A CURRICULUM STUDY OF THE BIOLOGICAL SCIENCE
COURSES IN THE SECONDARY SCHOOLS
AND COLLEGES OF UTAH
DURING 1947-48

by
Merrill H. Gunnell

A thesis submitted in partial fulfillment
of the requirements for the degree
of
MASTER OF SCIENCE
in
Zoology
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UTAH STATE AGRICULTURAL COLLEGE
Logan, Utah
ACKNOWLEDGEMENT

For the valuable suggestions, patient consideration, and encouragement received in this study, I wish to express appreciation to Dr. D. M. Hammond and Dr. John C. Carlisle.

Merrill H. Gunnell
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INTRODUCTION

At the present time there is a feeling among biologists in Utah that there should be improvement in biological science courses and course sequence to better fill the needs of the non-technical student. There are many students filling group requirements with an accumulation of courses which may not provide them with the more important fundamental concepts and principles in biology. Information concerning these courses in high schools and colleges is necessary to provide a basis for curriculum revision in the field. Such information should be useful in evaluating the present system and suggesting modifications. Because of the need for this information the present study was undertaken. However, it is not the object of this study to make recommendations about definite curriculum changes. The purpose, rather, is to determine the courses taught, the subject matter of such courses, student registration, and general student achievement in the various biological sciences as offered during the school year 1947-48, in the high schools of Utah, and in the lower division of the ten colleges in Utah.

The biological science courses taught and the enrollment in those courses in the secondary schools were determined by an analysis of the offerings of twenty schools in the state. The twenty schools selected were definitely chosen after consultation with the Director of Secondary Education in the State Department of Public Instruction. They were chosen in order to include a sampling of various sizes of schools in both urban and rural areas. The data concerning course offering and enrollment in these schools were obtained from the records in the State School Office. Similar information concerning course offering on the college level was obtained from the catalogues of each of the institutions, which
gave the names of courses offered in the respective schools. Concerning enrollment in biological science courses at the college level, figures were obtained from the Utah State Agricultural College only. Moreover, since figures for any one particular year were not needed, it was decided to use reports from the graduating class of 1939, the last class whose four years of attendance was not affected by war conditions.

After obtaining the names of the courses offered, an attempt was made in a limited way to evaluate the subject matter in these biological science courses as they are now taught in the secondary schools and colleges of Utah. This was done by a review of textbooks used—Bayles and Burnett (1), Beaver (9), Carlson and Johnson (10), Curtis et al. (2), Downing and McAtee (3), Fasten (4), Greaves and Greaves (11), Hegner (5), Mavor (12), Pool et al. (6), Strausbaugh and Weimer (13), Transeau (7), Williams (8), Woodruff (14)—and an analysis of the teachers outlines from various schools. From the above sources, summaries of the course offering in biology, physiology, botany, and zoology on the high school and college level were made and are reported later as a part of this study. Bacteriology as a course was not found in any of the twenty schools. It is therefore included only in the analysis of the college courses.

Student achievement in the various biological sciences was determined by giving standardized tests, one at the high school and one at the college level. The tests used were those prepared by the Examinations Staff for the United States Armed Forces Institute and distributed by the Cooperative Test Service of the American Council on Education and Science Research Associates. Both were copyrighted in 1945. Upon request the Test Service sent a sheet of results for each examination which showed the scores made by a random sampling of students and schools over the nation. On the
college level these "norms" had been drawn from scores made in 17 schools where 957 students took the examinations. On the high school level, twenty schools were used and 1378 students were given examinations. In comparison with this random group over the nation, these same examinations were given to a smaller, and in some ways more select, group at the Utah State Agricultural College. The high school level exam was given to 320 freshmen entering the college in 1947 and the college examination was given to 120 students who had filled the college group requirement for biological science.

The specific results from the tests are shown in tables throughout this study as are the detailed findings from other aspects of the study. The summary of findings and some conclusions drawn from them are set forth in the final part of this report. Nevertheless, it may be said at this point that there was found to be wide differences in the biological science courses offered in the various secondary schools of Utah and the student enrollment in such courses as were offered varied greatly from school to school. As measured by the tests given, neither the Utah college nor high school groups scored as high as the national norms, although in some parts of the examination, the Utah students did compare favorably with the students elsewhere. Of particular interest and perhaps significance is the fact that the area of bacteriology seemed to have been neglected to the extent to which it was included in high school biology courses, and thus in the opportunity students had to learn basic concepts in this field. Apparently, these deficiencies were not removed at the college level, though courses were available.
Schools surveyed and Courses Taught

One objective of this study was to find what biological science courses were taught in high school. Twenty secondary schools were surveyed in a sampling of the schools of the state. The following tables show the distribution of the selected schools according to biological science courses taught in each.
Table No. 1. Utah High Schools Sampled and the Biological Science Courses They Offered

<table>
<thead>
<tr>
<th>NAME OF HIGH SCHOOL</th>
<th>COURSES TAUGHT IN 1947-48</th>
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<td>American Fork High School</td>
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<tr>
<td>Beaver High School</td>
<td>Biology, Ag. Science I, II</td>
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<tr>
<td>Bear River High School</td>
<td>Biology, Physiology</td>
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<tr>
<td>Bingham High School</td>
<td>Biology</td>
</tr>
<tr>
<td>Box Elder High School</td>
<td>Biology, Physiology</td>
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</tr>
<tr>
<td>Davis High School</td>
<td>Biology, Physiology</td>
</tr>
<tr>
<td>Delta High School</td>
<td>Biology</td>
</tr>
<tr>
<td>East Salt Lake City High School</td>
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</tr>
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<td>Jordan High School</td>
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<td>Logan High School</td>
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<tr>
<td>Millard High School</td>
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<tr>
<td>Murray High School</td>
<td>Biology, Physiology, Genetics</td>
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<tr>
<td>Ogden High School</td>
<td>Biology, Physiology, Zoology</td>
</tr>
<tr>
<td>Provo High School</td>
<td>Biology, Botany, Zoology, Physiology, Health and Heredity</td>
</tr>
<tr>
<td>San Juan High School</td>
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<td>South Cache High School</td>
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### Table No. 2. Number of Schools Offering Respective Combination of Courses 1947-48

<table>
<thead>
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<th>Courses</th>
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<td>Biology and Physiology</td>
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<td>Health and Heredity, Biology, Botany, Zoology, Physiology</td>
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</table>

The foregoing tables show the variability of biological science courses given throughout the high schools of the state. The distribution of the courses as to number and kinds are here noted. Of the twenty schools studied, two offered five different courses, three schools gave four courses, five had three, four had two, and five only one course. One school did not list any biological science as such.

It is observed that of the twenty schools sampled, nineteen gave a course in biology, fourteen in physiology, six in botany, six in zoology, two in eugenics, two in genetics, and one gave a course in health and heredity. This shows that biology and physiology were the most widely offered of the biological sciences in the secondary schools of Utah for 1947-48.
Course Content

In evaluating the subject matter of biological science courses as they are now taught in the secondary schools and colleges of Utah, textbooks and teacher's outlines used by the various schools have been carefully analyzed.

Many of the curriculum studies that have been made in the past few years indicate a real concern about existing subject matter. The thought that some biological science courses fail to adequately prepare the individual for actual life situations has been brought forth and we have heard "not practical" and "not functional" being voiced against science courses the country over.

Biology teachers, in many instances, will recognize certain subject-matter inadequacies and realize that biological science courses must concentrate upon those things which apply to the problems of modern life and show how and why such relationships exist. Each individual teacher will place emphasis upon the particular part of the material he feels most important and because of this we find a wide variability of content material retained by the different students over the state.

It has been found that some biology courses make a more valuable contribution than others in giving the student a broader background or knowledge. But the tendency in recent years undoubtedly has been to broaden the base of undergraduate experience rather than to encourage specialization, and since this is especially significant at the present time, the following survey of actual content material used in the high schools and colleges of the state of Utah is presented. However, this is not necessarily the sequence in which the material is taught in each of the individual schools. Rather, the study is concerned with what is being taught.
The content of the courses, namely, biology, bacteriology, botany, physiology, and zoology, on the secondary or college level, will be presented in outline form. Agriculture Science, eugenics, genetics, health and heredity in high schools were taught in so few high schools that such subjects will not be considered here.
Some major problems living things must solve.

Factors affecting life: food, heat, oxygen, water, weather, climate, light, shelter, and soil.

Changes taking place in the environment.

Living matter contrasted with non-living matter as to form, size, structure, growth, reproduction, movement.

Protoplasm. Functions, cell, tissue, organ, system.

Struggle to live.

Balance in nature, survival of fittest.

Sun as source of energy. Energy and matter cycles.

Plants and the world's food supply.

Soil.

Evolution, kinds, and composition.

Green plant.

Parts studied, roots, stems, leaves, flowers.

Fruits and seeds. Kinds, structure and functions of each.

Photosynthesis, transpiration, respiration.

The kinds of living things.

Classification and naming, plan for.

Plant groups. Thallophyta, Bryophyta, Pteridophyta, Spermatophyta,

Fungi, Algae, Monocotyledons, Dicotyledons.

Economic importance of plants.

Food, clothing, shelter, medicine, soil, and water conservation.

Animal groups.

Phyla, invertebrates, vertebrates, characteristics, life histories, relationships.
Economic importance. Food, clothing, medicine, etc.

Conservation.

Soil. Erosion, and prevention of erosion.
Protection of crops and animals against insect pests and fungus diseases.

Forests. Enemies of.

Wild life. Birds, mammals, fish, plants.

Structures and processes concerned with nutrition.

Adaptations of organisms for securing food.

Some processes of plants and animals.

Digestion, enzymes, circulation, respiration, excretion, and metabolism.

Responses of living organisms.

Tropisms, reflexes, instincts, habits, and thought.

Nervous system of some animals.

Special sense organs.

Structure and function of eye, ear, nose, and skin.

Biology of human welfare.

Control of disease and improvement of health.

How science combats certain germ diseases.

Immunity. Kinds and how established.

Some scientists and their contributions in control of disease: Pasteur, Koch, Jenner, Lister, Smith, Carroll, Reed, Ross, and etc.

Foods, fads, and allergies.

Patent medicines, stimulants, and narcotics.

Continuance and improvement of living things.
Reproduction, kinds, asexual, sexual.

Factors and laws of inheritance. Mendel.

Application of laws of inheritance for improvement of living things.

Evolution.

How living things change.

Darwin's explanation.

High School Physiology Williams (8)

The Problem of Healthful Living.

What health is, knowledge and disease, rules of the game, air, food, care of body, rest and sleep, thinking and feeling, infections, and physical activity.

The Cells of the Body.

Unit of structure, protoplasm, nucleus, origin of cells, functions of living animal cells.

Tissues as Building Materials.

Epithelial, connective, vascular, muscular, and nerve tissues.

How to build good tissues.

Organs formed from Tissues.

Organs of each of the following systems in the body: muscular, skeletal, digestive, respiratory, circulatory, nervous, excretory, and endocrine.

The Skeleton Framework of the Body.

What is the skeleton and what are its uses?

Parts of the skeleton: skull, thorax, vertebral column, upper and lower extremities.

The composition of bone and how joints are constructed.
Hygiene of the Skeleton.

Essential facts in growth and development of bones.

Fractures, dislocations, and sprains.

Deformities of the spinal column.

The Muscles as the Motor Machinery of the Body.

Work of the muscles, kinds of muscles: voluntary, involuntary, cardiac muscular tissue.

The attachment, names, and positions of muscles.

The Muscles in Action and the Hygiene of Exercise.

Muscular energy, tone, activity and fatigue.

Effects of stimulants and narcotics on muscular action.

Effect of exercise on growth and health.

Food and Its Uses.

Food and energy: composition of food: carbohydrates, fats, proteins, vitamins, minerals, water.

Food allergy.

The Digestion of Food.

Structure and function of the alimentary canal: mouth, teeth, tonsils, pharynx, esophagus, stomach, small and large intestines.

Functions of the liver and the meaning of Enzyme.

The Hygiene of Nutrition.

Effects of health, emotions and environment on digestion.

Man's original food sources and how they have been enlarged to present day sources.

The Circulation of the Blood.

The nature of circulation and composition of the blood.

Work of red and white corpuscles and plasma.
How the heart works and disease of the heart.
Structure and adaptation of blood vessels.
How the heart is aided in its work.
The lymphatic circulation.
Hygiene of the circulation.

The Respiration.
Respiratory organs: nose, throat, larynx, trachea, bronchial tubes, lungs, and diaphragm.
The breathing process: inspiration, expiration.
Hygiene of respiration and consideration of tuberculosis.

The Nervous System.
Functions and units of the nervous system.
The nerve impulse, injury to nerves, spinal cord, autonomic system.
The brain - its parts, coverings, and work.

Hygiene of the Nervous System.
Connection between body and mind.
The effect of activity, sleep, fatigue, and alcohol on the nerves.
Improper functioning of the nervous system.

Sensation and the Special Senses.
Classification of the senses: taste, smell, sight, hearing, equilibrium.
General sensations: appetite, hunger, thirst, touch, temperature, pain.
Structure and function of eye and ear.

Some Special Regulative Processes.
Temperature of the body, activity, and growth, chemical regulation such as: thyroid, thymus, adrenal, pituitary, pancreas, sex glands.
Regulatory control of the voice.
Heredity and Health.

Chromosomes, genes, dominant and recessive traits.
Inheritance of acquired traits.
Heredity and environment.
Eugenics.

Bacteria, Protozoa, and Disease.

The germ theory of disease; antitoxins and immunity.
Injury of the body by poisons, physical agents, and chemical agents.
Prevention of communicable diseases.

The Effect of Alcohol and Tobacco.

The effect of stimulants on energy and nerves.
Alcohol as a food and as a poison.

Health Problems of the Machine Age and a Modern View of Health.

Need for industrial hygiene, accident prevention, and health service in industry.

High School Zoology Hegner (5)

Where animals live.
The grasshopper.

The habits, physiology, anatomy, and economic relations of a typical insect.

Some insect adaptations.

Locomotion, respiration, securing food, coloration.

Insects injurious to vegetation.

Extent of injury, army worm, chinoh bug, European corn borer, insects injuring cotton, field crops, garden vegetables, fruits and shade trees. Mediterranean fruit fly, Japanese beetle.

Insects parasitic on domestic animals and man.
Botflies, mosquitoes, fleas, and lice.

Insects of the household.

Silver fish, cockroaches, ants, cheese skipper, meal worm,
carpet beetles, clothes moth, termites, and bedbugs.

Beneficial insects.

Silkworm, honeybee, predacious insects, and parasitic insects.

The house fly and disease.

Bacterin, germ diseases transmitted by house flies, Typhoid fever,
Bacillary dysentery, Tuberculosis, Asiatic cholera, and Protozoan
diseases.

Mosquitoes and disease.

Malaria, Yellow-Fever, mosquito control.

Other insects that transmit disease germs.

Fleas and bubonic plague, blood-sucking flies and disease, deer
flies and tularaemia.

Classification in general and of insects in particular.

Artificial and natural classification. Reasons for and system used
by scientists. Value of classification.

Spiders and other arachnids.

Where spiders live, types of webs, sense organs, respiration,
reproduction. Tarantulas, scorpions, mites and ticks.

Relation of arachnids to man.

The Myriapoda or Centipedes and Millipedes.

Characteristics and classification.

The crayfish.

