for us to administer an essay examination in lieu of the announced multiple choice examination. While you have studied for the multiple choice, such study should have prepared you most adequately to support your essay answers with evidence as presented by Buchsbaum and Kormondy.

Answer only five of the six questions

Write your name on each of the question-answer sheets

Support your answers by citing evidence from one or both of your primary authors, Buchsbaum and Kormondy.

Make your answers both succinct and thorough.

1. Define the term ecosystem and identify those factors which are essential to the function of an ecosystem.

2. There is an African folk story about the foolishness of the hunter who shoots the bird which sits on his own head. Using your knowledge of ecological phenomena discuss the implications of this story for the heavily industrialized American society.

3. Trace the flow of energy into, through, and out of a model ecosystem--a pond, a forest, a desert, a grassland, or some other model which you can hypothesize.

4. Use a numbers pyramid or a food web to illustrate trophic relations in a living community. Label clearly!

5. Given a male and female fruit fly (or for that matter any other sexually and reproductively compatible pair), imagine that you place them in a limited space with limited amounts of essential nutrients. What factors of population dynamics will come into play before the population dies? Plot the anticipated population growth curve (in principle, not in exact numbers since no one knows them anyhow).

6. Both of your authors write about the limiting factors which determine organism distribution. One way of understanding this concept is to consider the factors which limit man's distribution.

   Imagine that you have no clothing, no man-made shelter, and no tools. What major categories of factors would determine where you could survive? In other words, what are the major ecological limiting factors?

MEMORANDUM
Portland State University
March 5, 1971

TO: Process-Centered Students

FROM: Glenn W. Murphy

SUBJECT: Final Examination, GS 102

1. Date: Tuesday, March 16

2. Time: 12:00 - 2:00 p.m.

3. Place: 71 CH

4. Examination Procedure

   (a) Prepare for the examination th rough study of the topic or topics you have studied in your laboratory and small group discussion.

   (b) When you arrive for the exam you may bring any published materials you like. <u>You may not bring any materials which you yourself have written</u>.

   (c) Upon arriving at exam you should prepare an <u>outline of your selected topic</u>.

   (d) After completing your outline, write a paper which clearly communicates a thorough knowledge of your quarter's study.

Spring, 1971 G.S 103 Final Exam Murphy

Process-Centered

MULTIPLE CHOICE

1. A cell can be defined as (a) any mass of cytoplasm with a cell wall, (b) any mass of cytoplasm with a cell membrane, (c) any protozoan, (d) a nucleus with cytoplasm.

2. According to the cell theory (a) the first law of thermodynamics is not applicable to cells, (b) any unit which carries out metabolism is a cell, (c) all organisma consist of cells and cell products, (d) an organism can function only as its cells function.

3. An organism is (a) a collection of tissues like the stomach, (b) a group of similar cells, (c) aliving unit found in nature, (d) anything living with a nucleus.

4. The lowest level at which matter can be said to be living is the level of the (a) organism (b) cell, (c) compound, (d) aggregate of compounds.

5. If the cells of a tissue are disaggregated and placed into a culture medium, the cells (a) die, (b) do not die, (c) become more specialized, (d) form a higher level or organization.

6. The control center for the activities of a cell is the (a) nucleus, (b) contractile vacuole, (c) collection of mitochondria, (d) cell wall.

7. A cytoplasmic mass containing many nuclei but not separated by cell membranes is a (a) syncytium in plants, (b) coenocyte in animals, (c) syncytium in animals, (d) synergism in any organism.

8. A cell nucleus contains (a) RNA but not DNA (b) DNA but not RNA, (c) neither RNA nor DNA (d) both DNA and RNA.

9. Chromosomes are (a) pigment-containing granules, (b) important oxygen carriers in cellular respiration, (c) found mainly in reproductive cells, (d) made up of nucleoproteins.

10. The nucleolus of a cell is (a) a spherical organelle in the cytoplasm containing DNA (b) a spherical organelle in the nucleus containing RNA, (c) a rod-shaped organelle in the cytoplasm near the nucleus (d) the site of protein synthesis.

