R E P O R T R E S U M E S

ED 020 102 SE 000 760

SCIENCE 7, 8, 9, EXPERIMENTAL SYLLABUS BLOCK A, TAKING CARE OF OURSELVES.

NEW YORK STATE EDUCATION DEPT., ALBANY
EDRS PRICE MF-$0.50 HC-$3.36 82P.

DESCRIPTORS- *COURSE CONTENT, *GENERAL SCIENCE, *HEALTH, *HEALTH EDUCATION, *SECONDARY SCHOOL SCIENCE, CURRICULUM GUIDES, GRADE 7, GRADE 8, GRADE 9, SCIENCE ACTIVITIES, RESOURCE MATERIALS, NEW YORK,

COURSE TOPICS, CONCEPTS, LEARNING ACTIVITIES, AND TEACHER REFERENCE INFORMATION ARE INCLUDED IN THIS TEACHER GUIDE FOR AN EXPERIMENTAL INSTRUCTIONAL BLOCK ON THE TOPIC "TAKING CARE OF OURSELVES". MAJOR TOPICS INCLUDE (1) UNDERSTANDING HOW WE LEARN, (2) MAINTAINING HEALTHY BODY SYSTEMS, AND (3) DEVELOPING BENEFICIAL PATTERNS OF BEHAVIOR. EACH OF THESE MAJOR TOPICS IS FURTHER DIVIDED INTO SUBTOPICS. FOR EACH SUBTOPIC, LISTS OF ASSOCIATED CONCEPTS, TYPICAL PROBLEMS, RELATED LEARNING ACTIVITIES, AND SPECIFIC SUGGESTIONS FOR TEACHERS ARE INCLUDED. THE SUGGESTIONS FOR TEACHERS INCLUDE PROCEDURES FOR THE USE OF EQUIPMENT, EMPHASES OF INSTRUCTION, AND REFERENCE INFORMATION. (RS)

SCIENCE
7,8,9

EXPERIMENTAL SYLLABUS

BLOCK A

TAKING CARE OF OURSELVES

The University of the State of New York/The State Education Department
Bureau of Secondary Curriculum Development

THE UNIVERSITY OF THE STATE OF NEW YORK

H860-Je65-5000

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BLOCK A - TAKING CARE OF OURSELVES

Understanding How We Learn

- perception
- memory
- reason
- action

Maintaining Healthy Body Systems Involves Understanding

- Fundamental System Structures
  - cells
  - tissues
  - organs
  - glands
- Fundamental System Functions
  - perception - senses
  - protection - skin
  - support - skeleton
  - locomotion - muscle
  - response - nerve
  - acquiring oxygen - respiration
  - distributing fluids - circulation
  - feeding cells - digestion
  - eliminating wastes - excretion

Developing Beneficial Patterns of Behavior

- inborn automatic behavior
- acquired automatic behavior
  - mental health - narcotics and drugs

FOREWORD

This is the second in the series of publications designed for the experimental syllabus in Science 7-8-9. Each of the units (blocks) is being printed and bound separately so that schools may organize grade level courses of study according to any of the suggested sequences on pages 4 - 5 or establish their own particular sequences. In addition to the sequences suggested, the following might be considered as an alternate: Grade 7 - A broad course in general science, of a summarizing nature, built to follow upon learnings of the elementary grades. Grade 8 - A modified earth science course with some attention to space exploration. Grade 9 - A general biology course with adequate attention given to health science.

Materials considered of an enrichment nature are indicated by an asterisk (*). Teachers and administrators are referred to the first of this series for introductory material on background, organization, and design. The references that are made in columns 3 and 4 are to activities that are described in the Appendix or in one of the three general science handbooks. Appendix activities are identified by the letter A and a number. All of these are described in this publication. Other activities are identified by number, such as 2725, 1104, 3037. Those beginning with 1 are in the General Science Handbook, Part 1; those beginning with 2 are in Part 2; and those beginning with 3 are in Part 3. All science teachers in grades 7-8-9 should have all three handbooks, a copy of Science 7-8-9 which contains an index to the activities in the three handbooks, and also Science Bibliography, 7-8-9.

The basic materials for Block A - Taking Care of Ourselves were written by Joseph M. Loudis, chairman of the science department at Shaker High School, serving as curriculum associate. Hugh B. Templeton, supervisor of science education, reviewed the materials and William A. Calhoun, associate in science education, recommended certain changes and revised portions of the original draft. Herbert Bothamley, temporary curriculum associate and Director of Secondary Curriculum at Brentwood, edited and prepared the final draft for publication.