Habitat, means of protection, locomotion, food and digestion,
absorption and circulation, respiration, and reproduction.
Crustacea in general.
   Crabs, shrimps, barnacles, Characteristics and classification.
The mussel or clam and other bivalves.
   Habitat, locomotion, protective shell, respiration, digestion, circulation, and reproduction.
A land snail and other mollusks.
   Protection, locomotion, method of feeding.
   Relation of mollusks to man.
The earthworm and other segmented worms.
   Burrows, locomotion, food, digestion, circulation, and excretion, respiration, nervous system, and reproduction.
The roundworms, flatworms. Characteristics and classification of each.
The Echinoderms.
   Starfishes, Brittle stars, Sea urchins, Sea cucumbers, and Sea lilies.
The Sponges. Characteristics and classification.
The Protozoa.
   Paramecium, amoeba, euglena, and the following protozoa: parasitic, pathogenic, colonial, and Marine.
Introduction to the vertebrates.
   Organs and systems of organs; cell, cell division, tissues, living and lifeless things, the origin of life.
The frog, a typical vertebrate.
   Movements, physiological processes, skeleton and its functions, muscular and nervous activity, and reproduction.
The lamprey eel and other cyclostomes.
The structure and activities of fishes.
Habitat, locomotion, sensations, respiration and reproduction.

Some common fishes of North America.

The relations of fish to man.

The amphibians. Tailed and tail-less.

Hibernation, poisonous type, common toad, and economic importance.

The Reptilia. Turtles, lizards, snakes, constrictors, crocodiles, and alligators. Economic importance of reptiles.

Structure and activities of birds.

Some common birds of North America.

Relations of birds to man. Bird protection.

Structure and activities of mammals.

Habitats, protection, locomotion, internal organs, digestion, circulation, respiration, excretion, nervous system, sense organs, and reproduction.

The orders of mammals. Egg-laying, pouches, flesh-eating, gnawing, toothless, even-toed, odd-toed, elephants, whales, and primates.

The relation of mammals to man.

The protection and propagation of wild life.

The conservation of our natural resources.

High School Botany Pool et al (6), Traneau (7)

Plants from our standpoint.

Foods, fuel, clothing, wood products, oils, resins, and drugs.

Plants as living things.

Parts of a plant and interdependence of the parts.

The plant and its environment.

Growth and distribution of plants determined by the environment.
The cellular structure of plants.

Protoplast, cytoplasm, and nucleus.

Leaves and their structures.

Parts of a leaf, and the different kinds of leaves.

Chloroplasts and chlorophyll.

The manufacture of food. Rather detailed study of photosynthesis.

The release of energy.

Respiration of fruits and vegetables.

Substances made from foods.

Chlorophyll, enzymes, tannins, alkaloids, and essential oils.

Leaves in relation to light and water.

Physical processes involved in the movement of materials in plants.

Osmosis and imbibition.

The water balance in plants.

The growth and fall of leaves.

The stems of plants.

Structure, size, and position. Part environment plays.


The forms and structures of roots. The processes of roots.

Environmental factors affecting growth and reproduction.

Light, atmospheric water, distribution of rainfall, effect of temperature, freezing, winds, gravity, chemical elements, and fertilizers.

Vegetative multiplication and plant propagation.

Flowers and flower clusters.
Parts of the flower and variety of structure.

Sexual reproduction in flowering plants.

Fruits and seeds.

Gymnosperms and angiosperms.

Dormancy and germination of seeds.

Plant breeding.

Variations and mutations.

Hybridization and selection.

Distribution of plants in nature.

The vegetation of North America.

The formation of the: Tundra, grassland, western evergreen forest, and southwest desert.

Relation of plant industries to climatic plant formations.

Weeds and their control.

The non-green plants.

Parasites, saprophytes.

Bacteria and their relations to life.

Soil bacteria and the nitrogen cycle.

Fungi.

Food supply, growth, reproduction and distribution.

Plant disease.

Prevalence, control, symptoms, causes and losses from plant disease.

Classification of plants.

Phylum, class, order, family, genus.

The algae.

Blue-green, the green, the brown, and the red algae.

Classification of each kind as to structure of cells, reproduction structures, and life history.
Bryophytes: Liverworts and mosses. Life history of each.

The Pteridophytes. (fern plant)

The sporophyte and gametophyte.

Fossil plants.

The story they tell.

Gymnosperms: The cycads and the conifers.

The Angiosperms or flowering plants.

Some families of angiosperms.

Monocotyledons and Dicotyledons.

The evolution of plants.

Variation, heredity, and natural selection.

The following table shows for the year 1947-48 the natural science courses taught, the grade level for each course, and the student enrollment in the respective courses.
<table>
<thead>
<tr>
<th>Name of High School</th>
<th>Course</th>
<th>Grade Level</th>
<th>No. Enrolled in Course</th>
<th>High School Enrollment</th>
<th>Percent of H.S. Enrollment in Biological Science</th>
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<tbody>
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<td>American Fork</td>
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<tr>
<td></td>
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Table No. 3. Grade Level of Courses and Enrollments. (Continued)

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<th>Name of High School</th>
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<th>Percent of H. S. Enrollment in Biological Science</th>
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Table No. 4. Number of Schools Giving and Per Cent of Students Taking Different Biological Science Courses.

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<th>Course</th>
<th>Grade Levels</th>
<th>Number of Schools Taught</th>
<th>Total Enrollment of Schools Offering Course</th>
<th>Number Enrolled in the Course Offering it</th>
<th>Number of Students Taking Biological Science Courses</th>
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As shown by the foregoing data for the year 1947-48, biology, physiology, botany, and zoology were offered on the 10th, 11th, and 12th grade levels. There were 13 out of 20 schools that had biology strictly for the 10th grade; 11 out of the 20 offered physiology for the 11th and 12th grades; 5 placed botany and zoology on the 11th and 12th grade level; eugenics, genetics, health and heredity courses were given for the 11th and 12th grades.

Biology and physiology as the most widely offered courses also had the largest percentage of students enrolled. However, on the basis of the data presented here, some students have graduated from high school that did not have any biological science. This was verified in a questionnaire attached to the college level examination, which showed there were 13 out of 120 students that had no biological science in high school. A copy of this questionnaire is found in the appendix. This would show
the need of a fundamental general course in biology on the college lower-division level.

Results of Examinations

Included in the appendix is a copy of each of the examinations that were used in this study. In spite of their limitations, they seemed to be the most satisfactory examinations available for the purpose of showing student achievement in this field. The results of these examinations were compared with results of examinations on a national scale, in terms of percentile rank and raw scores. The percentile ranks are expressed in terms of the percentage of scores a given score equals or exceeds. The score was the number of questions answered correctly. And raw scores are the scores as they were obtained from the examinations.

The examination is divided into three sections. The high school level Section I deals with basic facts and information. Section II includes the application of principles, and Section III reading, interpretation of data and applying the scientific method. The results and comparisons are on a sectional basis, a total basis, and a single question analysis as to subject matter.

Three hundred and twenty Utah high school graduates were given the examination.

The data in the accompanying tables give a comparative picture as far as this study goes, between the high school graduates of Utah and the national group as provided by the publisher of the examination.

The results for each of the three sections are presented as well as the total for the examination.
Table No. 5. Percentile Norms Section I Examination in Biology High School Level.

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<th>Percentile</th>
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</tbody>
</table>

* The number of high schools was not determined.
These represented a random sampling of graduates from most high schools of the state as they entered the Utah State Agricultural College in 1947.

The results are shown here by the raw scores and percentile rank. The maximum score for Section I was 68. The local group showed a wider range than the national group with a high score of 57 and a low of 19, whereas the corresponding national scores were 58 and 23. The 61st percentile of the local group was 38 and the 61st percentile of the national group was 43. The national achievement was thus slightly higher in this section of the examination.
Table No. 6. Percentile Norms Section II Examination in Biology High School Level.

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</table>
In Section II, which deals with the application of principles, the local group is above the national group, and also has a wider range of scores. The high of 58 and the low of 8 for the local group, with 51 and 18 respectively for the national group, confirms this fact. The 44th percentile for the local group is 37. For the national it is 53.

Table No. 7. Percentile Norms Section III Examination in Biology High School Level.

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</table>
In Section III, which deals with reading, interpretation of data, and applying the scientific method, the maximum score is 27. Again the local group shows a wider range in scores which may indicate a broader sampling. The local group was below the national group in this section. The 48th percentile equal to a score of 14 compared to 17 for the national.

Table No. 8. Percentile Norms Total Score Examination in Biology High School Level.

<table>
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<tr>
<th>Local as Compared with National</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of Cases</td>
</tr>
<tr>
<td>No. of Schools</td>
</tr>
<tr>
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<tr>
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The results of the total score for the examination indicate that the two groups were at very nearly the same level. The maximum score is 164 with the greater range of scores still being found in the local group. The 52nd percentile of the local group was 88 compared to the 52nd percentile of the national group which was a score of 91. According to these results, the national group scored higher. The score of 132 for the local group was in the 98th percentile and the score of 135 for the national group was also in the 98th percentile. Thus the local group ranked a little below the national group and showed greater extremes. The average difference of the twelve comparable percentiles of the two groups was 3.50 in favor of the national group. On the basis of statistical methods outlined in section 2.15 of Snedecor this difference is highly significant. The probable error is less than one per cent.

The examination questions were studied and according to the content of each of the questions they were grouped in one or more of the four areas of biology.

The tests were corrected by the use of four different keys, and were scored giving the number right in each of the four divisions.

The following tables show a question analysis of the examination as to the number of the question, the total number of tests, the number of questions right, the number wrong and the per cent right in the four areas of biology, namely, bacteriology, botany, physiology, and zoology.

The questions grouped in these four areas are found in the first two sections of the examination.
Table No. 9. Analysis of Bacteriology Questions

<table>
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</table>

The difference in the number of questions in these four different areas may indicate the time and emphasis given to each. Some of the questions are considered in more than one field. There are five questions listed in the field of bacteriology, forty-eight in botany, fifty-one in physiology, and forty in zoology.

The bacteriology questions are in Section I of the examination. All were the multiple choice type of question. The question that 58 per cent answered correctly dealt with what is responsible for most contagious diseases. The question only 22 per cent got right was, "Who was responsible for discovering a way of preventing smallpox by vaccination?"
Table No. 10. Analysis of Botany Questions

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In considering the botany questions, 33 out of the 49 were found in Section II of the examination. With two exceptions, the upper 25 per cent of these in Table 8 were dealing with forestry and crop cultivation and relation of crops to the soil. The lower 25 per cent of the questions in the table were equally distributed in Section I and II and most of them were considered more technical or specific and represented a much broader scope. Also, two of the lower questions were dealing with forestry practice. The types of questions that about 50 per cent answered correctly were on osmosis, a process, and on the structural make-up of a living organism.

The question 98 per cent answered correctly dealt with the identification of the nucleus of a plant cell. The one only 6 per cent answered correctly was concerned with the description of a diatom.

Of the 44 zoology questions, 24 dealt with basic facts and information, and 20 with application of principles. The upper 25 per cent of the questions was mixed in so far as subject matter goes as shown by the following phases: evolution, reproduction, entomology, ornithology, genetics and heredity. The majority of the lower 25 per cent of the questions was concerned with genetics and heredity. From this study it is indicated that students are not learning this phase of biology as well as some others. The types of questions that 50 per cent answered correctly were on stages of development of higher animals and the structural make-up of living organisms.
Table No. 11. Zoology Question Analysis as to Number Right, Wrong, and Per Cent Right.

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<td>52.00</td>
</tr>
<tr>
<td>39</td>
<td>164</td>
<td>156</td>
<td>51.25</td>
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<tr>
<td>70</td>
<td>163</td>
<td>157</td>
<td>50.51</td>
</tr>
<tr>
<td>45</td>
<td>159</td>
<td>161</td>
<td>49.69</td>
</tr>
<tr>
<td>22</td>
<td>153</td>
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<td>49.30</td>
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<tr>
<td>54</td>
<td>155</td>
<td>165</td>
<td>49.44</td>
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<td>154</td>
<td>166</td>
<td>48.00</td>
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<td>47.50</td>
</tr>
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<td>90</td>
<td>146</td>
<td>174</td>
<td>45.62</td>
</tr>
<tr>
<td>21</td>
<td>145</td>
<td>175</td>
<td>45.51</td>
</tr>
<tr>
<td>37</td>
<td>145</td>
<td>175</td>
<td>45.51</td>
</tr>
<tr>
<td>47</td>
<td>146</td>
<td>175</td>
<td>45.51</td>
</tr>
<tr>
<td>52</td>
<td>130</td>
<td>190</td>
<td>40.63</td>
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<tr>
<td>46</td>
<td>126</td>
<td>194</td>
<td>39.33</td>
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<tr>
<td>35</td>
<td>121</td>
<td>199</td>
<td>37.81</td>
</tr>
<tr>
<td>124</td>
<td>116</td>
<td>204</td>
<td>36.26</td>
</tr>
<tr>
<td>25</td>
<td>115</td>
<td>205</td>
<td>35.94</td>
</tr>
<tr>
<td>3</td>
<td>112</td>
<td>223</td>
<td>34.00</td>
</tr>
<tr>
<td>92</td>
<td>94</td>
<td>226</td>
<td>29.35</td>
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<td>27</td>
<td>90</td>
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<td>28.15</td>
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<td>57</td>
<td>53</td>
<td>237</td>
<td>26.94</td>
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<td>49</td>
<td>62</td>
<td>239</td>
<td>26.63</td>
</tr>
<tr>
<td>88</td>
<td>62</td>
<td>258</td>
<td>19.37</td>
</tr>
</tbody>
</table>
Of the fifty-one physiology questions, thirty-four were in Section I, which dealt with basic facts and information, and seventeen dealt with the application of principles. The upper twenty-five per cent of the questions, as well as the lower twenty-five per cent, were varied and mixed as far as subject matter went.

As represented by these questions and results there seems to be no particular phase of physiology which has been especially emphasized or neglected. The question 96 per cent answered correctly and the one only 10 per cent answered correctly were both dealing with anatomical structures. Such questions as the following were answered correctly by 50 per cent of the group.

What is a small calorie?

A. The amount of heat necessary to raise the temperature of 1 gram of any substance 1 degree Centigrade.

B. The amount of heat necessary to raise the temperature of 1000 grams of any substance 1 degree Centigrade.

C. The amount of heat necessary to raise the temperature of 1 gram of water 1 degree Centigrade.

D. The amount of heat necessary to raise the temperature of 1000 grams of water 1 degree Centigrade.

E. None of these.

Which of the following lists is correctly arranged in order of increasing complexity (from simple to more complex)?

A. Protoplasm, tissues, cells, organs, systems, organisms

B. Protoplasm, cells, organs, tissues, systems, organisms

C. Protoplasm, cells, tissues, organs, systems, organisms

D. Protoplasm, cells, tissues, organs, organisms, systems

E. Protoplasm, cells, organs, tissues, organisms, systems

The scores obtained from the physiology questions could be interpreted to mean that the more specific subject matter has not been emphas...
in the field of biology or physiology in high school.

It is interesting to note that the discoverer of such an important and widely used contribution to human welfare as smallpox vaccination was unknown to a great majority of high school graduates. There may be several explanations for this, two of which are:

1. That this particular fact is omitted on the assumption that high school courses should be more generalized and less specialized.

2. That it has not been considered important enough to receive any special emphasis and hence has not been remembered by the students.

It was interesting to observe question number seventy. It was stated in the exam as follows: "Which of the following lists is correctly arranged in order of increasing complexity (from simple to more complex)?" Five different arrangements of these terms were given to choose the correct one: "Protoplasm, cells, tissues, organs, systems, organisms." The subject matter covering this particular question might have been considered of fundamental importance in botany, physiology, and zoology, yet only 50 per cent answered it correctly.