11. The endoplasmic reticulum (a) functions as a network binding cells together, (b) is a network of fibrils to which the chromosomes are attached, (c) functions as a dividing layer during cell reproduction, (d) serves as an ultrastructural framework in the cytoplasm.

12. The mitochondria (a) give rise to the endoplasmic reticulum, (b) are usually double-layered organelles with finger-like extensions from the outer layer, (c) are centers of cellular respiration (d) are centers of RNA synthesis.

13. Ribosomes (a) appear as tiny rods under the light microscope, (b) are the basal granules of flagella, (c) are found in the nucleus in association with chromosomes, (d) are sites of protein systhesis.

14. Golgi bodies (a) were first described in 1949, (b) are associated with secretory activities of cells, (c) carry out synthesis in green plant cells, (d) are located at the base of flagella.

15. Plastids (a) all contain at least chlorophyll, (b) all contain pigments of some sort, (c) are common in animal cells, (d) are common in plant cells.

16. The centriole (a) functions in cell reproduction, (b) is located near the cell surface close to kinetosome, (c) is a small DNA-containing body inside the nucleus, (d) is found only in plant cells.

17. Vacuoles are (a) empty spaces in the cytoplasm (b) formed between two adjoining cells, (c) the places where pigment is found in plant cells, (d) vesicles containing fluids.

18. Cyclosis is (a) a condition in which an organism has only one eye, (b) a condition immediately preceding cell death (c) a term that describes cytoplasmic streaming, (d) an expression of the cyclical nature of development.

19. The cuticle of plant cells (a) serves as a structural support, (b) is a product of the cell wall, (c) makes the epidermal cells waterproof, (d) is present only in highly specialized cells on the root surface.

20. Phagocytosis (a) is a rare disease of the blood, (b) is the process by which a cell engulfs particles by amoeboid movement, (c) occurs only in plants, roots particularly (d) involves the intake of inorganic materials by diffusion.

21. Cilia (a) occur in protozoa, animals, and most plants (b) are not found in mammals (c) are used chiefly for locomotion (d) are found in the interior tissues of most animals.

22. Water conduction in plants is accomplished by (a) sclerenchyma cells, (b) root hair cells (c) sieve tubes (d) tracheids and vessels.

23. Mature stem cortex is chiefly (a) pith (b) sclerenchymatous, (c) collenchymatous (d) parenchymatous.

24. Phloem does not contain (a) sieve tubes, (b) vessels, (c) companion cells, (d) sieve-tube cells.

25. Connective tissues consist of (a) flat layers of cells, (b) relatively unspecialized cells separated by intercellular material, (c) highly specialized cells all serving similar functions, (d) many-sided cells packed tightly together.

26. Fibrocytes (a) secrete fibers in connective tissue, (b) occur commonly in sclerenchyma, (c) are components of epithelia, (d) are able to engulf foreign bodies.

27. Elastic fibers are present in (a) tendons, (b) ligaments, (c) muscle, (d) basement membranes.

28. The epidermis of man is (a) a simple columnar epithelium, (b) a simple cuboidal epithelium, (c) a stratified cuboidal epithelium (d) a stratified squemous epithelium.

29. The main tissue of the intestinal submucosa in man is (a) columnar epithelium (b) loose connective tissue, (c) muscle, (d)ligament

30. The intestinal wall in man is (a) a tissue, (b) an organ system, (c) an organ, (d) groups of specialized cells all performing the same functions.

31 A cell wall is characteristic of (a) all cells, (b) most animal cells, (c) all cells with a cell membrane, (d) most plant cells

32. Epithlial cells are (a) the smallest cells (b) usually densely packed, (c) without nuclei, (d) always hexagonal.

33. Connective tissues (a) are made up of densely packed cells, (b) are composed of cells embedded in much intercellular material, (c) are joined together very tightly, (d) consist mainly of sperical cells.

34. Fibrocytes are components of (a) parenchyma, (b) connective tissues, (c) phloem, (d) epithelia.

35. Phloem does not contain (a) vessels, (b) sieve tubes, (c) companion cells (d) parenchyma.

36. In terms of the second law of thermodynamics, living systems are (a) stable, (b) disordered, (c) random, (d) improbable.