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SCIENCE 7-8-9

Orientation
The Nature of Science
Measurement
Tools of the Scientist

Recommended Regular Sequence - 1

A Taking Care of Ourselves	B The Body in Action	7 Biological Science Emphasis	C Living Things Around Us	D Living in An Ocean of Air
E Our Planet Earth	F The Universe	8 Earth Science Emphasis	G Living in the Space Age	H Weather and Climate
I Mechanics of Fluids and Solids	J The Chemistry of Matter	9 Physical Science Emphasis	K Energy at Work	L Living with the Atom

SCIENCE 7-8-9

Orientation
The Nature of Science
Measurement
Tools of the Scientist

Recommended Regular Sequence - 2

A Taking Care of Ourselves	C Living Things Around Us	7	D Living in an Ocean of Air	E Our Planet Earth
B The Body in Action	G Living in the Space Age	8	H Weather and Climate	F The Universe
L Living in a Nuclear Age	J The Chemistry of Matter	9	I Mechanics of Fluids and Solids	K Energy at Work

SCIENCE 7-8-9

Orientation
The Nature of Science
Measurement
Tools of the Scientist

Accelerated Program - 1
Earth Science - Grade 9

7

A	C	D	J & K	F
Taking Care of Ourselves	Living Things Around Us	Living in an Ocean of Air	Introduction to Matter & Energy	The Universe

8

B	I	J	K	L
The Body in Action	Mechanics of Fluids and Solids	The Chemistry of Matter	Energy at Work	Living with the Atom

9

Regents Earth Science

SCIENCE 7-8-9

Orientation
The Nature of Science
Measurement
Tools of the Scientist

Accelerated Program - 2
Biology in Grade 9

7

A	B	C	D & H	E
Taking Care of Ourselves	The Body in Action	Living Things Around Us	Living in an Ocean of Air Weather and Climate	Our Planet Earth

8

I	J	K	L	F & G
Mechanics of Fluids and Solids	The Chemistry of Matter	Energy at Work	Living with the Atom	The Universe Living in the Space Age

9

Regents Biology

Reference Outline	Major Understandings and Fundamental Concepts
I. Understanding how we learn	All learning processes are fundamentally related to our ability to perceive sensations.
A. Perceive - messages from external environment	Our senses function to provide us with the external features of an object. At birth, the pathways over which messages are sent by our sense receptors are not sufficiently developed to allow efficient use of our senses.
1. sight	
2. smell	
3. hearing	
4. taste	
5. touch	
B. Remember - previous experiences	In order to learn new things we must relate these things to previous experiences.
C. Reason	Reasoning is a necessary means of advancing man's knowledge beyond that which he already "knows."
1. consideration - comprehension	
2. Judge	To make judgements we must mentally decide between two or more distinct concepts.

Typical Problems and Related Learning Activities	Supplementary Information For Teachers
How do our five senses keep us healthy and safe?	The development of our senses is dependent upon the nourishment and care that is provided the organism.
1104, 1116, 1545-46, A-1	
1118	
1117, A-2	
1118, A-3	
A-4	
How do we learn?	
3154, A-5, A-6, A-7	
How can a better understanding of behavior help us solve problems?	Reason is based upon our concept of how we "know" things - not upon imagination.
3159, A-8	By reasoning inductively, we are able to project our thoughts to arrive at general principles or laws by examining individual or particular things.
	Deductive reasoning allows us to analyze general principles so as to arrive at other general principles or to particulars which might be a basic part of a generalization.
	Intuitive thinking involves immediate understanding; it is a mental "leap" which may frequently provide the wrong conculsion.
How do we make judgements? 1135	

Reference Outline	Major Understandings and Fundamental Concepts
D. Reaction	
1. protective	Every animal comes into the world possessing certain behavior patterns which function automatically and serve for his protection. At birth we perform "unlearned acts" which do not require much use of our sense receptors. Inborn reactions are unlearned and independent of intelligence. They are simple reflexes which are usually beneficial to the human race as well as the individual.
2. voluntary	Voluntary acts involve some kind of intelligence - such acts include memory, reasoning, speed of recognition, space perception, and possibly others.
3. habitual	Habits involve learning; they begin as conscious responses which may become automatic as a result of constant repetition.
4. conditioned	
II. Maintaining healthy body systems	
A. Fundamental (systems) structures	
1. cells	There are many kinds of cells, but each kind of cell is structurally adapted to perform one <u>specific</u> role better than others. Every cell consists essentially of a gel-like mass (protoplasm) which is differentiated into a growing area (cytoplasm) and an area which controls most of the cellular functions (nucleus).
2. tissues	Tissues are composed of similar cells which perform a specific function.