According to this study, Utah high school students scored highest in physiology, followed in order by botany, zoology, and bacteriology. This is confirmed by the fact that 58 per cent of the physiology questions, 55 per cent of the botany questions, 46 per cent of the zoology questions, and 46 per cent of the bacteriology questions were answered correctly.
Observations

Concluding the first part of this study, which has been concerned with biological sciences on the high school level, the following observations are made:

1. The knowledge of biological science shown by high school graduates varies greatly.
2. The college cannot assume that all entering freshmen have an understanding knowledge of any particular basic facts or information in this field.
3. Some phases of the different courses were slighted or neglected.
4. Some students did not have the opportunity of receiving such training or gaining information in this field.
5. The Utah group was slightly below the national group in the achievement test given.
6. The difference in the test results of the two groups was found to be of statistical significance.

The above conditions can be partially explained on the basis of the difference in the courses offered throughout the schools of the state, the size of the school, the nature and content of the course, and, perhaps, above all, the quality and preparation of the teacher in the field.

These observations would seem to indicate the need for a closer articulation of high school and college lower division courses.
SCHOOLS USED AND COURSES TAUGHT

The second part of this study has been made on the college lower division level and parallels that of the high school. For each of the ten colleges of the state the biological science courses and the number of hours required to fill that group are given in the table below. Although there were many more courses that may have been used for filling this group requirement, they have been considered as more specialized.

Table No. 13. General Biological Science Courses Offered in Colleges of Utah, 1947-48.

<table>
<thead>
<tr>
<th>Course</th>
<th>Number of Hours Given</th>
<th>Hours Required</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prin.of Biology</td>
<td>6 quarter hours</td>
<td>8-12</td>
</tr>
<tr>
<td>Botany I</td>
<td>6 quarter hours</td>
<td></td>
</tr>
<tr>
<td>Zoology I</td>
<td>6 quarter hours</td>
<td></td>
</tr>
<tr>
<td>Bacteriology I</td>
<td>4 or 5 quarter hours</td>
<td></td>
</tr>
<tr>
<td>Physiology 4</td>
<td>5 quarter hours</td>
<td></td>
</tr>
<tr>
<td>Biology I, Prin. of Bio.</td>
<td>6 quarter hours</td>
<td>12</td>
</tr>
<tr>
<td>Bacteriology I, El. Bact.</td>
<td>5 quarter hours</td>
<td></td>
</tr>
<tr>
<td>Botany I</td>
<td>5 quarter hours</td>
<td></td>
</tr>
<tr>
<td>Zoology I</td>
<td>6 quarter hours</td>
<td></td>
</tr>
<tr>
<td>Physiology I</td>
<td>6 quarter hours</td>
<td></td>
</tr>
<tr>
<td>Biology I</td>
<td>3 quarter hours</td>
<td>12 hours Bio-</td>
</tr>
<tr>
<td>General Botany I</td>
<td>5 quarter hours</td>
<td>logical Science</td>
</tr>
<tr>
<td>General Zoology I</td>
<td>5 quarter hours</td>
<td>and Psychology</td>
</tr>
<tr>
<td>Bacteriology I</td>
<td>3 quarter hours</td>
<td>12</td>
</tr>
<tr>
<td>Botany I</td>
<td>6 quarter hours</td>
<td></td>
</tr>
<tr>
<td>Physiology I</td>
<td>3 quarter hours</td>
<td></td>
</tr>
<tr>
<td>Zoology I</td>
<td>4 quarter hours</td>
<td></td>
</tr>
<tr>
<td>Branch Agricultural College</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bacteriology I</td>
<td>3 quarter hours</td>
<td>8-12</td>
</tr>
<tr>
<td>Biology I</td>
<td>5 quarter hours</td>
<td></td>
</tr>
<tr>
<td>Physiology 4</td>
<td>5 quarter hours</td>
<td></td>
</tr>
<tr>
<td>Zoology 3-4</td>
<td>5 quarter hours</td>
<td></td>
</tr>
<tr>
<td>Botany 12-21-22-30</td>
<td>5 quarter hours</td>
<td></td>
</tr>
</tbody>
</table>

Continued -
### Table: Credit Hours for Biological Science Courses

<table>
<thead>
<tr>
<th>Course</th>
<th>Number of Hours Given</th>
<th>Hours Required</th>
</tr>
</thead>
<tbody>
<tr>
<td>Principles of Biology I</td>
<td>5 quarter hours</td>
<td>12</td>
</tr>
<tr>
<td>General Botany I</td>
<td>5 quarter hours</td>
<td></td>
</tr>
<tr>
<td>General Zoology</td>
<td>5 quarter hours</td>
<td></td>
</tr>
<tr>
<td>General Physiology for Medicine and Nursing</td>
<td>5 quarter hours</td>
<td></td>
</tr>
<tr>
<td>General Biology I</td>
<td>5 quarter hours</td>
<td>12</td>
</tr>
<tr>
<td>General Botany I</td>
<td>5 quarter hours</td>
<td></td>
</tr>
<tr>
<td>General Bacteriology I</td>
<td>5 quarter hours</td>
<td></td>
</tr>
<tr>
<td>General Zoology I</td>
<td>5 quarter hours</td>
<td></td>
</tr>
<tr>
<td>Biology I</td>
<td>5 quarter hours</td>
<td></td>
</tr>
<tr>
<td>General Botany I</td>
<td>5 quarter hours</td>
<td></td>
</tr>
<tr>
<td>Physiology</td>
<td>5 quarter hours</td>
<td></td>
</tr>
<tr>
<td>General Biology 101-102</td>
<td>4 semester credits</td>
<td>12</td>
</tr>
<tr>
<td>General Botany 201-202</td>
<td>4 semester credits</td>
<td></td>
</tr>
<tr>
<td>Bacteriology 2C5</td>
<td>4 semester credits</td>
<td></td>
</tr>
<tr>
<td>Zoology 203-204</td>
<td>4 semester credits</td>
<td></td>
</tr>
<tr>
<td>Bacteriology I</td>
<td>4 semester hours</td>
<td></td>
</tr>
<tr>
<td>Biology I</td>
<td>3 semester hours</td>
<td>Science, 12 units</td>
</tr>
<tr>
<td>Physiology I</td>
<td>3 semester hours</td>
<td></td>
</tr>
<tr>
<td>Anatomy I</td>
<td>3 semester hours</td>
<td></td>
</tr>
<tr>
<td>Survey of Biological Science I</td>
<td>3 semester hours</td>
<td></td>
</tr>
</tbody>
</table>

Seven of the ten colleges require twelve quarter hours to fill the biological science group. One required ten and two require eight. There are nine out of the ten schools that have courses in general biology and botany. Eight of the schools have general courses in bacteriology and zoology, and seven offered a general physiology course. On the basis of this information, it appears there is more uniformity of the college courses offered than there is in high school, but they differ as to the number of credit hours for the respective courses.

It is rather generally accepted that the students, after having had courses in biological science, should have a broad general knowledge of the field, and that they should have had an introduction to some of the
basic concepts, such as organization of living things, metabolism, growth, relation to environment, reproduction, development, inheritance, and evolution. The non-biological science majors, with whom this study is directly concerned, may have filled this group requirement by taking courses within one or more of the four most commonly considered areas, namely, bacteriology, botany, physiology, and zoology. In order to determine what courses students were taking to meet the biological science group requirement, a survey was made by using the class of 1939 at Utah State Agricultural College as a sample to show courses taken and the distribution of students in those courses. This was exclusive of those registered in the schools of Agriculture, Engineering, and Forestry, because these schools already had their own prescribed course of study. The accompanying table gives the courses taken, the number enrolled, and their class standing. It should be noted that zoology 1 and botany 1, although listed separately, were actually the same course.

Table No. 14. Courses Taken to Fill Group Requirement
by Class of 1939 at U. S. A. C.

<table>
<thead>
<tr>
<th>Course</th>
<th>Number of Freshmen</th>
<th>Number of Sophomores</th>
<th>Number of Juniors</th>
<th>Number of Seniors</th>
<th>Total</th>
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<tr>
<td>Physiology No. 4</td>
<td>123</td>
<td>24</td>
<td>6</td>
<td>2</td>
<td>155</td>
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<tr>
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<td>78</td>
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<td>2</td>
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<tr>
<td>Bacteriology No. 1</td>
<td>38</td>
<td>26</td>
<td>15</td>
<td>2</td>
<td>81</td>
</tr>
<tr>
<td>Botany No. 21</td>
<td>40</td>
<td>10</td>
<td>0</td>
<td>0</td>
<td>50</td>
</tr>
<tr>
<td>Botany No. 22</td>
<td>36</td>
<td>8</td>
<td>0</td>
<td>0</td>
<td>44</td>
</tr>
<tr>
<td>Foods and Nutrition</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. 5</td>
<td>18</td>
<td>12</td>
<td>3</td>
<td>1</td>
<td>34</td>
</tr>
<tr>
<td>Botany No. 23</td>
<td>19</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>19</td>
</tr>
<tr>
<td>Botany No. 1</td>
<td>15</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>18</td>
</tr>
<tr>
<td>Zoology No. 3</td>
<td>3</td>
<td>5</td>
<td>0</td>
<td>0</td>
<td>13</td>
</tr>
<tr>
<td>Zoology No. 4</td>
<td>5</td>
<td>5</td>
<td>1</td>
<td>0</td>
<td>11</td>
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</tbody>
</table>

520
It is significant to note that in this particular year, 1932, there were 165 taking physiology, 131 taking botany, 121 taking zoology, 61 taking bacteriology, and 34 taking foods and nutrition.

Following is given a brief outline for each of the four areas that have been used in this study. This is for the purpose of an over-all view of the subject matter in the respective courses for comparison of course content on the college level with the high school. Brief outlines are given in bacteriology, botany, zoology, and physiology.

Outline of General Biology, Botany I, and Zoology I.
Beaver (9), Mavor (12), Strausbaugh and Reimer (13), Woodruff (14).

Introduction

Scope of Biology, Relation of Biology to other fields of knowledge.

The cell

Organization, size, shape. The cell theory.

Protopenism

Organization in cell, physical and chemical properties, physiological activities, reproduction, irritability.

Metabolism of organisms

2. Animals: single celled organism absorption, food, respiration.

Reproduction of cells by division. (Details of mitosis deferred).

Multicellular organisms


The plant body: flowering plant.

Structure, functions of roots, modifications of stems, conduction,
storage, support.

Structure, functions of leaves. Photosynthesis reviewed.

Physiology of seed plant, viewed as a working organism.
Absorption, translocation, photosynthesis, respiration, transpiration, food storage and utilization, irritability.

Reproduction in plants.
A. Asexual: spores, etc., cuttings, bulbs, tubers.
B. Sexual: origin of sex, sex organs.

Life history of moss, alternation of generations.
Life history of fern.
Life history of seed plant.

Flower, seed, fruit.

Brief survey of plant groups, classification.
Thallophytes: algae, fungi.
Bryophytes: mosses, liverworts.
Tracheophytes: gymnosperms, angiosperms, monocotyledons, dicotyledons.

Plants of past.
Plant distribution.

The animal body, invertebrates.

Hydra: structure, metabolism.
Earthworm: body plan, tissues, organs, metabolism.
Crayfish: body structure, organs, metabolism.

Survey of animal kingdom.
Invertebrates.

Vertebrates, emphasis on changes involved in structure of fishes to mammals.

Physiology of mammals.
Nutrition

Digestive systems: enzymes, absorption, distribution of food, utilization of food, vitamins.

Circulation: emphasis on exchanges between blood and body cells.

Respiration: emphasis on energy relations.

Excretion: lungs, skin, liver, kidneys (evolution of kidneys).

Reproduction, man.

Coordination: hormones, nervous.

Origin of life

Biogenesis and abiogenesis.

Origin of life on earth.

Continuity of life

Reproduction, cell, mitosis.

Origin of germ cells: spermatogenesis, oogenesis.

Chromosome cycle.

Fertilization: gametes, union of, synkaryon significance of fertilization.

Embryology, problems of development.

Epigenesis versus preformation, organizers.

Genetics

Mendelism, mechanism of inheritance.

Mutations, modifications, recombinations, Galton's studies.

Nature and nurture.

Organic Adaptations

Adaptations to physical environment, functional and structural.

Adaptive radiation.

Adaptations to the living environment.

Individual adaptability.
Origin of species.

Evidence of evolution: classification, comparative anatomy, paleontology, embryology, physiology, distribution.

Factors in evolution: Lamarckism, Darwinism, genetics and evolution.

Origin of man.

Fossil man: Java, Peking, Piltdown, Heidelberg, Neanderthal, Cro-Magnon.

Cultural development: Paleolithic culture, Mesolithic culture, and Neolithic culture.

Biology and human welfare.

Medicine: Microorganisms and disease.

Biology and agriculture: plant and animal food.

Harmful and beneficial relationships between living organisms.

Conservation of natural resources.

**College Physiology** Carlson and Johnson (10)

Introduction

Place of physiology in the field of biology.

Relationships of sub-sciences of biology.

Living as contrasted with non-living things.

The cell.

Discovery of the cell, its structure and function.

Different kinds of cells.

Specialized activities of the cells.

Protoplasmic concept.

Characteristics, chemical composition, internal organization,
physical states.

Energy relationships.

The circulatory system and the body fluids.

Evolution of the circulatory system in animals up to and including man.


Structure and function of red and white blood cells, platelets, and the plasma proteins.

Blood clotting and the successive reactions which occur.

Life cycle of the corpuscles.

Origin, place, time, and their disposal.

Blood disorders.

Hemophilia, anemia, pernicious anemia, leucocytosis, leucemia, diabetes, leucopenia and others.

Blood counts, blood types, transfusions.

Hemolyses and phagocytosis.

The heart.

General anatomy of the heart and the vascular system.

Experiments of William Harvey and a general evolution of the vertebrate heart.

Cardiac tissue, sinus node, cardiac cycle.

Use of stethoscope and the electrocardiograph.

Some disorders of the heart.

Law of Starling.

Nerves of the heart and cardiac reflexes.

Blood flow and blood pressure.

Physiological anatomy of the arteries, veins, and capillaries.
Circulation time, rate and constancy of blood flow, resistance to flow, nerves of the blood vessels, factors influencing the blood flow to the organs.

Arterial blood pressure.

Systolic and diastolic pressures.

Adjustment of the pressure to varying physiological conditions.

Cardiac output and peripheral resistance influenced by viscosity.

Tonic action of vaso-constrictor nerves, vaso-motor nerve centers, carbon dioxide, and modulator nerve reflexes.

Common disorders of circulation.

Hypertension, hypotension, embolism, varicosities, and many others.

Lymphatic circulation.

Morphology and physiology of the lymph and the system.

Importance of the fluid and system to the normal functioning of the body.

Respiration and the respiratory system.

Organs of respiration and how they are adapted for their particular functions.

Lung tissue, phases and kinds of respiration.

Intercostal muscles, the diaphragm, nerves, breathing center, carbon dioxide, and difference in air pressure.

Different kinds of air in lungs.

Complemental, supplemental, reserve, residual, and minimal.

Artificial respiration, the gaseous exchange that occurs in the lung tissue.

Modifications of breathing.

Disorders of the respiratory tract.
The alimentary canal.

Evolution and anatomy.

Mechanical and chemical phases of digestion.

Digestive glands, juices, enzymes.

Movements of the alimentary canal during digestion.

Hunger, appetite, thirst, and absorption.

Disorders of the alimentary canal.

Indigestion, ulcers, cancer, appendicitis, and gallstones.

History of foods in the body.

Fats, carbohydrates, and proteins.

Utilization of each by the cells of the body.

Production of animal heat, caloric content for each of the above nutrients, basal metabolism.