37. A perichondrium is present (a) just underneath the cortex of a plant stem, (b) at the ends of tendons, (c) at the surface of cartilage, (d) in the zone where phloem tubes are forming.

38. In man, replacement of cartilage by bone (a) occurs throughout life, (b) is completed by about the 20th year, (c) is substantially completed at birth, (d) never ceases in the long bones.

39. A periosteum is formed during the development of (a) any bone, (b) dermal bone only (c) repla cement bone only (d) any connective tissue.

40. A syncytial organization is not characteristic of (a) any muscle (b) smooth muscle, (c) striated muscle, (d) cardiac muscle.

41. The structure of any living organism consists (a) partly of chemical substances and partly of nonchemical materials, (b) entirely of chemicals (c) of numbers of cells in difinite patterns, (d) of numbers of cells in random arrangements.

42. Brownian movement is due to (a) temporary inequalities in salt balance, (b) molecular bombardment, (c) cytoplasmic streaming, (d) diffusion.

43. Buffers control (a) salt balance (b) [illegible] (c) diffusion, (d) osmosis.

44. Diffusion only takes place (a) across a semipermeable membrane (b) in the presence of concentration differences, (c) in true solutions, (d) in living cells.

45. A micron equals (a) 1/10 mm, (b) 1/100 mm, (c) 1/1000 (d) $1/10^6$mm.

46. All enzymes are (a) fats, (b) carbohydrates, (c) proteins, (d) nucleic acids.

47. A cell will swell if the external medium is (a) hypotonic, (b) hypertonic, (c) isotonic, (d) more concentrated than the protoplasm of the cell.

48. Osmosis involves (a) diffusion of suspended particles from higher to lower concentration, (b) diffusion of suspended particles from lower to higher concentration, (c) diffusion of water from the more concentrated side.

49. Phase reversal in cellular colloids (a) invariably leads to death, (b) occurs normally many times, (c) is equivalent to osmosis, (d) is due to Brownian movement.

50. Colloids are forms of matter in which (a) particles are larger than molecules but still small enough to remain suspended, (b) particles are smaller than molecules and therefore pass easily through cell membranes, (c) one substance is always a liquid, the other is always in the form of dispersed solid particles, (d) one substance is always a liquid, and the other may be solid particles or another liquid.

51. Diffusion is (a) the loss of a material from cells, (b) the tendency of particles to become evenly distributed, (c) of no significance in cells, (d) a substitute for osmosis.

52. According to the Watson-Crick model, only one of the following is a possible purine-pyrimidine pair: (a) adenine-guanine, (b) adenine-thymine, (c) adenine-cytosine, (d) adenine-uracil.

53. When the surface of a cell is punctured (a) the interior flows out and the cells dies (b) a membrane regenerates over the puncture, (c) phase reversal occurs immediately and converts the cellular cytoplasm to a gel, (d) diffusion carries the cellular cytoplasm away from the puncture.

54. Cellular DNA is known to (a) control the Watson-Crick model, (b) remain completely stabel, (c) reproduce to form RNA, (d) control protein manufacture.

55. Adenine is (a) a purine, (b) a 5-carbon sugar, (c) a pyrimidine, (d) a nucleotide.

56. RNA contains (a) thymine (b) cytosine, (c) deoxyribose, (d) protein.

57. DNA, but not RNA, contains (a) adenine (b) guanine (c) thymine (d) cytosine.

58. In cells (a) O, (b) H, (c) N, (d) C, occurs in the highest proportion by weight.

59. An example of a polysaccharide is (a) glycogen, (b) lactose, (c) fructose, (d) maltose.

60. In maltose, the two glucose units arelinked via (a) a 1, 4-bond, (b) a 1, 6-bond, (c) a 1, 5-bond, (d) both 1, r and 1, 6-bonds.

61. Adenine and guanine are components of (a) DNA only, (b) RNA only, (c) both DNA and RNA (d) the protein fraction of nucleoproteins.

62. Desaturation of a protein (a) is caused by heat or heavy metals, (b) represents thebreakdown to amino acids, (c) occurs during use of an enzyme, (d) is always permanent.