Typical Problems and Related Learning Activities	Supplementary Information For Teachers
How do "unlearned acts" serve for our protection? A-9	Breathing, coughing, sucking, sneezing, and blinking are unlearned acts. Each of these occurs as a series of inborn reflexes that maintain or protect the newborn organism. Chains of reflex actions are sometimes referred to as instincts.
How are the activities of the body controlled? 3126	
How can a better understanding of behavior help us to solve personal problems? 3157, 3158, 3159 3128, 3131, A-10	In one kind of conditioning (the conditioned reflex) there is a substitution of a new stimulus for the original stimulus. Our whole body functions only as well as its individual parts. (Body systems which perform inadequately frequently are the cause of behavior problems.)
What are the smallest units of living matter? 3021-22	
What can we discover about the physical properties of cytoplasm? A-51	The cytoplasm in living active cells is a dynamic moving material. This movement (cyclosis) may be speeded up or slowed down by warming or cooling processes. Any inclusions or structures within the cytoplasm are carried along with the movement of cytoplasm in which they are suspended.
How do cells form tissues? 3024, A-21	Some cells or groups of cells secrete substances which are useful to the body.

Reference Outline	Major Understandings and Fundamental Concepts
	The cells of a tissue are so abundant that they divide the work of the tissue among themselves to produce the desired results. (physiological division of labor) Cells are organized into tissues, tissues into organs, and organs into systems.
3. organs	Organs are composed of similar or dissimilar tissues which act together as a unit to form a system. Systems perform certain functions such as digestion and circulation. *In all living things, the more complex the organization, the greater is the differentiation, division of labor, and the dependence of one structure upon the performance of another.
B. Fundamental (system) functions	
1. vision -	
maintaining effective perception (receptors)	The best way to protect and maintain the efficiency of our receptors is to understand how they work, and to take steps to keep them working at their best.
a. structure of the normal eye	Each part of the eye is structurally adapted to perform a special function.
b. visual defects	The eye works improperly if it develops faulty structure either before or after birth.
(1) astigmatism (lens) (2) near vision (lens, eyeball) (3) far vision (lens, eyeball) (4) lack of accommodation (lens, ciliary muscles)	The most common visual defects are caused by faulty lenses in the eye, abnormal shape of the eyeballs, or improper muscular action.

Typical Problems and Related Learning Activities	Supplementary Information For Teachers
How are cells organized into tissues? 3024, A-21	To prepare a stock solution of methylene blue stain (used in A-21), dissolve 1.48 gm. of the stain in 100 ml. of 90% isopropyl (rubbing) alcohol. In actual use it will be necessary to dilute the stock solution by adding 90 ml. of distilled water to each 10 ml. of the stock solution.
How are the various tissues and organs coordinated? A-22	
How are organs integrated into organ systems? 1133	
How is the eye structured to serve us? 1113, A-11	Additional visual defects may include: cataract (cornea), night blindness (rods-retina), crossed eyes (extra-oscular muscles), and glaucoma (cornea).
What are some common defects of the eye, and how can they be corrected? 1116, 3134 A-12, A-13, A-14	Impaired sense receptors may provide us with incorrect or faulty impressions upon which we may base our concepts. Inadequate sense reception may lead to social and mental behavior which may make it difficult for us to be accepted by others. Some of these behavior problems include: squinting, blinking, staring, poor posture, reading problems, and fatigue.

Reference Outline	Major Understandings and Fundamental Concepts
c. corrective measures for visual defects (1) cylindrical lenses (2) concave lenses (3) convex lenses	Visual defects such as astigmatism, nearsightedness, and farsightedness may be corrected by lenses.
d. safeguarding eyesight (1) sufficient light (2) glare and shadows (3) diet	The best way to protect and safeguard eyesight is to provide adequate illumination and reduce glare and shadows when we read.
2. hearing	Each part of the ear is structurally adapted to perform a specific function.
a. structure of the ear	
b. auditory defects (1) wax (outer ear) (2) colds, throat infection (middle ear) (3) measles, mumps (middle ear)	The eardrum and other internal structures of the ear are adapted to perform specific functions. These structures may be incapable of working efficiently because of damage resulting from injury or disease. Auditory receptors which function improperly, tend to limit our efficiency during the learning process.
c. associated defects - impaired balance; semicircular canals	*Certain <u>internal</u> messages are constantly provided which automatically help us to maintain our balance.