Factors influencing size, weight, and sex.

Diets.

Water, inorganic salts, and vitamins.

Metabolic wastes and the work of the kidney.

Skeletal, muscular, and nervous systems.

Special senses and their sensory organs.

Vision, hearing, balance, smell, taste, and touch.

Glands of internal secretion.

Pineal, pituitary (hypophysis), thyroid, parathyroids, thymus, adrenals, pancreas, ovary, and testis.

Hormones and uses of hormones in the body.

Abnormalities resulting from a malfunctioning of glands.

Diabetes mellitus, goiters, Cushing disease, cretinism, gigantism, acromegaly, Addison's disease.
Body defenses against disease.

Body's adaptations.
Margin of safety, replacement of damaged tissues, function of pain.
Parasitic infections.
Bacterial diseases, species, and tissue immunity.
Mechanical factors such as skin and secretions.

Ciliary motion, reflexes, chemical factors.

Localizations of infections, inflammation, phagocytosis, lymph vessels and nodes.
Pasteur's and Koch's experiments.

Reproduction and early development.

Asexual and sexual reproduction.
Carried on in simpler plants and animals, higher plants and animals, and sexual reproduction as found in mammals.

Production of gametes and fertilization.
Early embryonic stages and development of primary germ layers.
The recapitulation principle. Gestation of different species.
Changes that occur at birth.

College Bacteriology  Greaves and Greaves (11)

The founding of bacteriology.

Discovery of bacteria, its origin and early classifications.
Spontaneous generation.

The conquest of disease.
Smallpox, Pebrine, Anthrax, Rabies, Yellow Fever, and other plagues conquered.
Pasteur honored.

Micro-organisms become the allies of man.
Fermentation, fermentation and bread making, biological changes during leavening, and bread and disease.

Bacteria, occurrence and function.

Morphology of bacteria.

The cell, shape of bacteria, structure, movement, reproduction, longevity, size, weight, and spore formation.

Yeast, molds, and actinomycetes.

Each considered as to structure, classification, occurrence, functions, and methods of multiplication or reproduction.

Classification of bacteria.

Functions, method, and nomenclature of classification.

Bacterial variation both temporary and hereditary.

Microscopical study of bacteria.

Composition, chemical activities, and food requirements of bacteria.

Products of bacterial activity.

Influence of environment and influence of chemicals on bacteria.

The carbon and nitrogen cycles.

Occurrence and properties of each.

Nitrogen fixation, nonsymbiotic and symbiotic.

The phosphorus and sulfur cycles.

Occurrence, properties, and functions.

Bacteria in relation to other elements.

Iron and salts.

Water, importance of, classification of, Micro-organisms in water, water and disease, natural and artificial purification.

Bacteriology of sewage.
Milk, milk products.
Consumption of, value of, classes of.
Bacteria in milk. How to produce clean milk. Evaporated, condensed, pasteurized.
Butter, cheese, ice cream.

Bacteria in other foods.
Meats, fresh vegetables, fresh fruits and confections.

Botulism.
Historical, causative organism, distribution, pathogenicity, symptoms, toxin, antitoxin, and prevention.

Food preservation.
Methods: heat, cold storage, frozen pack, drying, pickling, by use of salt, sugar, and chemical preservatives.

Bacteria in other arts and industries.
Silage, vinegar making, curing of tobacco, cocoa, retting of flax and hemp, and tanning of hides.

Bacteria in the air and the intestinal bacteria.

Bacteria as the cause of disease.
Theories of disease, the germ theory, Koch's postulates, pathogenicity, and how bacteria produce disease.

Immunity, antitoxins, and vaccines.
Natural, active, passive, and acquired immunity.

The pyogenic cocci.
Morphology and physiologic properties of staphylococci and streptococci.

Detailed study of each of the following diseases: Pneumonia, tuberculosis, diphtheria, tetanus, typhoid, syphilis.

Infections common to man and lower animals: Anthrax, glanders, meli.

Infections common to man and lower animals: Anthrax, glanders, meli.
Fever, foot and mouth disease, and tularemia.

Some insect-borne diseases.

Classes of, and characteristics of insect-borne disease.

Malaria and plague.

The bacteriophage.

Source, propagation, properties and nature.

The viruses and some virus diseases.

History, properties, nature, size, resistance, immunity, and control.

Smallpox, rabies, or hydrophobia, common cold, infantile paralysis, and measles.
Table No. 15. Percentile Norms for Section I Examination with Biology College Level.

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The examination on the college level was given to 120 students who had completed the science group requirement, and the analysis of the examination and the results are on the same basis as for that of the high school.

The results for Section I as given in the foregoing table show the range of scores to be nearly the same. The high score in each group
was 56 and the low score of the local group was 18 as compared to 20 for the national group. However, the 57th percentile of the local group shows a score of 30, and the 57th percentile of the national group shows a score of 40. The average of the local group is below that of the national, which indicates our college students have not acquired the factual material to the same degree that the national group did.

Table No. 16. Percentile Norms for Section II Examination in Biology College Level.

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For Section II, which deals with identification of structure and function, the scores of the local group are below those of the national group in all respects. The highest score of the local group was 24 compared to 27 for the national, and the lowest score of the local group
was 1 compared to 7 for the national. The 54th percentile of the local
group had a score of 13, the 54th percentile of the national group had
a score of 17.

Table No. 17. Percentile Norms for Section III Examination in Biology
College Level.

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The results of Section III (interpretation of data) showed the local group to be below the national. The high scores for both groups was 36 and low scores were 0 and 8. The 47th percentile of the local group showed a score of 20 and the 47th for the national showed a score of 24.
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Table No. 18. Percentile Norms Total Score for Examination in Biology, College Level.
The results of the total score showed the local group to be below that of the national. The high score was 111 for the local group as compared to 114 for the national, but the low scores of 36 were the same for both groups. The 53rd percentiles had scores of 64 for the local and 78 for the national.

As indicated by the results of this examination, the local college student's achievement level in the biological sciences is slightly below that of a national group. The average difference of the twelve comparable percentiles of the two groups was 9.93 in favor of the national group. On the basis of statistical methods outlined in section 2.13 of Snedecor this difference is highly significant. The probable error is less than one per cent. This can partially be accounted for on the basis that students may fill this group requirement from courses in one area and thus they fail to become acquainted with the other fields.

Out of the 100 questions in the first two sections of the examination, the question analysis showed the following distribution as to subjects: There were 7 in bacteriology, 48 in botany, 15 in physiology, and 52 in zoology. Thus, these subjects have not received equal emphasis in the examination.

In comparing the examination on the high school and college levels, it was noted in the fields of botany and bacteriology that the number of questions was about the same. In the field of physiology the high school examination had 51 questions, compared to 15 for the college, and in zoology the high school had 40 questions and the college had 52.
Table No. 19. Analysis of College Bacteriology Questions

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<td>108</td>
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</table>
Of the 48 botany questions, the one 82 per cent answered correctly was on the aim of classification, while the one only 10 per cent answered correctly was on the identification of a part of a mold plant.

The two that 50 per cent answered correctly were: One dealing with the value of sexual reproduction, and one with the law of segregation.

The upper and lower 25 per cent of the questions in this division were mixed as far as subject matter was concerned. They represented a very broad scope in botany.

Table No. 21. Analysis of Physiology Questions as to Number Right, Wrong, and Per Cent Right in Rank Order on the College Level.

<table>
<thead>
<tr>
<th>Question Number</th>
<th>Number Right</th>
<th>Number Wrong</th>
<th>Per Cent Right</th>
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The physiology question that was answered correctly by 82 per cent (which was the highest) was on the identification of an eye part, and the one only 16 per cent answered correctly was on bone tissue, while the one 64 per cent answered correctly was on the cause of diabetes.

In this field also the questions were selected from a wide range of information. They did not follow a type or pattern in the upper and lower 25 per cent.
Table No. 22. Analysis of Zoology Questions as to Number Right, Wrong, and Per Cent Right.

<table>
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Of the 52 questions in zoology, there was not a type or pattern question in the upper or lower 25 per cent. The questions represented a broad range in this science. It was interesting to note that some of the questions that most answered correctly, as well as some that most answered incorrectly, were in the part dealing with identification of structural parts of organisms, and the three questions that 50 per cent answered correctly represented entirely different phases of the science.

The Utah college students answered a higher percentage of the questions correctly in physiology than they did in the other subjects, as also did the high school students. But they ranked second in zoology and the high school students ranked third. In botany the college group ranked third and the high school students ranked second. Bacteriology was the lowest in both groups. This is shown by the fact that on the college level, 45 per cent of the physiology questions, 41 per cent of the zoology questions, 41 per cent of the botany questions, and 27 per cent of the bacteriology questions were answered correctly.
DISCUSSION AND CONCLUSIONS

This study shows a wide variation in the biological science courses offered in the high schools of the state. In the colleges there was more uniformity as to courses offered, yet differences existed in those courses as to credit hours and number of hours for group requirements.

In some high schools there was rather a small percentage of the students enrolled in biological science courses, and some high school graduates did not receive any training in biological science. Since many of them do not go on to college, they are failing to learn important facts which this science affords them in understanding themselves and the world they live in. For example, it is of great value socially and politically for everyone to understand the principle of the genetic inequality of human beings. It is possible that the value of some of these facts, and perhaps the value of biological science as a whole in the high school curriculum has been underestimated. Because the elective system results in some students missing biology entirely, and others gaining only scattered concepts from specialized courses, it would seem that general biology should be reorganized and made a required subject for graduation.

The group of college students this study was concerned with did not rank equally with a national group on the test given. Of course, there is no particular reason why local students should just equal the norms elsewhere, fall below them, or exceed them. It does seem, however, that Utah high school students who go on to college and are thereby a somewhat selected group ought to equal a random selection of high school students elsewhere on a test developed by the Armed Forces Institute in an area of such generally accepted importance as biological science.
Similarly local college students ought to do at least equally as well as students elsewhere. It might be that if a broad course in biology were used as a pre-requisite for any of the other natural sciences in college and that if it were planned to meet the needs of the general student, it would help to improve the standing of the Utah students in this field. Of more importance, it might also help the average student to obtain a working knowledge of more of the fields of biology, rather than a special training in any one of them. For example, an understanding knowledge of the Mendelian law of inheritance would not be sacrificed for a knowledge of the circulatory system. Rather, the basic concepts and principles would be learned which should enrich any individual's life and make it possible for him to make a greater contribution to mankind.

The college courses of physiology, biology, botany, and zoology were much more advanced and detailed than the high school courses. Bacteriology is receiving very little emphasis on the high school level. Many of the high school texts and outlines were very brief in their discussions of heredity, genetics, and eugenics. Basic facts in all of the courses were given on both the high school and the college level, just as basic facts in mathematics or English are repeated in both high school and college courses but closer articulation between the high schools and colleges would make for courses which would better fit the needs of all students.

On the achievement level, the local high school group rated very near the national group, while the local college group ranked considerably below the national college group. This may mean that we are still placing too much emphasis on specialization in our colleges and neglecting the general student.
The examination showed a difference in emphasis on various phases of biological science. Question analysis showed that the high school students answered a larger percentage of their questions correctly than did the college students on similar subject matter. Nevertheless, this may not mean anything in particular except that the college questions were more difficult. It could mean, however, that the college students were proportionately less well prepared after completing group requirements in biological sciences.

It is doubtful if the data from this study are adequate to show conclusively that these conditions found are uniform throughout the state, and it is felt these problems warrant further study.

This study which has been concerned with what courses were taught, their specific content, student registration, and student achievement in the field of biological science may suggest further study which would include teaching methods, teacher interest, preparation and load. Another study may be concerned with the physical facilities of the schools and their effect upon the training of the students. A more important study would be to determine the effect or influence of biological training upon the lives of individuals.
SUMMARY

1. This study was undertaken because of a need for closer relationship between the biological science courses of high school and college, and as a means of attempting to determine whether or not these courses were meeting and satisfying the needs of the students.

2. The biological science courses offered in Utah were determined by a sampling of twenty high schools. The data used were obtained from the State School Office and by examination of catalogues from the ten colleges.

3. The specific content of the respective courses was obtained from textbooks, outlines, and the state course of study. The college course is more detailed and advanced; yet, there are some things common to both.

4. A larger percentage of high school students were enrolled in physiology and biology than in any of the other biological sciences. These were the two most widely taught courses on the high school level. There was a larger percentage of students registered in physiology than in any of the other college courses in 1959 at the Utah State Agricultural College.

5. The examinations used in connection with the achievement levels of the two groups were given to 320 high school graduates and 120 college students who had filled the science group requirement. The results of the examination have been presented with respect to total achievement, sectional achievement, and on a subject basis by means of question analysis. From these results, it was concluded the Utah groups did not rank equally with the national groups.
6. With respect to total achievement, the national high school group ranked slightly above the local high school group. The national college group ranked considerably above the local college group.

7. With respect to sectional achievement, both the national groups ranked higher than the local groups.

8. The Utah high school students scored highest in physiology, followed in order by botany, zoology, and bacteriology. The local college students scored highest in physiology, followed in order by zoology, botany, and bacteriology.
BIBLIOGRAPHY

High School Textbooks


College Textbooks


General


Appendix

The numbers written in ink on the margin of the examination copies indicate the number of times that question was answered correctly. For example, the college examination was given to 120 students. Therefore, if every student who took the test answered the question correctly, the number shown would be 120. Similarly, there were 320 high school level examinations given and if everyone answered the question correctly, the number shown would be 320.
This form was attached to the examinations given on the college level.

In connection with the attached examination the following information is needed:

Student's name__________________________

High School attended______________________

City________________ State_______________

Number of units of credit completed in each of the following in grades 9 to 12:

General Biology__________________________
Zoology__________________________
Botany__________________________
Physiology__________________________
Genetics__________________________

Total__________________________

What lower division courses in Biological Science have you completed at the U. S. A. C. and any other college or university you may have attended.

<table>
<thead>
<tr>
<th>Course</th>
<th>Quarter Credits</th>
<th>Class Rank when taken</th>
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Major__________________________ Minor__________________________
Directions: You have two hours for this examination. As you answer the questions you should omit any that seem unusually difficult until you finish the others.

Your answers to the exercises in this examination are to be recorded on the separate ANSWER SHEET which is loosely inserted in the examination booklet. Remove this answer sheet now; write your name and the other information called for in the blanks at the top of the answer sheet; then finish reading these directions.

After the number on the answer sheet corresponding to that of each exercise, mark the one lettered space which designates the answer you have selected as correct. If your answer sheet contains rows of squares, indicate each answer with a cross (X), for example,

A B C D E
[ ] [X] [ ] [ ] [ ]

If your answer sheet contains rows of paired dotted lines, indicate each answer with a heavy black mark with the special pencil, for example,

A B C D E
[ ] [ ] [ ] [ ] [ ]

Avoid resting the point of your pencil on the answer sheet while you are considering your answer. Do not make unnecessary marks. If you change an answer, erase your first mark completely. Do not fold or crease your answer sheet.

EXAMPLE

0. Which of the following organisms is a mammal?

A. A clam
B. A man
C. A fish
D. An earthworm
E. An amoeba

[The correct answer is a man; therefore, space B would be marked on the answer sheet.]

Prepared by the
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SECTION 1

Basic Facts and Information

1. How many main types of human blood are there?
   A. Two
   B. Three
   C. Four
   D. Five
   E. More than five

2. Which name is given to that part of the plant cell marked in the diagram?
   A. Cell membrane
   B. Nucleus
   C. Cytoplasm
   D. Chloroplast
   E. Tissue

3. Who is credited with the discovery that blood circulates?
   A. Harvey
   B. Lavoisier
   C. Leeuwenhoek
   D. Schleiden
   E. Lamarck

4. Which of the following is the best description of a diatom?
   A. Each is composed of two atoms.
   B. Each is composed of two cells.
   C. Each is composed of one cell.
   D. Each is composed of a double cluster of cells.
   E. Each is composed of a tiny group of living cells surrounded by a colony of dead cells.