63. Proteins consist entirely of (a) amino acids linked together, (b) glycerol and fatty acids linked together, (c) carbon, hydrogen, and oxygen, (d) phosphates and glycerol.

64. Carbohydrates consist of (a) amino acids linked together, (b) glycerol and fatty acids linked together, (c) carbon, hydrogen, and oxygen, (d) phosphates and glycerol.

65. Lipids are (a) fats and sterols, (b) fats and proteins, (c) sterols and proteins, (d) carbohydrates and sterols.

66. Fats consist of (a) amino acids linked together, (b) glycerin and fatty acids linked together, (c) carbon, hydrogen, oxygen and nitrogen, (d) phosphate and glycerol.

67. The element nitrogen is always found in (a) fats, (b) organic compounds, (c) glucose (d) proteins.

68. A fat consists of (a) fatty acids joined, (b) lipids joined, (c) three fatty acids and glycerol joined, (d) three glycerol molecules and a fatty acid joined.

69. Approximately 95% of living matter is made up of (a) carbohydrates, fats, proteins, nucleic acids, and minerals, (b) carbohydrates, lipids, proteins, and water (c) carbon, hydrogen, nitrogen, and oxygen, (d) carbon, sulfur, phosphates and hydrogen.

70. Purines (a) are components of proteins, (b) are certain kinds of amino acids, (c) have a molecular skeleton made of carbon rings, (d) have a molecular skeleton made of carbon-nitrogen rings.

71. Organic compounds differ from inorganic ones in their (a) molecular complexity, (b) containing carbon atoms, (c) colloidal state, (d) occurrence in protoplasm.

72. The ratio of H:O in a molecule of carbohydrate is (a) 2:1 (b) 1:2, (c) variable, (d) the same as the ratio of C:O.

73. Glycogen consists of (a) one simple sugar molecule, (b) glucose molecules linked by loss of water, (c) maltose and fructose linked (d) glucose and fructose linked.

74. Particles of a colloid tend to remain suspended (a) because electric charges at their surfaces often produce natural repulsion, (b) because gravity is without effect, (c) because they have such minimal surface area in relation to their volume, (d) in spite of the addition of other ions.

75. Osmosis (a) is a process involving the movement of particles suspended in water, (b) tends to equalize the concentration of particles by a movement of water molecules, (c) pulls water from a region of higher concentration of particles to a region of lower concentration, (d) continues until the medium on one side of a membrane is hypertonic to the medium on the other side.

76. A nucleotide is a complex of (a) nitrogen base, an organic phosphate, and a hexose sugar, (b) a nitrogen base, and inorganic phosphate, and a 3-carbon sugar, (c) a nitrogen base, an organic phosphate, and a pentose sugar, (d) a nitrogen base, an inorganic phosphate, and a pentose sugar.

77. When ATP is formed (a) two additional phosphate groups are added to AMP without extra energy expenditure, (b) two high-energy expenditure, (b) two high-engrgy bonds are built into the compounds, (c) extra energy is expended and two phosphate groups become split off, (d) energy is released as two high-energy phosphate bonds are converted to low energy bonds.

78. Lipases catalyze reactions involving (a) polysaccharides, (b) disaccharides, (c) glycogen, (d) fats.

79. The specificity of DNA resides in (a) the sequence of the phosphate-sugar components, (b) its protein, (c) the sequence of the purine-pyrimidine components, (d) the number of nucleotide components.

80. An example of a tetrapyrrol pigment is (a) carotene, (b) cytochrome, (c) cholesterol, (d) cortisone.

81. Chlorophyll, heme, and the cytochromas have in common that they are (a) derivatives of carotene, (b) red in color, (c) tetrapyrrol derivatives, (d) all bonded to lipids.

82. The primary structure of a protein is maintained by (a) peptide bonds, (b) hydrogen bonds, (c) disulfids bonds, (d) ionic bonds.

83. The spiral shape of a protein molecule is maintained by (a) hydrogen bonds, (b) electromagnetic attraction between the positively and negatively charged parts of the constituent amino acids, (c) carbon-nitrogen bonds, (d) carbon atoms double-bonded to oxygen atoms.