Typical Problems and Related Learning Activities	Supplementary Information For Teachers
How do lenses help to correct certain eye defects? 1114, A-15, A-16	Night blindness may be prevented and/or cured by the addition of sufficient amounts of vitamin A to the diet. A physician may prescribe certain eye-muscle exercises and/or surgical operation in order to correct crossed eyes.
How can proper lighting aid us in the care of our eyes? 1114, 1115, 1538	
How is the ear structurally adapted to perform its function? A-17	
What are some common defects of the ear? A-2	Other auditory defects may result from mastoiditis, otosclerosis, impaired nerve (auditory) function, and damage to the tympanum. These and other defects may be due to disease or injury. They require early medical diagnosis since speech defects, learning difficulties, lack of balance, and other behavior problems may result from auditory impairment.
How do the semicircular canals work? A-18	Other internal messages are constantly provided which enable us to know where our appendages (arms, legs, fingers) are located in space. Loss of this automatic information would be harmful to our survival. The functions of any living thing, including its component structures can be directly related to fundamental chemical, physical, or biological laws or principles. Thus functions of the semicircular canals may be explained by

Reference Outline	Major Understandings and Fundamental Concepts
d. corrective measures for auditory defects (1)irrigation (remove wax) (2)treat colds	Some auditory defects may be offset by maintaining free passage for sound waves into the middle ear.
e. safeguarding hearing	Early recognition of auditory impairments is important in safeguarding our hearing.
3. smell and taste	
a. structures of smell and taste	*The sense receptors of smell and taste are especially located and structurally adapted to augment and improve some of the sense impressions that we receive. Our taste buds depend upon chemical reactions for relating differences within a common sense impression. Thus we know sour, bitter, sweet, and salty.
b. defective perception - colds, hayfever	
c. corrective measures (1)treatment of upper respiratory infection (2)diet	
d. care of nose and mouth - oral hygiene, diet	

Typical Problems and Related Learning Activities	Supplementary Information For Teachers
	physical phenomena involving the mechanics of fluids and Newton's first law of motion (inertia).
	Certain auditory impairments may be concomitant with upper respiratory infection. Thus oversecretion of mucus and the role of vitamin A in the maintenance of mucous membranes are important.
Where are special taste areas located? A-19	
How can we test our ability to distinguish between impressions of smell and taste? 1118-19, A-20	The characteristic tastes of most foods are really combinations of taste and smell. The food in our mouths is smelled, and the sensation combines with that for taste in the cerebrum. By holding the nose, the circulation of vapor from food from the mouth to the nasal passages is prevented eliminating the factor of odor from the taste sensation. This is similar to what happens during a cold when the nasal passages are clogged with secretions.
	Inadequate hygienic measures may contribute to behavior problems.

Reference Outline	Major Understandings and Fundamental Concepts
4. touch	Some sense receptors are located in greater abundance in areas of our bodies where the need for such perception is the greatest. We have greater touch discrimination in our fingers and lips than we have on our elbows or the heel of the foot. Some receptors are located at different depths in our skin so that we will not react constantly to the slightest sensory stimulation.
a. defects of touch-impaired sensations (1)heat and cold (2)pressure and pain	Insensitivity to normal physical stimulations may result in an inability to protect ourselves against the dangers of body damage.
b. associated defects - knowing the position of appendages in space	
c. general body care and hygiene	Undesirable habits often cause sense receptors to function improperly, whereas habits involving healthful body care maintain the efficiency of receptors.
5. protection	Most of our contacts with the environment are through the skin. The skin is made up of two distinct layers-an outside layer (epidermis) and an inside layer (dermis) each of which is especially adapted to perform specific functions.
a. structural adaptations (1)skin, hair, (2)nails, glands	The skin covers the entire body and protects underlying tissues from invasion by infectious organisms; it prevents loss of body fluids; it is adapted to the elimination of some wastes; it is adapted to receive stimuli from the environment; it is adapted to

Typical Problems and Related Learning Activities	Supplementary Information For Teachers
How does our sense of touch help us to keep healthy and safe? 1120	Many behavior problems may result from touch defects; for example, slow reaction time, poor sensitivity to harmful stimuli. Extremities that "fall asleep" illustrate how poor circulation or (momentary) occlusion of blood vessels and/or nerves tend to diminish tactile sensitivity. This produces poorly coordinated motion and reduces our ability to "know" where our extremities are located in space.
How is the skin structurally adapted for protection? 1105	Cells of the inner layers of the epidermis are constantly pushed to the outside, shrinking and undergoing chemical changes. This tends to cement cells together and render them waterproof.