5. In what phylum do the seed-bearing plants with true roots, stems, and leaves belong?
   A. Thallophytes
   B. Bryophytes
   C. Spermatophytes
   D. Pteridophytes
   E. Fungi

6. Which of the following crops can best be used for adding organic material to the soil?
   A. Oats
   B. Soy beans
   C. Corn
   D. Wheat
   E. Rye

7. What mineral is commonly added to the soil to counteract the acidity?
   A. Rock salt
   B. Limestone
   C. Any nitrate
   D. Charcoal
   E. Any ammonium compound

8. What part of the apple blossom produces the pollen grains?
   A. Part A
   B. Part B
   C. Part C
   D. Part D
   E. Part E

9. Why is the earthworm called a hermaphrodite?
   A. The young develop in a cocoon-like structure.
   B. Each worm has both ovaries and testes.
   C. It often reproduces without being fertilized.
   D. An earthworm will devour its own young.
   E. An earthworm will regenerate parts of its body which may have been injured or torn off.

10. What is the name of the connective tissue which binds one bone to another?
    A. Muscle
    B. Tendon
    C. Ligament
    D. Suture
    E. Tourniquet

11. Which of the following functions or processes is least essential to life or to the continuation of a species?
    A. Reproduction
    B. Thinking
    C. Respiration
    D. Growth
    E. Digestion

12. Which of the following best describes the behavior of a cockroach as it runs away from the light?
    A. Positive geotropism
    B. Negative geotropism
    C. Positive phototropism
    D. Negative phototropism
    E. None of these terms

13. Which of the following most closely describes the sex of the worker bee?
    A. A fully developed female
    B. A poorly developed female
    C. A fully developed male
    D. A poorly developed male
    E. One possessing both male and female organs
Identify the following structures in the figure above.

14. The pancreas
A. 1
B. 2
C. 3
D. 5
E. 7

15. The liver
A. 1
B. 2
C. 3
D. 5
E. 7

16. The small intestine
A. 2
B. 3
C. 4
D. 5
E. 6

17. What is the stimulus for bird migrations?
A. Biological changes in the birds
B. Seasonal weather conditions
C. To carry on reproduction
D. To secure a variety of food
E. To protect themselves from their enemies

18. Which of the following pests are kept from multiplying because they are killed by hawks and owls?
A. Termites
B. Mice
C. Grasshoppers
D. Earthworms
E. Mosquitoes

19. Why do plants such as wheat need nitrates?
A. Nitrogen is needed for building protoplasm.
B. Nitrogen is needed for building sugars.
C. Nitrogen is needed for changing sugars into starches.
D. Nitrogen acts as a catalyst in the building of proteins.
E. Nitrogen acts as an enzyme in the building of proteins and carbohydrates.

20. What characteristic does the leaf of a monocotyledonous plant have which the leaf of a dicotyledonous plant does not have?
A. A major vein with smaller radiating veins
B. A network of veins
C. Veins radiating from the stem to all the edges
D. No well-defined veins
E. Parallel veins

21. How does reproduction take place in the common amoeba?
A. The cell divides, the original nucleus remains in one part, and another nucleus grows in the other part.
B. Both the nucleus and the cell divide with a nucleus in each part.
C. The nucleus is absorbed by the protoplasm, the cell divides and new nuclei finally appear in each cell.
D. Nuclear material disintegrates into many tiny particles, the cell divides, and a nucleus re-forms in each cell.

22. How does the amoeba move?
A. By movement of thread-like projections called cilia.
B. By a projection of its own body called a pseudopodium.
C. By expansion and contraction of its vacuoles.
D. By extension of its stem or stalk.
E. By a whipping motion of its flagellum.

23. What is the stimulus for bird migrations?
A. Biological changes in the birds
B. Seasonal weather conditions
C. To carry on reproduction
D. To secure a variety of food
E. To protect themselves from their enemies

24. Which of the following pests are kept from multiplying because they are killed by hawks and owls?
A. Termites
B. Mice
C. Grasshoppers
D. Earthworms
E. Mosquitoes
25. For what kind of experiments on the training of dogs is Pavlov famous?
   A. Performance of tricks following a single command
   B. Solving simple puzzles
   C. Following the path of intricate mazes
   D. Memory experiments
   E. Association between food stimulus and other stimuli

26. What is the function of the three tiny bones in the middle ear?
   A. To provide a sense of balance
   B. To act as a valve-like mechanism on the opening to the Eustachian tube
   C. To connect the eardrum with the semicircular canals
   D. To transmit vibrations from the eardrum to the liquid of the inner ear
   E. To reinforce the eardrum and prevent its rupture

27. During which of the following processes is oxygen released?
   A. Respiration
   B. Oxidation
   C. Oxygenation
   D. Photosynthesis
   E. Assimilation

28. Which of the following excretes most of the wastes from the human body?
   A. Kidneys
   B. Sweat glands
   C. Liver
   D. Intestines
   E. Endocrine glands

29. Which of the following animals does not lay eggs?
   A. Snake
   B. Frog
   C. Fish
   D. Owl
   E. Kangaroo

30. Which of the following processes plays the greatest role in the passage of water from the soil into the roots of plants?
   A. Capillary action
   B. Osmosis
   C. Chemical action
   D. Adsorption
   E. Photosynthesis

31. How can one tell the age of a tree?
   A. By the thickness of its bark
   B. By its diameter
   C. By its height
   D. By its diameter and its height
   E. By its rings

32. What name is given to reproduction where there is only one parent?
   A. Sexual reproduction
   B. Asexual reproduction
   C. Spontaneous generation
   D. Regeneration
   E. Fertilization

33. When Myrtle looked at the center of the chart, the lines running in one direction appeared lighter and less distinct than the others. Which of the following is the best explanation for this?
   A. It is always easier to focus on vertical lines than horizontal lines.
   B. It is always easier to focus on horizontal lines than vertical lines.
   C. With some eye conditions, the eye cannot bring all lines or figures on a single surface into focus.
   D. Near-sighted people usually see vertical objects more clearly than horizontal objects.
   E. Far-sighted people usually see horizontal objects more clearly than vertical objects.

34. How do the temperature and pressure on a high mountain compare with those at sea level?
   A. There is a lower temperature and a lower pressure on top of the mountain.
   B. There is a lower temperature and a higher pressure on top of the mountain.
   C. There is a higher temperature and a lower pressure on top of the mountain.
   D. There is a higher temperature and a higher pressure on top of the mountain.
   E. There is a higher temperature on the top of the mountain but the pressure is the same.

35. When the human eye is focused on a distant object how does the curvature of its lens compare with its curvature when focused on a nearby object?
   A. Same curvature in both instances
   B. Greater curvature for nearby objects
   C. Greater curvature for distant objects
   D. Impossible to tell, for in some instances the curvature is greater for distant objects and in other cases the curvature is greater for nearby objects.

36. Where does the embryo of a mammal develop?
   A. In the ovary
   B. In the oviduct
   C. In the uterus
   D. In the umbilical cord
   E. In the syphilis

37. Which of the following combinations correctly names all the elements contained in sugars and starches?
   A. Carbon and oxygen
   B. Carbon and nitrogen
   C. Carbon, hydrogen, and nitrogen
   D. Carbon, hydrogen, and oxygen
   E. Carbon, hydrogen, oxygen, and nitrogen
38. What name is given to the muscular movements which push food through the intestines?
A. Villi
B. Peristalsis
C. Osmosis
D. Tropism
E. Metamorphosis

39. What is a small calorie?
A. The amount of heat necessary to raise the temperature of 1 gram of any substance 1 degree Centigrade
B. The amount of heat necessary to raise the temperature of 1000 grams of any substance 1 degree Centigrade
C. The amount of heat necessary to raise the temperature of 1 gram of water 1 degree Centigrade
D. The amount of heat necessary to raise the temperature of 1000 grams of water 1 degree Centigrade
E. None of these

40. What is the study of diseases called?
A. Genetics
B. Physiology
C. Eugenics
D. Pathology
E. Embryology

41. Which of the following foods has the largest percentage of protein?
A. Lettuce
B. Corn
C. Lean beef
D. Watermelon
E. Green beans

42. From which of the following does the average human being secure most of his energy?
A. Fat and carbohydrate
B. Fat and protein
C. Carbohydrate and protein

43. Which disturbance of gland function causes diabetes?
A. Surplus of thyroxin from the thyroid gland
B. Lack of sufficient thyroxin from the thyroid gland
C. Lack of sufficient insulin from the pancreas
D. Lack of adequate secretion from glands of the stomach
E. Lack of hormone from the parathyroid gland

44. Which of these diseases is caused by a worm-like parasite?
A. Anthrax
B. Bubonic plague
C. Tetanus
D. Trichinosis
E. Diphtheria

45. A deficiency in which vitamin from the list above will cause scurvy?
A. Vitamin A
B. Vitamin B₁ (thiamin)
C. Vitamin C
D. Vitamin D
E. Vitamin B₂ or G (riboflavin)

46. Which of the vitamins listed above prevents rickets and dental defects?

47. Which of the vitamins listed above will prevent night-blindness?

48. Who was responsible for discovering a way of preventing smallpox by vaccination?
A. Koch
B. Pasteur
C. Jenner
D. Schleiden
E. Hooke

49. A pound of which of the following groups of foods will provide the largest proportion of all three foods, carbohydrates, proteins and fat?
A. Potato, bacon, and cheese
B. Potato, bacon, and bread
C. Potato, cheese, and beef
D. Bacon, cheese, and beef
E. Cheese, bread, and beef

50. The law requires that food manufacturers include on their labels
A. only composition and correct weight
B. only composition and a list of foreign substances.
C. only correct weight and a list of foreign substances.
D. only composition, correct weight, and a list of foreign substances.
E. composition, correct weight, a list of foreign substances, and date prepared

51. What disease is the Wasserman test used to detect?
A. Scarlet fever
B. Smallpox
C. Pneumonia
D. Syphilis
E. Diphtheria

52. Through what solution should gas be bubbled in order to test for carbon dioxide?
A. Carbon tetrachloride
B. Lime water
C. Hydrochloric acid (muriatic acid)
D. Silver nitrate
E. Fehling's solution
53. Which of the following kinds of foods does the human body need mainly for the building of new protoplasm?
   A. Carbohydrate
   B. Fat
   C. Protein
54. What is the function of an enzyme?
   A. It acts as a catalyst.
   B. It acts as an oxidizing agent.
   C. It acts as a reducing agent.
   D. It acts as a dehydrating agent.
   E. It acts as a hormone.
55. What is pasteurization?
   A. A treatment carried on under high pressure
   B. A treatment carried on under a vacuum or under low pressure
   C. A treatment carried on under elevated temperatures
   D. A treatment carried on under low temperatures or refrigerating conditions
   E. Any treatment designed to purify food
56. Which of the following changes is commonly produced by yeast?
   A. The change of sugar to oxygen, carbon and hydrogen
   B. The change of sugar to carbon dioxide and oxygen
   C. The change of sugar to alcohol and carbon dioxide
   D. The change of alcohol to sugar and carbon dioxide
   E. The change of alcohol, carbon dioxide, and oxygen to sugar
57. Energy in a living cell is normally produced by
   A. absorption of heat from outside
   B. combination of food and oxygen
   C. decomposition of food
   D. combination of carbon dioxide and water
   E. combination of water and oxygen
58. Which of the following elements helps in the clotting of blood, the prevention of rickets, and the building of bones?
   A. Calcium
   B. Copper
   C. Iron
   D. Iodine
   E. Phosphorus
59. Who studied racial development and origin of species?
60. Who discovered that new forms may arise suddenly?
61. An organism produced by cross-fertilization of different species or varieties is called
   A. an embryo
   B. a tropism
   C. a hybrid
   D. a mutant
   E. a parthenogenesis
62. The theory that all living things are descended from previously existing forms from which they have developed through a long series of changes is called
   A. paleontology
   B. evolution
   C. metamorphosis
   D. geneology
   E. reproduction
63. Which of the following is an example of a sex-linked trait?
   A. Color of hair
   B. Color-blindness
   C. Right or left-handedness
   D. Feeble-mindedness
   E. Extra fingers
64. When did the cave men appear?
   A. Before the time of the dinosaurs
   B. During the time of the dinosaurs
   C. After the dinosaurs were extinct
   D. There is nothing to indicate which of these statements is correct
65. The development of feathers
   A. The development of scales
   B. Wings of a bird
   C. Wings of an insect
   D. Notochord
   E. Vertebral column
66. Primitive mammals
   A. Primitive reptiles
   B. Wombats
   C. Penguins
   D. Turtles
   E. Birds
SECTION II
Application of Principles

69. How does the air pressure exerted on a person at sea level compare with the pressure that would be exerted on him if he were on top of a mountain, two miles above sea level?
A. The same pressure is exerted in both cases.
B. More pressure is exerted at sea level.
C. More pressure is exerted on the mountain top.

70. Which of the following lists is correctly arranged in order of increasing complexity (from simple to more complex)?
A. Protoplasm, tissues, cells, organs, systems, organisms
B. Protoplasm, cells, organs, tissues, systems, organisms
C. Protoplasm, cells, tissues, organs, systems, organisms
D. Protoplasm, cells, tissues, organs, organisms, systems
E. Protoplasm, cells, organs, tissues, organisms, systems

71. There is some difference of opinion as to whether the Euglena should be classified as a plant or as an animal. Which of the following characteristics favors its classification as a plant?
A. Red eye spot
B. Cell wall containing no cellulose
C. Chloroplasts
D. Mouth
E. Nucleus

72. A corn crop raised in a field where clover was grown the previous year has a greater yield than the crop from a field in which corn has been planted every year. What is the main reason that planting of clover affected the growth of the corn crop?
A. It prevented the loss of moisture from the soil.
B. It prevented soil erosion.
C. It enriched the soil with proteins.
D. It enriched the soil with nitrates.
E. Any change of crops from year to year is beneficial.

73. Why is it impossible to kill some insects by spraying food poison on the plants on which they live?
A. Some insects will not eat any kind of poison.
B. The digestive systems of some insects are able to counteract most food poisons.
C. Some insects consume only the juice from inside the plant.
D. Some insects can neutralize the poison by secretions from their bodies.

74. Which of the following best explains how soil may be robbed of its mineral and organic material?
A. By erosion and by crop rotation
B. By erosion and failure to use crop rotation
C. By erosion and by allowing the land to remain idle
D. By plowing the land at intervals during the time it is allowed to remain idle
E. By erosion and extreme changes in weather conditions

75. What has been the main purpose of the scientists who have attempted to produce paper from cornstalks and straw?
A. To prepare a strong paper
B. To increase the production of corn
C. To avoid infringement upon present patents
D. To prepare a special waterproof, parchment-like paper
E. To conserve the supply of wood and the forests

76. How are the eggs or ovules of a blossom such as the apple blossom or gladiolus blossom fertilized?
A. The ovary breaks open, exposing the ovule which then is fertilized by sperm or pollen falling on it.
B. The ovule passes up the pollen tubes, and reaches the stigma where it is fertilized by pollen.
C. Pollen reaches the stigma, its sperm passes down pollen tubes and comes in contact with the ovule which is thereby fertilized.
D. Pollen reaches the stigma, passes down the pollen tubes and comes in contact with the ovule which is thereby fertilized.
E. Pollen reaches the stigma and passes down the pollen tubes and fertilizes the ovule which is moving in from another part of the blossom.