84. Insulin and hemoglobin are examples of proteins (a) about which little structural information is available, (b) that have quaternary configurations, (c) consist of single polypeptide chains, (d) that were described for the first time in 1954.

85. Keratin is (a) a fibrous protein of hair and skin in mammals, (b) so named because it occurs mainly in carrots, (c) a readily soluble protein, (d) a nonfibrous protein that contributes to cell membranes.

Appendix II

Titles of Student Laboratory Reports

G.S. 101, 102 and 103

Fall Term — Lab Projects

The effect of insecticides on fruit flies

The Diamond Back Rattle Snake

Comparison between "Street" drugs and pure laboratory drugs

Chickens

Does sound effect man?

Yeast - Testing how the population growth vary under different conditions

The growth cycle of alga green chlorella

The progressive visual observation of the stages in development of the chick embryo

DDT dangers to plant life as experimented in algae

The effects of sandy, humus, forest, and rotting wool soil on corn plants

Air pollution: The effects of sulphur dioxide on plant tissues

The effects of smoke on fruit flies

Study of effects of organic and inorganic detergents on growth of algae

The study of rats in regard to birth

Mercury deposits in pheasants and fruit flies

Study of Schistosoma of a punicum

- The effect of the returning meruediu on the lumph cavities of the snail
- The effects on the mammalian host
- Effect of the drugs used in treatment on the host

The effects of asbestias dust on the lungs

Effects of motor vehicle exhaust pollution on plants directly associated with freeway

The effects of log jams on the Willamette River

Poisoning in the canning food process

A study of Food and Food supplement (Feeding of rats with a controlled diet and supplemented diet)

Effects of pollution on organisms in unpure water samples

The effects of outboard motor oil and crude oil on fresh water algae

Frog hormonal reaction

Growth and storage of pigments in chlorella in a Tamiya medium with the addition of Potato juice

Effect of auto pollution on plant life

The study and structure of the heart

Effects of organic and non-organic (biodegradable & others) in given concentrations on algae and its growth

How do the chemicals discharged into the Willamette River by Crown Zellerbach affect the lives of copapods?

Mold

Do escaping rays from color TV affect the drosophila in anyway, and if so how, and through what generation?

Air pollution & its effects on the growth of chlorella vulgaris

The effects of noise (different levels of noise) on man

What changes occur to duck week, when put into polluted water, with additives of Phosphates and nitrates in solution at various percentages, (abnormalities, etc.)

Creation of a mutant population of fruit flies - mutant to a pesticide

What is the effect of automobile exhaust on young bean plants?

The effect of wavelength-differentiated filtered light upon the growth of chlorella algae

Effects of overpopulation on a limited environment

The effects of heat & cold on algae

Water pollution (how it effects plant life in the area and possible drink water

Thermal pollution of chlorella vulgaris and the effects on the growth & population density of chlorella vulgaris

Manufactured ready to eat food vs. health foods in mammals

Thermal pollution experienced with chlorella vulgarius

Fungus and pollution (Heat, DDT, oil)

Study of growth of plant life in soil from the Willamette River Bank. Reaction to fertilizers added to the soil on plants

The effects of the herbicides simazine, amitrols, and diuson on the alga eugleana, applies at various dosages

Interchange possibilities available to persons willing to supplement from sources available in any North American forest (generally coniferous)

The effect of temp. on fruit fly population - The effect of limiting space on fruit fly population

The effect of freeway traffic on algae and plant life, special emphasis on exhause relationship in an algae culture

The effect of continued environmental concentration on moisture loss in slubs (limax maximus) and activity levels

Solid waste decomposition

Increasing or doubling of chromosomes in plants by use of PDB

The effects different cycles of noise have on humans

The effects of different doses of shell no-pest strip (D,D,V,P) on drosphila

Study of DDT residue in animal livers from a known area of DDT spraying in 1962, compared to animals for a non-sprayed area

Effect of insecticide on chlorella vulgaris cellular structure and growth

An observation of the effects of repeated doses of hormones on female rats

Chlorella vulgaris population density
Chlorophyll levels and production photosynthesis

Fruit flies on a different environment and reproduction in a small or larger home