Reference Outline	Major Understandings and Fundamental Concepts
	help maintain the regulation of the body temperature; and it has absorptive powers. The skin does not stop at the mouth, nose, and ears. It enters the openings in our bodies (as protective membranes). It lines the inside and covers the outside of internal organs and organ systems.
b. nutrition and growth (1)dietary requirements vitamins, minerals c. personal care, hygiene	
6. structure and support of the skeletal system a. structural adaptations	The skeletal system affords organs of support and instruments for locomotion.

Typical Problems and Related Learning Activities	Supplementary Information For Teachers
	Water is eliminated from the body via four channels: kidneys, lungs, skin, and alimentary canal. The amount of excretion by each depends upon many external and internal conditions but under usual atmospheric conditions (and when the body is at rest) the ratio for the organs listed above is about 6:2:2:1. An increase in elimination by one organ decreases correspondingly the output by the other organs. Thus the warmer and drier the air, the more water is lost via skin and lungs and the less by other organs. (physiological division of labor) Heat is lost by the body via the skin, lungs, and excretions. Loss through the skin is influenced by the temperature and humidity of the external environment, but in general, body heat is lost by: (1) radiation - when the temperature of surrounding objects is less than the body temperature, (2) convection - when the temperature of the air is below that of the body, (3) evaporation - (perspiration) since some of the heat required for evaporation of body fluids is absorbed from the surface tissues of the body.
How can we keep our skin healthy and looking its best? 1107, 1108	Body systems which are not properly cared for, tend to function poorly and be less resistant to disease.

Reference Outline	Major Understandings and Fundamental Concepts
	Bone is a tissue.
(1)long bones	*Long bones act as (first or third class) levers in the body.
(2)flat bones	*Flat bones such as those in the skull have special adaptations (sinuses) which afford lightness to the skull and resonance to the voice.
(3)irregular bones	*Irregularly shaped bones (vertebrae, wrist, and foot) provide a maximum of support and flexibility of motion.
(4)joints-hinges	Bones are adapted to connect (articulate) with one another to provide mobility.
	*Some sacral bones and bones of the skull are very tightly joined (sutures). This type of joint limits movement in all directions.
	Vertebrae and some pelvic bones have thin pads of fibrocartilage between them which cushion the bones and help prevent injury from pressure, but permit only limited motion.
	Bones are structurally adapted to perform a specific kind of motion.
	*Gliding joints are structurally adapted so that the rubbing surfaces accommodate each other.
	*Hinge joints are structurally adapted to permit back and forth motion.
	*Some structural adaptations permit angular motion in two directions (wrist joint).

Typical Problems and Related Learning Activities	Supplementary Information For Teachers
	Bone is composed of a group of similar cells separated by a hard intracellular matrix.
How do muscles and bones move the body? 3101, 3111	Since most cells (in this case osteocytes) are incapable of manufacturing materials necessary for their own life functions, the intracellular substance produced by such cells must be derived from minerals (calcium and phosphorus) originally secured in the diet.
What functions are performed by the bones of the skull? 3122	
What functions are performed by the back-bone? 3123	
	In a gliding joint one of the articulating surfaces is concave; the other convex. This provides gliding motion only; wrist-carpels, ankle-larsals. Hinge joints allow angular motion in one direction only; knee, ankle, fingers.
How can the movements of our bones help us to discover more about their structural adaptations? (See Supplementary Information for Teachers.)	Certain adaptations in the articulating surfaces of bones concave in one direction, convex in another allow similar motion since they are located at right angles to each other (thumb and wrist joint).

Reference Outline	Major Understandings and Fundamental Concepts
(5)ball and sockets	Some structural adaptations permit angular motion in all directions. The ball and socket are held in place by ligaments connecting the ball with the center of the socket.
(6)tendons - ligaments	
(7)cartilage	
b. functional applications	*Special structural adaptations reduce friction in joints.
(1)support	
(2)protect brain, heart, lungs	
(3)blood formation	*Bone marrow is a site for the manufacture of blood cells.
c. nutrition and growth	Any living thing requires certain materials for its life processes. Each organism must secure the required materials that it cannot manufacture itself.
(1)diet vitamins, minerals, and elements	Minerals containing calcium and phosphorus are necessary for the proper development and maintenance of bone tissue.