77. The illustration shows an apparatus which supplies the jar and plant with water. If the air bubble in the tube is at point X in the morning, where will it be in the evening and where will it be the next morning?
A. At Y in the evening, and at Z the next morning
B. At Y in the evening, and still at Y the next morning
C. At Y in the evening, and back to X the next morning
D. At Y in the evening, and at W the next morning
E. At W in the evening, and at Y the next morning

78. Apple trees were planted on both the north and south slopes of a hill in the state of Washington. How would you expect the size of the apples on the south slope to compare with those on the north slope if there had been only a little rain during the season?
A. The apples on the south slope would be larger.
B. The apples on the south slope would be smaller.
C. The apples would be about the same size on both slopes.
79. This illustration shows a large jar containing a green water plant which is covered with a funnel and a test tube. If this jar remains in a window of a classroom all day and all night what will happen to the water level in the test tube during that time? (Assume that very little oxygen can be dissolved in the water and that carbon dioxide dissolves very readily in water.)
A. The water level will fall during the daytime and will not change during the night.
B. The water level will fall during the night and will not change during the daytime.
C. The water level will fall during both the daytime and the night.
D. The water level will fall during the daytime and rise during the night.
E. The water level will remain stationary during the daytime and night.

80. A plot of very moist soil has the same initial temperature as a plot of dry soil. If there is a gentle wind blowing, how will the temperature of a plot of very moist soil compare with that of dry soil after both have been exposed to the sun’s rays for the same length of time?
A. The moist soil will attain a higher temperature.
B. The dry soil will attain a higher temperature.
C. Both will attain about the same temperature.

81. Two pocket gardens, placed in the window of a science room, were constructed by placing a moistened blotter with radish seeds on it between two plates of glass. How will the growth of the seedlings in A, made of colored glass plates, compare with that in B, made of clear glass plates?
A. The seeds in neither A nor B will sprout.
B. The seeds in both A and B will sprout and both will die shortly after that.
C. The seeds in A will sprout but will soon die while those in B will sprout and continue to grow much longer.
D. The seeds in both A and B will sprout and continue growing for some time.
E. It will depend to a considerable degree on the color of the glass in A.

82. Why do bird’s eggs produce a higher percentage of offspring that become mature than do fish’s eggs?
A. Bird’s eggs contain more food than fish’s eggs.
B. It is easier for the embryo bird to get sufficient oxygen.
C. It is easier for birds to conceal their eggs in a land habitat than for fish to conceal their eggs in a water habitat.
D. Birds generally care for their young; fish generally do not.
E. Many more bird’s eggs actually become fertilized than fish’s eggs.

83. A handful of beans which have been soaked in water overnight are placed in moist cotton as shown in the diagram. If the temperature reading is taken at the beginning of this experiment and taken again a day or so later, how will the two temperature readings compare?
A. There will be no difference between the two readings.
B. The last reading will be lower than the first.
C. The last reading will be higher than the first.

84. Which of the following statements best explains why the temperature in the thermos bottle behaves as it does?
A. The walls of the thermos bottle prevent outside temperature changes from affecting the temperature of the beans.
B. The beans respire and liberate heat.
C. It gradually becomes colder inside the thermos bottle because of the darkness.
D. As the beans swell, friction on their surface generates heat.
E. The thermos bottle changes the temperature of its contents.
85. Does the development of the embryo of the higher animals (such as the dog or horse) go through stages which resemble certain stages of simple animals?
   A. No; there are no stages which resemble each other.
   B. No; there is usually no resemblance, but in some rare cases slight resemblances have been reported.
   C. Yes; there is a slight resemblance during the first few hours of embryonic development.
   D. Yes; there are resemblances throughout embryonic development.

86. Which of the following best represents all the stages in the life history of the housefly?
   A. Larva, pupa, adult
   B. Egg, pupa, adult
   C. Egg, larva, adult
   D. Egg, larva, pupa, adult
   E. Egg, pupa, larva, adult

87. What would happen if the blood vessel connected to the lower left chamber of the heart were pinched by a clamp so that blood could not flow through this vessel?
   A. The left side of the heart would expand.
   B. The left side of the heart would collapse.
   C. The right side of the heart would expand.
   D. The right side of the heart would collapse.
   E. Both sides of the heart would collapse.

88. From which chamber of the human heart does the blood which enters the lungs come?
   A. The left auricle
   B. The right auricle
   C. The left ventricle
   D. The right ventricle

89. How do the chemical elements in dead protoplasm compare with those in a living cell?
   A. A living cell contains more elements.
   B. A dead cell contains more elements.
   C. Both contain the same number and same kind of elements.
   D. It is impossible to tell, for it depends upon the particular situation.

90. Why is an explosion less apt to break one’s eardrums if one’s mouth is open?
   A. Pressure is applied on both sides of the eardrum.
   B. Opening of the jaws closes the passages to the eardrums.
   C. Opening of the jaws causes the eardrum membrane to become loose and therefore less subject to rupture.
   D. When the mouth is open, a bone presses against the inside surface of the eardrum causing it to resist any sudden impact.
   E. The sound wave enters the mouth instead of the ear.

91. What would probably happen if a man had one of his kidneys removed?
   A. The man would probably die.
   B. A new kidney would grow to replace the one which had been removed.
   C. The remaining kidney would double in size in order to replace the tissue which had been removed.
   D. The man could exist only by following a special diet and by lying quietly in bed all the time.
   E. The remaining kidney is sufficiently large so that, after slight enlargement, the man can lead a practically normal life.

92. What structure contains more bacteria than any other part of the body?
   A. Liver
   B. Stomach
   C. Small intestine
   D. Large intestine
   E. Pancreas

93. What is probably the best evidence that petrified wood was once a part of a living tree?
   A. The amount of mineral matter contained in it
   B. The cell structure which is visible
   C. The large amount of nitrogen which it contains
   D. The large amount of protein material which it contains
   E. The low proportion of silicon which it contains

94. Many research workers and doctors found that a certain chemical (substance A) was a beneficial drug to use for a specific ailment and also that it caused no ill effects. A reputable drug company found that this material could be dissolved in substance B which in turn had been safely used with other medicines. What special precautions should the drug company take before marketing this drug in bottles?
   A. None, for each substance has been proved safe.
   B. They should first test whether substance A is soluble in B in all proportions.
   C. They should first advertise the new form in which the drug is now available and distribute free samples to the doctors.
   D. The solution should be tried out on experimental animals such as guinea pigs.
   E. The solution should be tried out in all possible concentrations on at least 500 men and women of all ages.

95. In a tightly closed garage, a man had his car running while making adjustments on the motor. If the air in the garage continued to have a very high concentration of oxygen would you expect the man to suffer ill effects from the carbon monoxide given off by the motor?
   A. No, because sufficient oxygen was available
   B. No, because carbon monoxide is not poisonous
   C. Yes, because the carbon monoxide is absorbed by the blood faster than oxygen
   D. Cannot tell from the information available
96. A 15-year-old boy who weighed 110 pounds and a 30-year-old man who weighed 170 pounds both had the same kind of heart trouble. Both were given the same kind of medical care, plenty of rest and fresh air. Which of the following best explains why the man did not recover as completely as the boy did?
A. The man was overweight and the boy was not.
B. It is more serious for an older person to be overweight than it is for a young one.
C. There is no replacement or repair of tissue in a person 30 years old or older.
D. There is less replacement or repair of tissue in a person 30 years of age than in one who is much younger.
E. It is generally known that the above case is true but there is no known explanation for it.

97. What should an adult do if he was sure that he was taking the measles or mumps but did not feel particularly sick?
A. Secure the advice of a doctor.
B. Go on about his work as usual as long as he was aware that this disease was so common among children.
C. Go to bed early each evening and do no more than an average amount of work during the daytime.
D. Go to the drug store and buy medicine suggested by a registered pharmacist.
E. Consult a medical book, diagnose the case and follow suggested treatments given in the book.

98. In which of the following situations will a bone with a section of grafted bone heal most quickly?
A. Elderly person with a bone from a young person used for grafting
B. Middle-aged person with bone from another part of body used for grafting
C. Young person with bone from another part of his body used for grafting
D. Middle-aged person with bone from a younger person used for grafting
E. Middle-aged person with bone from an elderly person used for grafting

99. The diet of a ten-year-old boy had always contained sufficient calcium and phosphorus and yet the bones in his arms and legs were poorly shaped and his teeth were crooked. Which is the most probable reason for this condition?
A. He was allowed to walk too soon.
B. He was dropped when an infant.
C. His system had absorbed too much calcium and phosphorus.
D. He did not get enough sunshine.
E. He had had many children's diseases.

100. Dan's forearm was severely torn on a barbed-wire fence. If the blood flows in spurts which of the following treatments should one use?
A. Apply a bandage on the wound.
B. Apply a very tight bandage on the wound.
C. First apply a temporary tourniquet between the wound and the shoulder and then bandage the wound.
D. First apply a temporary tourniquet between the wound and the hand and then bandage the wound.

101. Why should this type of treatment be used?
A. A blood vessel leading from the heart was severed.
B. A blood vessel leading to the heart was severed.
C. It is not possible to tell what kind of a vessel was cut and the method of bandaging selected is the best general method.
D. It makes little or no difference what kind of a vessel was cut and the method of bandaging selected is the best general method.

102. Treat the forest as a crop.
103. Cut all young trees that, because of some blemish, will never grow into good lumber trees.
104. Leave all of the brush and other wastes from the cutting to decay and add humus to the forest soil.
105. Plant trees in cleared areas found unsuited for anything but forests.
106. Burn out all the brush and short, stubby trees frequently with small grass fires.
107. Trim tops of trees to keep the entire forest about the same height.
108. Fence the forested areas.
In items 109-116 you will find that it will be helpful to know the following definitions:

A **cover crop** is one that is grown merely to cover the soil during the time that no other crop is being grown.

A **dust mulch** is a loose dry layer of surface soil maintained by frequent cultivation.

**Strip farming** refers to the practice, in areas where the surface is sloping, of growing different crops in long and comparatively narrow strips running across the direction of the slope. For example, the crops on a given slope might consist of a strip of clover, a strip of corn, and a strip of wheat.

A **cultivated crop** is one that is tilled while growing.

A **non-cultivated crop** is one that is not tilled while growing.

Mark answer space
A. if the item describes the best agricultural practices of conserving the soil
B. if the item describes a practice for conserving soil moisture
C. if the item does not refer to practices which are used for the conservation of either soil or soil moisture

109. The practice of following a cultivated crop with a **non-cultivated** crop

110. Growing a small grain crop, such as wheat, many years in succession in the same field

111. Adding commercial fertilizers to the soil

112. Keeping a dust mulch on the soil of fields planted to cultivated crops

113. The practice of growing cotton in the same field year after year

114. The addition of a substance such as lime to flocculate the soil particles so clods will not form

115. The addition of the greatest amount of fertilizer to the lowest strip on a slope where strip farming is practiced

116. The practice of crop rotation

It was the custom among early settlers to have small cemeteries on their farms or estates in which their families could be buried. When Betsy Williams, a descendant of Roger Williams, gave the Williams homestead to the city of Providence for a public park, the private cemetery had to be moved from the old homestead to the village cemetery. When they dug down to remove the remains of Roger Williams who had been buried for 173 years, they found that the wooden casket had decayed and only its metal handles remained. The body of Roger Williams had also decayed and it was found that the roots from a nearby apple tree had grown into the grave and the roots themselves had taken a shape somewhat resembling the outline of a body. Evidently, the roots had absorbed soluble compounds from these bones and these compounds had been transformed to the tree and to its fruit, which in turn had been eaten by the people of Providence for many years. This incident illustrates a common, basic relationship between the decaying of vegetable and animal matter and the trees growing in the soil when the decay occurs; the fact that vegetation requires some of the elements introduced to the soil by decay; the passing on of these elements into fruit which in turn is eaten, thereby becoming again a part of animal tissue and bone.

The following figure illustrates the cycle through which the body elements from a human passed before they finally were again a part of another human being.

For each of the following terms (items 117-121), mark answer space
A. if it is most closely related to A in the diagram
B. if it is most closely related to B in the diagram
C. if it is most closely related to C in the diagram
D. if it is most closely related to D in the diagram
E. if it is not related to any of the parts of the diagram

117. Manure scattered on a farmer's field

118. Growing berry bushes

119. Growing rabbits

120. Soluble nitrates in the soil

121. Active, adult salmon
122. Which of the following is responsible for most contagious diseases?
A. A vitamin deficiency
B. A mineral deficiency
C. Glandular troubles
D. One-celled plants or animals

123. Why should a person drink some salt water or take salt pills during extremely hot weather?
A. So that it will not seem so disagreeably hot
B. To replace the salt lost by perspiring
C. To keep the blood from becoming too thick
D. To keep the blood from congealing
E. To make the nervous system function more efficiently

124. What change may occur in the blood as a result of bacterial infection?
A. The number of white corpuscles may increase.
B. The number of red corpuscles may increase.
C. The number of both red and white corpuscles may increase.
D. The number of both red and white corpuscles may decrease.
E. The amount of blood plasma may decrease.

125. What is the best method for producing seed for commercial hybrid corn?
A. Using only the hardiest ears from the hybrid crop.
B. Recrossing the pure lines from which the hybrid came.
C. Using any ears from the hybrid crop.
D. Using only those ears from the hybrid crop which can be made to produce the proper kinds of corn.
E. Using only those ears from the tallest hybrid plants.

126. A pure strain of horned cattle had been crossed with a pure strain of hornless cattle. Two hornless offspring which result from this original crossing are crossed with each other. If the hornless trait is dominant and the horned trait is recessive, what proportion of the cattle from this last crossing will be hornless?
A. All will be hornless.
B. Half will be hornless and half will be horned.
C. Three-quarters will be hornless and one-quarter horned.
D. One-quarter will be horned, one-half partially horned, and one-quarter hornless.
E. None of these proportions will appear.

127. In shorthorn cattle, there is no dominance for coat color. \( RR \) is red, \( Rr \) is roan, and \( rr \) is white. If two roan cattle are mated, approximately what percentage of their offspring will be roan?
A. All
B. 75%
C. 66.6%
D. 50%
E. 25%

128. Two normal parents have a feeble-minded child.
If one assumes that feeble-mindedness is hereditary, what does this prove about the recessiveness or dominance of feeble-mindedness?
A. Feeble-mindedness is dominant.
B. Feeble-mindedness is recessive.
C. This proves nothing about the dominance or recessiveness of feeble-mindedness.

129. If a man with hemophilia is mated with a woman whose parents did not have hemophilia, which of their offspring are apt to be hemophiliacs (bleeders)?
A. All sons and daughters
B. Only sons
C. Only daughters
D. Only grandsons and granddaughters
E. Only grandsons

130. If animals of all kinds could successfully mate with each other, how would the animals of today appear?
A. All would look alike.
B. Most would look considerably alike but there would be some which would differ greatly.
C. All would differ and there would be no tendency toward similarity.

In the accompanying diagram assume that the dominant character is represented by \( D \) (dark hair) and the recessive character by \( d \) (light hair).

131. What character should be represented in the chart at the place marked \( x \)?
A. DD
B. Dd
C. dd

132. What proportion of the offspring will have light hair?
A. None
B. 1 out of 4
C. 2 out of 4
D. 3 out of 4
E. 4 out of 4

133. What proportion of the offspring will have the characters \( dD \)?
A. None
B. 1 out of 4
C. 2 out of 4
D. 3 out of 4
E. 4 out of 4
In the accompanying dihybrid checkerboard are shown the traits for offspring of a mare (female) and a stallion (male). Assume that the characters are inherited. The dominant characters are represented by B (black) and T (trotter) and the recessive characters by b (chestnut) and t (pacer).