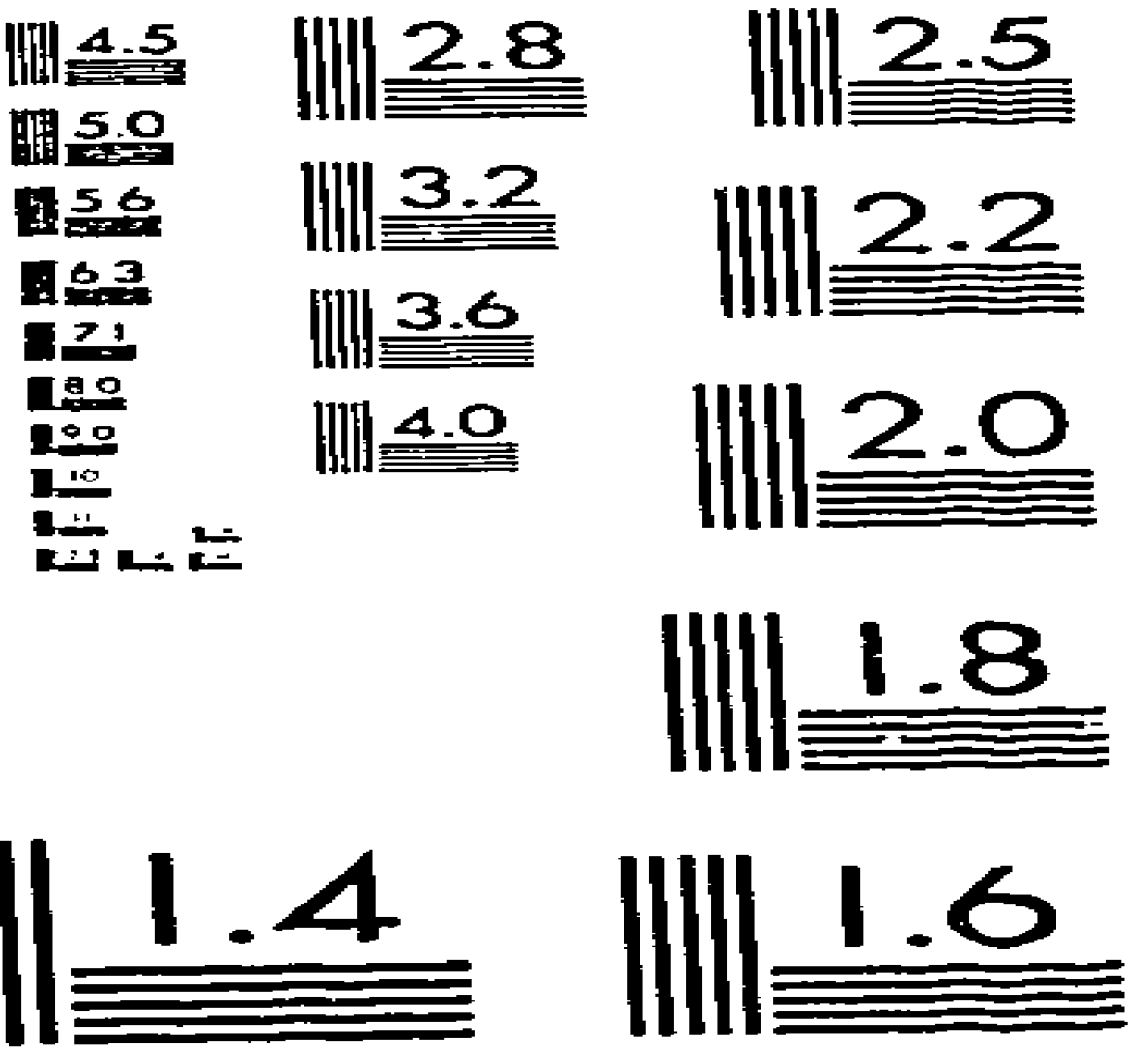
To study the effect of deficiencies and additions of minerals on thegrowth of bush bean seedlings - in water culture

The observance of population increase, the effects of this increase and what can be done about this increase?