134. What characters should be represented in the chart at the places marked W?
A. BT
B. Bt
C. bT
D. bb
E. bt

135. What characteristics should the offspring indicated at the place marked X possess?
A. Black trotter
B. Black pacer
C. Chestnut trotter
D. Chestnut pacer
E. None of these

136. What proportion of the offspring will be black pacers?
A. 1 out of 16
B. 2 out of 16
C. 3 out of 16
D. 9 out of 16
E. None of these ratios

137. What proportion of the offspring will be chestnut?
A. 1 out of 16
B. 2 out of 16
C. 3 out of 16
D. 9 out of 16
E. None of these ratios

SECTION III
Reading, Interpretation of Data and Applying Scientific Method

Directions: Read the following passage carefully and then answer the questions which refer to it.

Function of the Cerebellum

The brain of vertebrates consists of three parts: the cerebellum, the cerebrum, and the medulla, the last being attached to the upper end of the spinal column. The cerebellum, which is situated between the medulla and the cerebrum, controls the coordination of skeletal muscles. Experiments show that the cerebellum has no control over the involuntary muscles. Moreover, no consciousness is experienced in this portion of the brain, for stimulation of the exposed cerebellum in humans causes no sensations whatever. Furthermore, the destruction of the cerebellum does not impair the senses. Injury or destruction of the cerebellum, while not producing a real paralysis, may cause a generalized diminution in muscle tone and, in some cases, it has also been found to affect the muscular strength. Whenever the cerebellum is damaged, the muscle movements become jerky and decidedly ineffective. For example, a pigeon whose cerebellum has been removed is unable to walk or fly although there is actually no paralysis. Whenever he attempts to fly, his wings simply thrash about in an aimless manner indicating total lack of coordination.

Damage to the cerebellum of a man produces definite defects in muscular movement. The smooth, sweeping, continuous movements of the normal individual become dissociated into their constituent parts. For example, raising the hand to the face will be done jerkily and in stages. First, the arm may be flexed at the elbow, then brought forward, and then the entire arm raised. Fine movements requiring delicate coordination are impossible. All of this signifies that the chief role of the cerebellum is that of lending refinement to the muscle movements by helping to coordinate them. It is also interesting to observe that, while one would expect to find a larger cerebellum in large animals than in small ones, the size of the cerebellum in proportion to the animal's weight is found to increase as the skeletal muscular movements increase in complexity.

(Now answer the questions on the next page.)
138. Would you expect a dog whose cerebellum has been injured to be paralyzed?
A. Yes, however slight the injury
B. Yes, but only if the injury is severe
C. No; probably no paralysis would take place
D. It is impossible to tell because the dog is not a vertebrate.

139. According to the passage, would you expect a person with an injured cerebellum to be able to smell, feel, see, and hear as well as he could before this injury?
A. Yes, probably just as well
B. No; there would probably be a noticeable effect on these senses no matter how slight the injury.
C. No; any injury to these brain areas immediately destroys all of these senses.
D. It is impossible to tell from the information available.

140. What is meant by the term, paralysis?
A. Loss of only coordination
B. Loss of power or ability to move
C. Loss of consciousness
D. Dissociation of movements into their constituent parts

141. According to the passage, would you expect the destruction of the cerebellum to affect the muscular action of the heart and diaphragm?
A. Probably to a slight extent
B. Probably to some extent, but it is impossible to tell how much
C. Probably not, because involuntary muscles are not controlled by any part of the brain
D. Probably not, because these muscles do not move bones

142. A certain prehistoric animal weighing several hundred pounds has a cerebellum which is about the same size as the cerebellum in an ordinary cat. What can be said about the relative complexity of the movements of these two animals?
A. The cat's movements are more complex.
B. The cat's movements are less complex.
C. Complexity of movements is about equal in both.
D. It is impossible to tell from the information available.

143. How well would you expect a typist to type after having suffered a serious injury to his cerebellum?
A. About as well as before
B. About as well as before, provided sufficient time is taken for relearning
C. About as well as before but with slightly diminished speed
D. Would find it practically impossible to type

144. According to the passage, which part of the brain is located farthest from the spinal column?
A. Cerebellum
B. Cerebrum
C. Medulla
D. Impossible to tell from the information given

145. What would a person probably feel if his cerebellum were injured but no other part of the brain were touched?
A. He would have a very painful sensation.
B. He would not feel any sensation.
C. He would have only a slightly painful sensation.
D. It is impossible to tell from the information given.

146. Which of the following statements is implied in the passage?
A. Muscle control is localized in certain parts of the brain.
B. All muscle control is localized in one part of the brain.
C. The brain does not control the sensory organs.
D. Every muscle in the body is controlled by some part of the brain.

147. Which of the following would be affected to the greatest extent by the removal of the cerebellum?
A. Ability to discriminate odors
B. Ability to discriminate sounds
C. Ability to remember
D. Ability to lift weights
The accompanying chart, prepared from information for several years, shows the average number of cases of chicken pox, syphilis, influenza, and tuberculosis found to occur during the different months in a certain locality. Mark answer space

A. if the information supports the statement
B. if the information contradicts the statement
C. if the information neither supports nor contradicts the statement

148. The number of cases of syphilis shows less fluctuation and change during the year than any of the other diseases listed.

149. During August, there are fewer cases of chicken pox than any of the other diseases listed.

150. More people die from influenza during January than during July.

151. There is less sickness due to all of these diseases together during the summer months than during the winter.

In his travels as a naturalist, a man discovers that the insects on a wind-swept island are wingless, while the corresponding species on the mainland of the nearby continent are winged. For each of the following assumptions mark answer space

A. if the assumption helps to account for this situation on the basis of modern biological concepts
B. if the assumption does not help to account for the situation on the basis of modern biological concepts

156. During a storm, winged insects were blown from the continent. Most of them drowned, but, as the storm subsided, some landed on the island and made the new land their home.

157. The new environment affected the germ plasm of the insects in such a way that wings did not grow.

158. The insects of the island produced offspring with wings of varying length, but the longer-winged individuals died before reaching maturity.

159. The winged insects, finding wings ill-adapted to their new environment, gave birth to a wingless generation which continued to produce wingless insects.

160. The wingless forms which appeared as one of the variations were better fitted to survive because they crawled close to the ground where the wind could not blow them away.

152. The time of the year when the locality is comparatively free of chicken pox is shorter than the time when it is comparatively free of influenza.

153. More people have influenza than tuberculosis during the year.

154. The average number of syphilis cases per month is more than the average number of chicken pox cases.

155. Most of the severe cases of influenza occur during spring or fall.

161. Most of the wingless variations grew to maturity and produced an abundance of offspring like themselves. After a time all the island insects were wingless.

162. Robert Koch found bacilli in the blood of sheep suffering from anthrax but no bacilli in the blood of healthy sheep. What conclusion can be drawn from his observations?

A. These bacilli cause anthrax.
B. These bacilli result from anthrax.
C. Anthrax is caused by a bacillus.
D. Anthrax is similar to many other diseases in which bacilli are involved.
E. These bacilli are probably related to either the cause or result of anthrax.

163. Is it true that a child can be “marked” before birth by some emotional stress of the mother?

A. It is not true.
B. It is probably not true, but more evidence is needed.
C. It is probably true, but more evidence is needed.
D. It is true.

164. Can horsehairs themselves be made to produce or generate worms under the proper conditions?

A. Yes, under very special conditions
B. No, under no conditions
C. Impossible to tell at the present time, for there is much contradictory evidence
Directions: You have two hours for this examination. As you answer the questions you should omit any that seem unusually difficult until you finish the others.

Your answers to the exercises in this examination are to be recorded on the separate ANSWER SHEET which is loosely inserted in the examination booklet. Remove this answer sheet now; write your name and the other information called for in the blanks at the top of the answer sheet; then finish reading these directions.

After the number on the answer sheet corresponding to that of each exercise, mark the one lettered space which designates the answer you have selected as correct. If your answer sheet contains rows of squares, indicate each answer with a cross (X), for example,

```
A B C D E
[ ] [x] [ ] [ ] [ ]
```

If your answer sheet contains rows of paired dotted lines, indicate each answer with a heavy black mark with the special pencil, for example,

```
A B C D E
[ ] [ ] [ ] [ ] [ ]
```

Avoid resting the point of your pencil on the answer sheet while you are considering your answer. Do not make unnecessary marks. If you change an answer, erase your first mark completely. Do not fold or crease your answer sheet.

**EXAMPLE**

0. Which of the following organisms is a mammal?

A. A clam  
B. A man  
C. A fish  
D. An earthworm  
E. An amoeba

[The correct answer is A man; therefore, space B would be marked on the answer sheet.]
Selection and Discrimination of Factual Material

1. Flowers which contain only female reproductive structures are called
   A. monoecious.
   B. monomorphic.
   C. pistillate.
   D. staminate.

2. An example of polymorphism is the
   A. reproductive and feeding polyps in Obelia, a hydroid.
   B. different uses made of appendages by the crayfish.
   C. appearance of organ systems to carry on each function in the earthworm.
   D. appearance of gill slits in embryos of higher vertebrates.

3. In a two-year-old root the phloem and xylem are produced by the
   A. cambium.
   B. cortex.
   C. endodermis.
   D. pericycle.

4. The type of symmetry in the crayfish is
   A. radial.
   B. biradial.
   C. bilateral.
   D. asymmetrical.

5. Paramecium ingests food
   A. through the oral groove and gullet.
   B. by osmosis through the body wall.
   C. by flowing around in.
   D. through a protrusile proboscis.

6. The seed-producing plants belong to the division
   A. Bryophyta.
   B. Pteridophyta.
   C. Spermatophyta.
   D. Thallophyta.

7. The hypocotyl is a structure present in
   A. a staminate flower.
   B. a dicotyledonous seed.
   C. the pistil of a monocotyledonous flower.
   D. the life cycle of Spirogyra.

8. The Japanese beetle is
   A. useful as a pollinator.
   B. useful as a destroyer of harmful insects.
   C. a carrier of human diseases.
   D. harmful as a destroyer of vegetation.

9. The bark of a mature tree contains the
   A. heartwood.
   B. phloem.
   C. pith.
   D. xylem.

10. Through the heart of the frog
    A. only impure (unoxegenated) blood flows.
    B. only pure blood flows.
    C. pure and impure blood are mixed in the ventricle.
    D. pure and impure blood are kept completely separate by means of two sets of chambers.

11. A fungal thread or filament is called a
    A. root.
    B. hypha.
    C. vascular strand.
    D. fiber.

12. The Mammalia are distinguished from the Reptilia by
    A. a five-part brain.
    B. an embryo protected by an amnion.
    C. young nourished by mammary glands.
    D. lungs for breathing air.

13. Stipules are the
    A. openings in the stem through which gases pass.
    B. pollen-receiving structures of the flowers.
    C. stem of the leaf.
    D. small leaf-like structures at the base of the petiole.

14. The middle ear is connected with the pharynx by the
    A. olfactory chamber.
    B. Fallopian tube.
    C. Eustachian tube.
    D. external auditory meatus.

15. Dicotyledonous plants are characterized by
    A. a fibrous root system.
    B. the conducting bundles scattered throughout the stem.
    C. the conducting bundles arranged in a cylinder between the pith and cortex.
    D. leaves with parallel veins.

16. Parthenogenesis is
    A. presence of both sexes in the same individual.
    B. spontaneous generation.
    C. development of unfertilized eggs.
    D. budding.

17. Rigidity of young herbaceous plants, such as lettuce, is due to the
    A. woody tissue in the plant.
    B. necessity for the stem to be erect.
    C. presence of a xylem.
    D. turgor pressure in the cells.
18. Osmosis is the term applied to the
    A. diffusion of substances from one
    B. passing of dissolved substances
    C. passing of a liquid through a
    D. passing of a liquid through a
diffusely permeable membrane.

19. The blood in the earthworm is kept in
    circulation by
    A. several pairs of hearts connecting
    B. a dorsal heart consisting of a
    C. contractions of the dorsal blood
    D. contractions of the ventral aorta.

20. The heart beat of the frog is initiated in
    the
    A. sinus venosus.
    B. left auricle.
    C. ventricle.
    D. conus arteriosis.

21. Concentration of protoplasm of the cell
due to the loss of water is called
    A. anabolism.
    B. assimilation.
    C. dialysis.
    D. plasmolysis.

22. Some fixation of atmospheric nitrogen
    is accomplished by
    A. a symbiotic relationship between
    B. certain bacteria living in the
    C. leaves of green plants.
    D. fungi living symbiotically in the
soil.

23. The embryos of land vertebrates are
    surrounded by a sac of watery fluid
    known as the
    A. chorion.
    B. allantois.
    C. placenta.
    D. amnion.

24. In the angiosperms the female gamete
    is produced in the
    A. ovule.
    B. pistil.
    C. placenta.
    D. stigma.

25. The most important result of the matura-
    tion of the male gamete is
    A. loss of cytoplasm.
    B. formation of the middle piece with
    its spiral filament.
    C. reduction of chromosomes by one-half.
    D. formation of polar bodies.

26. The paired somites give rise to
    A. myotomic muscles.
    B. kidneys.
    C. spinal cord.
    D. notochord.

27. Characteristic of the Bryophyta is the
    A. presence of roots, stems, and leaves.
    B. absence of roots, stems, and leaves.
    C. production of flowers.
    D. presence of a pollen tube.

28. Ecology is the science of
    A. the distribution of organisms.
    B. the relationship of organisms to
    their environment.
    C. the development of organisms.
    D. heredity.

29. The relationship of the wing of a bird
    to the arm of man is one of
    A. analogy.
    B. homology.
    C. commensalism.
    D. polymorphism.

30. Pollen is produced in the
    A. anther.
    B. filament.
    C. stigma.
    D. style.

31. A vestigial organ is one that is
    A. in the process of developing into a
    B. of great physiological importance.
    C. in the process of deterioration.
    D. found only in the embryo.

32. The mammal life of the Australian region
    is unique because
    A. the marsupials evolved there and
    have not been able to leave the
    islands.
    B. the Australian region is better
    adapted to marsupials than the rest
    of the world.
    C. the isolated position of Australia
    has prevented more specialized
    mammals from migrating there.
    D. higher mammals cannot live in the
    Australian region even when they
    are introduced there.

33. Autophytic plants are those that
    A. obtain their energy foods from
    decaying organic matter.
    B. obtain their energy foods from
    other living organisms.
    C. are able to manufacture their own
    energy-containing food substances
    from water and nitrogen.
    D. are able to manufacture their own
    energy-containing food substances
    from water and carbon dioxide.

34. Animals introduced into America, such
    as the European starling or gypsy moth,
    probably became overabundant because
    A. America has a more favorable food
    supply.
    B. America has a more favorable climate.
    C. they have left behind their chief
    diseases and predators.
    D. their bodies undergo rapid modifica-
    tion under the influence of the new
    environment.
35. The rate of photosynthesis may depend upon the amount of
A. moisture in the air.
B. boron in the air.
C. carbon dioxide in the air.
D. carbon dioxide in the soil.

36. A fruit is a structure that develops from
A. the corolla.
B. an ovulary.
C. an ovule.
D. the perianth.

37. The greatest value of sexual reproduction as compared with asexual is
A. a greater uniformity of offspring.
B. greater variability among offspring.
C. a lower mortality among offspring.
D. that the offspring are more like their parents.