The maternal behavior of the rat

The effect of squash (as a cannery by product) on the growth of algae in the Tualatin River

The effects of sodium chloride on chlorella vulgaris - biomass



OLUTION TEST CHART

OF STANDARDS-1963-A

The effect of thermal pollution on smallfish

Water pollution and how it effects fish

The evaluation of stree LSD (chemical evaluation)

The effects of smoke pollution & tobacco on water fleas

Winter Term

Lab Projects

Effects of DDT on adult and larvae fruit flies

Physiological effects of sound on blood pressure

Report on lichens

Effects of NTA (nitritotriacetic acid) on algae and fish life.

Effects of Ph solutions and salt solutions and distilled water on fresh blood under a microscope

Study on rats

Effect of MSG (monosodium glutemate)

Report on drosophila

Experiment on the effects of asbestos on rats

Study of chicken embryology

Study of sound on the human ear

Discussion of slaiva and related studies, involving the disection of a fetal pig and an experiment with starch and saliva

The effects of crude oil on agitated salt water with stephanortera (unicellular flagellate) and crude oil on unagitated aguarium tank and guppies

Effects of flouride on tap water bacteria

Study of the respiratory system

The effects of sugar and saline solution on the human blood cell

Chromosomal analysis of leukocytes made from peripheral blood

Effect of protein on laboratory mice

Study of olfaction in fish

What is the effect of authomtive exhaust on corn plants

Effects of different wavelengths (colors) of light upon a green algae

Study on perception

Study of the photoperiod and fruit and flower formation

Winter reports continued

Study of the giant chromosomes in drosophila

Study of the nervous system of man using a dogfish shark

Study of Rh disease

The study of regeneration in the tail of Anolis carolinensis

Study of the human chromosomes

Study of the earthworm

Study of plant respiration

Study on heredity

Study on blood

Study on the life cycles of certain plants

Can goldfish be trained to come for food after a sound signal is given

Study of growing crystal

Spring Term Lab Reports

Study on mercury poisoning

Effects of polution upon ecology systems

Reactions of blood cells to various solutions

To see the effects of motor oil and outboard oil on fresh water algae, chlorella

Study on the ribosome

Study on the gland cell

Study on sickle cell anemia

Study on blood cells

Incubation of chick eggs

Collection of water samples to study one celled organisms

Study of the eye

Study on photosysthesis

Study on plants

Technical procedure for doing a sperm count

Study of the nerve cell

Appendix III

Instruments of Tests and Measurement

Appendix III A

Watson-Glaser Critical Thinking Appraisal

Appendix III B

BSCS Comprehensive Test

Appendix III C

Murphy Interest Inventory

INVENTORY OF INTEREST IN BIOLOGY

Read each of the following questions carefully. Then using no more than one sentence, answer the questions as honestly as you can. (Your answers will not be analyzed until after this semester: therefore, no response can work to your advantage or disadvantage.)

1. What is your primary reason for taking General Biology?

_____

2. Do you hope to take another biology course? Yes ( ) No ( )

3. Do you often find yourself thinking about the answers which the science of biology might be able to provide with respect to (1) origin of life, (2) future evolution of organism; (3) production of food sufficient to support our rapidly increasing population, (4) curtail disease and human defects? No ( ) Yes ( )

_____

4. When you read the daily newspaper, do you make special note of the articles relating to biological problems? Yes ( ) No ( )

_____

5. a. If you know of any magazines or journals which are devoted primarily or partially to biological problems, list their titles below. If not, write NONE in the space.

_____

_____

b. Do you read any of the periodicals you have just listed? Yes ( ) No ( ) If so, give the title, author or subject of an article you have recently read:

_____

6. Name one or more biological books or periodicals which you have examined in the library or checked out. _____

7. Would you enjoy conducting a biological experiment as biologists do? Yes ( ) No ( ) Why? _____

_____

8. Would you like teaching biology? Yes ( ) No ( ) Why? _____

_____

9. If you presently had no major or specific goal, would you like to major in biology? Yes ( ) No ( ) Why? _____

_____

10. Do you plan to change your major to biology? Yes ( ) No ( ) Why? ___

_____