38. If a tall variety of garden pea is crossed with a dwarf variety of garden pea and their offspring is self-pollinated, the second generation (F₂) will be on the average (tallness is dominant)
A. all tall.
B. half tall and half dwarf.
C. three-fourths tall to one-fourth dwarf.
D. one-fourth tall, one-half intermediate, and one-fourth dwarf.

39. The principle of segregation of heterozygous pairs of unit characters was first discovered by
A. Linnaeus.
B. Gregor Mendel.
C. Thomas Hunt Morgan.
D. Sir Francis Galton.

40. The fossil Archaeopteryx (or Archaeornis) is considered one of the most important discoveries in paleontology because it
A. is the most ancient fossil known.
B. shows relationship between two great classes of vertebrates.
C. is so large.
D. has teeth.

41. Streptococci are
A. spiral-shaped bacteria.
B. rod-shaped bacteria.
C. spherical bacteria occurring in irregular groups.
D. spherical bacteria occurring in regular chains.

42. The Mesozoic Era is known as the age of
A. unincellular life.
B. fish.
C. amphibians.
D. reptiles.

43. The aim of classification is to place
A. closely related organisms in the same genus.
B. organisms of similar habits in the same genus.
C. organisms of similar external appearance in the same genus.
D. organisms from similar environments, as aquatic, in the same genus.

44. Man is classified in the order
A. Carnivora, flesh eaters.
B. Primates, the climbing mammals.
C. Marsupialia, the pouched mammals.
D. Rodentia, the gnawers.

45. A tuber is
A. an enlarged underground bulb.
B. an elongated stolon.
C. an enlarged stem.
D. a short thick underground stem that serves the plant in storage and reproduction.

46. In seed plants the spore is the
A. first cell of the gametophyte generation.
B. agent of distribution for the species.
C. first cell of the sporophyte generation.
D. first cell formed in the anther.

47. The names of Schleiden and Schwann are associated with the
A. theory of recapitulation.
B. cell theory.
C. theory of organic evolution.
D. theory of the continuity of the germ plasm.

48. In the anaphase of mitosis the chief activity is
A. formation of the spireme.
B. disappearance of the nuclear membrane.
C. splitting of the chromosome longitudinally.
D. migration of the chromosomes to opposite poles of the cell.

49. The cell was first figured and named from a piece of cork by the microscopist
A. Malolghi.
B. Swammerdam.
C. Robert Hooke.
D. Max Schultze.

50. Climbing perennial plants with woody shoots are called
A. herbs.
B. lianas.
C. shrubs.
D. tendrils.

51. Ergot is a disease of
A. apples.
B. turnips.
C. grapes.
D. rye.

52. The frog differs from the earthworm by having
A. a hollow dorsal nervous system.
B. reflex arcs which work automatically.
C. a well-developed body cavity.
D. a digestive tube with specialized regions and two openings.

53. Cellulose is found in
A. the nuclear membrane.
B. the cell walls of higher plants.
C. cytoplasm.
D. the walls of the chloroplast.
54. The digestive juices in the stomach are primarily concerned with digestion of
A. sugars.
B. starches.
C. fats.
D. protein.

55. The type of diabetes characterized by an excess of sugar in the blood is caused by
A. bacterial infection.
B. structural damage to the kidneys.
C. degeneration of the islands of Langerhans in the pancreas.
D. degeneration of the liver.

56. Plants living in a mesophytic habitat are generally characterized by
A. thick leaves with sunken stomata.
B. broad leaves with numerous surface stomata.
C. leaves covered with spines.
D. the predominance of evergreen leaves.

57. The relationship between the animal phyla is best represented by
A. a single linear series from the simple to the complex.
B. a branching treelike arrangement from a central axis.
C. a circular arrangement for each of the main types.
D. a series of separate compartments into which all animals can be lumped.

58. According to the theory of recapitulation, the embryos of higher animals pass through stages resembling the adults of lower animals.
A. animals may form spontaneously from mud, soil, water, and other materials.
B. all animals are built on a single type or archetype.
C. acquired characters are inherited.
D. bone.

59. The relationship between two plant species in which each derives some benefit from the presence of the other without injury to the other is called
A. commensalism.
B. economic equilibrium.
C. saprophytism.
D. symbiosis.

60. A mutation may be defined as the modification of a structure by use or disuse.
A. gradual change of an organ or structure through selection of favorable variations of the fluctuating type.
B. sudden appearance of a new trait which breeds true.
C. sudden appearance of a new characteristic which is due to the environment and does not last if the environment changes.

61. A structure found in the life history of the fern is
A. an spermatium.
B. an ascogonium.
C. a prothallium.
D. a protonema.

62. Secondary sex characters such as spurs, antlers, and human beard are
A. caused by the activity of the male sex chromosomes.
B. due to the hormones secreted by the testis.
C. due to the environment.
D. due to sex-linked genes.

63. In a large wild-life reservation, hawks, owls, foxes, snakes, and similar predatory animals are
A. mildly injurious and should occasionally be controlled.
B. extremely injurious and should be kept under strict control.
C. neutral, for they prey chiefly on each other.
D. beneficial in preventing overproduction and preserving proper balance.

64. Yeast is
A. an algae.
B. a bryophyte.
C. a fungus.
D. a liverwort.

65. The Cro-Magnon man had
A. a very ape-like appearance.
B. a brain capacity intermediate between man and great apes.
C. tusk-like canines and heavy grinding molars.
D. a brain capacity equal to modern man.

66. The tendency for organic structures to develop in a given direction is called
A. orthogenesis.
B. perthenogenesis.
C. regeneration.
D. preformation.

67. A cactus is generally classified as a
A. halophyte.
B. hydrophyte.
C. mesophyte.
D. xerophyte.

68. Tissue consisting of a laminated matrix containing numerous lacunae connected by canaliculi is
A. adipose tissue.
B. cartilage.
C. bone.
D. stratified squamous epithelia.

69. A good source of vitamin D for animals is
A. green vegetables.
B. fresh meat.
C. sunlight.
D. fruit juice.

70. The calyx is the collective name for the
A. anthers.
B. pistils.
C. stamens.
D. sepals.
SECTION II

Identification of Structure and Functions

Directions: Following are a number of diagrams with some of the structures indicated by letters. To the left of each diagram is a list of structures and their functions. Mark the answer space for the letter which indicates each structure or function.

Diagram of an Amoeba

Structure:
71. A Contractile vacuole
72. B Pseudopodium
73. C Nucleus
74. D Structure which functions in digestion of food
75. E Structure which functions in discharge of liquids

Diagram of a Hydra

Structure:
76. A Ectoderm
77. B Bud
78. C Tentacle
79. D Structure which functions in reproduction
80. E Structure which functions in digestion and circulation of food

Diagram of Cross Section of a Leaf

Structure:
81. A Cuticle
82. B Stoma
83. C Xylem
84. D Structure through which available nitrogen enters the leaf
85. E Structure which may carry on photosynthesis
86.3 Endoderm of gut
87.3 mesodermal somite
88. Neural groove
89. Structure which produces the brain and spinal cord
90. Structure which produces an axial, supporting rod

Diagram of Transverse Section of Typical Vertebrate Embryo

Structure:
91.57 Iris
92.70 Cornea
93. Retina
94.4 H Structure which functions in focusing the light rays
95. Structure which functions in carrying the visual stimuli to the brain.

Diagram of a Typical Vertebrate Eye

Structure:
96.6 Gamete
97. Sporangium
98. Zygospore
99. Structure which is directly involved in fertilization
100. Structure which is directly involved in producing asexual spores

Diagram of Bread Mold (Rhizopus)
SECTIOIII
Interpretation of Data

Directions: This is a test of your ability to draw conclusions or make interpretations from data presented to you. Following each problem in the examination you will find a number of statements. You are to assume that the data as given are true. In arriving at your decision, you are to confine yourself to the evidence as given in the problem, even though you may be acquainted with other evidence which indicates clearly whether the statement is true or false.

Problem I. The life of the honeybee. The queen lays as many as a thousand eggs per day. She leaves the hive only to mate and to swarm. If a second queen hatches, the two queens fight to the death. Otherwise she is entirely helpless and depends upon the workers for food and care. The drone fertilizes the queen during the nuptial flight, but makes no other contribution toward the welfare of the hive. The workers (imperfect females) gather the nectar and pollen, secrete the wax, make the combs, feed the queen and larval bees, defend the hive, and do all the other necessary work. When a worker finds a new source of honey as when a new species of flower comes into bloom, she returns to the hive and executes the so-called honey-dance upon the combs. The other workers gather round and apparently identify the new source of nectar by its odor. They then leave in all directions in search of the new nectar source. The queen usually lives several years; the drones, of which there are only a few, for one summer; and the workers, 30 to 40 days during the summer. But the last workers to hatch in the fall live through the winter.

For each of the following items, mark answer space

A. if the statement is true
B. if the statement is probably true
C. if the evidence is not sufficient to indicate that there is any degree of truth or falsity in the statement
D. if the statement is probably false
E. if the statement is false

STATEMENTS

101. The queen gathers nectar and pollen to feed the larvae.

102. The workers lead each other to patches of honey plants.

103. The drones aid in the manufacture of the honeycomb.

104. Drones of one variety will not mate with queens of another variety of honeybee.

105. The workers have means of communicating ideas to each other.

106. There is more nourishment in pollen than in nectar.

107. The queen bee rules the hive with autocratic authority and all the other bees accept her decisions.

108. Honeybees prefer buckwheat nectar to goldenrod nectar.

109. Bees have a good sense of smell.

110. Worker bees hatched in the spring live on an average a shorter time than those hatched in the fall.

111. Workers cannot modify their behavior to meet a change in conditions of nectar secretion.

112. The habits of bees have changed radically since they were first domesticated.
Problem II. The effect of 2000 atmospheres pressure at 18°C. on the germination of seeds of alfalfa.

The graph represents total germination.

\[
\begin{align*}
V &= \text{control} \\
X &= 1\text{-minute exposure} \\
Y &= 2\text{-minute exposure} \\
Z &= 5\text{-minute exposure} \\
W &= 10\text{-minute exposure}
\end{align*}
\]

For each of the following items, mark answer space

A. if the statement is true
B. if the statement is probably true
C. if the evidence is not sufficient to indicate that there is any degree of truth or falsity in the statement
D. if the statement is probably false
E. if the statement is false

STATEMENTS

113. With the exception of the seeds exposed to pressure for 10 minutes and germinated immediately after the pressure was applied, all the percentage in germinations were above the percentage germination of the control.

114. The germination records of alfalfa seeds exposed to pressure and tested immediately after the pressures were applied indicate that as the pressure increased the percentage germination increased.

115. Sweet clover seed, if subjected to 2000 atmospheres pressure for 5 minutes and germinated after 30 days, would have a percentage germination greater than would be obtained in sweet clover seed not subjected to pressure.

116. When it is necessary to store the seed for 6 months before the tests can be made, the best period to subject alfalfa seed to 2000 atmospheres pressure at 18°C, in order to gain the highest percentage germination, is exposure for 10 minutes.

117. Seed subjected to 2000 atmospheres pressure for 4 minutes and then stored for 10 months before the germination tests are made would yield a percentage germination at about the same level as that obtained in the 1, 2, and 5 minute exposures and stored for the same period before testing.
Problem III. The average increase in weight and length of feathers of four starlings is shown in the following table together with notes on the development of mental and physical traits. One of the parents was captured and weighed also. The average weight of the four eggs when first laid was 7.5 gm, whereas their weight shortly before hatching was 6.2 gm.

<table>
<thead>
<tr>
<th>Days old</th>
<th>Weights in gm</th>
<th>Wing feathers in mm</th>
<th>Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>6.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>9.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>16.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>25.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>30.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>37.9</td>
<td>2</td>
<td>Feeding reflex; no fear</td>
</tr>
<tr>
<td>6</td>
<td>47.1</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>55.5</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>61.1</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>66.5</td>
<td>22</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>72.9</td>
<td>28</td>
<td>Fear; no feeding reflex; ran away</td>
</tr>
<tr>
<td>11</td>
<td>76.9</td>
<td>35</td>
<td>Took short flights when released</td>
</tr>
<tr>
<td>12</td>
<td>77.0</td>
<td>40</td>
<td>Left nest and hid in attic</td>
</tr>
<tr>
<td>13</td>
<td>71.8</td>
<td>44</td>
<td>Flew around in attic</td>
</tr>
<tr>
<td>14</td>
<td>70.8</td>
<td>48</td>
<td>Flew out into trees in afternoon</td>
</tr>
<tr>
<td>Adult</td>
<td>76.0</td>
<td>68</td>
<td></td>
</tr>
</tbody>
</table>

For each of the following items, mark answer space

A. if the statement is true
B. if the statement is probably true
C. if the evidence is not sufficient to indicate that there is any degree of truth or falsity in the statement
D. if the statement is probably false
E. if the statement is false

124. The wing feathers lengthened more rapidly from the 7th to the 10th day than from the 11th to the 14th day.
125. On the 16th day the wing feathers will be from 54 to 58 mm long.
126. On the 16th day the weights will be from 85 to 90 gm.
127. The average increase in weight per day from the 5th to the 9th day was 7.15 gm.
128. The increase in weight is correlated with the type of food eaten by the nestlings.
129. The increase in weight and the lengthening of the feathers showed the same trend throughout the fifteen days.
130. The irregularities in growth shown in the table are due to weather conditions.
131. The loss of weight by the egg during incubation indicates that the shell is porous.
132. When the nestlings were first hatched, they lacked wing feathers.
133. The nestlings tripled their weights during the first two days.
134. Starling broods grow faster in the summer than in the spring.
Problem IV. Effects of various nitrogen compounds on nodule formation by red clover grown in nutrient agar.

<table>
<thead>
<tr>
<th>MILLIGRAMS OF NITROGEN ADDED TO NUTRIENT AGAR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
</tr>
<tr>
<td>---------</td>
</tr>
<tr>
<td>2</td>
</tr>
<tr>
<td>5</td>
</tr>
<tr>
<td>10</td>
</tr>
</tbody>
</table>

For each of the following items, mark answer space

A. if the statement is true
B. if the statement is probably true
C. if the evidence is not sufficient to indicate that there is any degree of truth or falsity in the statement
D. if the statement is probably false
E. if the statement is false

**STATEMENTS**

135. With the exception of 2 and 5 milligrams of potassium nitrate, the nodule formation in all the cultures was below that of the control.

136. The experimenter added the different amounts of the various nitrogen compounds to nutrient agar to show that they would either increase or decrease the number of nodules in red clover.

137. The smallest number of nodules was obtained when 10 milligrams of clover seed extract was added to the nutrient agar.

138. If 8 milligrams of urea had been added to the nutrient agar, over 100 nodules would have been formed by red clover.

139. The largest number of nodules was produced by red clover when 5 milligrams of potassium nitrate was added and the smallest number when 10 milligrams of urea was added.

140. Nodule formation below that of the control when urea, asparagin, clover seed, and yeast extracts were added was due to the toxicity of the nitrogen preventing the roots from obtaining water and food substances from the nutrient agar.

141. If pink clover had been used in this experiment, the addition of yeast extract would have caused a formation of nodules similar to that obtained from red clover.

142. Had the experimenter added 3 milligrams of urea to the nutrient agar, the number of nodules developed would have been less than the number developed in the control.

143. The addition of 5 milligrams of asparagin produced a smaller number of nodules than the same amount of urea and a larger number than the same amount of yeast extract.

144. The farmer should add sodium nitrate to his soil to increase the yield of red clover seed.

145. Two milligrams of yeast extract produced more nodules than the same amount of clover seed extract but less than the same amount of either asparagin or urea.