Typical Problems and Related Learning Activities	Supplementary Information For Teachers
	Pivot joints are rounded so as to allow rotation in one axis. (axis atlas - skull and neck) (radius - ulna to rotate hand palm up, supinate; or palm down, pronate)
	Ball and socket joints are adapted to afford angular motion (with a pivoting action) in all directions.
How do ligaments bind the ends of bones together? 3105	
How do tendons enable us to move? 3106	
	The synovial membrane envelops highly movable joints. It secretes a viscous, mucin-like fluid which lubricates the articulating surfaces.
	Certain cells called osteoblasts influence the deposition of calcium salts in the interstitial material between widely separated bone cells. The composition of the salt is complex. It is a large molecule formed by the union of calcium carbonate and calcium phosphate - the latter accounting for the greater part of the molecule.

Reference Outline	Major Understandings and Fundamental Concepts
7. muscle system - locomotion	The power of contraction which results in movement is possessed by all protoplasm to a greater or lesser degree.
a. structural adaptations	Muscle fibers move when stimulated by nerve impulses and by other physical or chemical means.
	Muscle fibers have the power of contraction and relaxation; they do not contract and expand.
(1) voluntary muscle cells	Voluntary (striated) muscle cells are long and slender, are attached to bone, and are adapted to voluntary control.
(a) size and shape	
(b) location	
(2) involuntary muscle cells	Involuntary (smooth) muscles are short, slender, and are usually wrapped around or imbedded in tissue where an automatic squeezing action is required.
(a) size and shape	
(b) location	
(3) cardiac muscle cells	Cardiac muscles are similar to striated cells except that they are interconnected in the form of a network (synotium). The whole network contracts <u>entirely</u> upon stimulation.
(a) shape	
(b) arrangement	
b. functional applications	
(1) voluntary motion	
(a) bone to bone	
(b) tendon to bone	
(2) involuntary motion	

Typical Problems and Related Learning Activities	Supplementary Information For Teachers
	Motion occurs within cells (cyclosis) or within tissues and organs of more complex organisms. Some animals possess bilaterally symmetrical bodies. This is an adaptation for forward motion.
What are the physical characteristics of voluntary and involuntary muscle cells? A-23	Striated muscles are arranged in the body so that they are antagonistic to each other. When one contracts another relaxes permitting purposeful movements (biceps and triceps). Various structures illustrate squeezing action caused by smooth muscle. Some of these include cardiac, pyloric, ileocaecal, and other spinctre valves of the digestive and/or urinary systems. In addition, the wave-like contractions of some blood vessels (see tunica media, c.s. arteries, veins) also exemplify squeezing effects resulting from muscle action.
How do voluntary muscles move the skeleton? 3107-08, 3110	Many muscle fibers resist stretching. Their automatic contractions are partly due to the force of gravity; for example, jaw and abdomen muscles. (See muscle tone.)
What is peristalsis? 3117	

Reference Outline	Major Understandings and Fundamental Concepts
(a)digestion (b)circulation (c)pupil-lens-accommodation	
c. nutrition and growth (1)diet, protein and B-complex (2)storing sugar	A large blood supply is necessary for most muscles since they require large amounts of energy-supplying nutrients in addition to a way of disposing their wastes.
d. personal care (1)muscle tone (2)fatigue (3)exercise and circulation	Muscles function poorly when fatigued, when the blood supply is diminished, or when the efficiency of nerve transmission has been affected by narcotics.
8. response (irritability) nervous system	All living things respond to environmental stimuli and in most complex organisms there is differentiation of tissue which is particularly well adapted to perform a specific function.
a. structural adaptations (1)sensory nerve cells - shape, location (2)motor nerve cells - shape, location	
(3)connecting (associative) nerve cells - shape, location	The numerous interrelated nerve cells of man form a complex system through which every organ of the body is connected to every other organ.
b. functional applications	The nerve cells (neurons) which form nerve tissue are structurally well adapted to transmit messages from one location to another.

Typical Problems and Related Learning Activities	Supplementary Information For Teachers
How can we show the involuntary and rhythmic action of the heart? 3119	
How is energy related to the contraction of our muscles? 3121	Tissues which are required to work constantly require a larger amount of energy.
How do we store some of the energy-supplying nutrients that our muscles require? A-24	The hepatic portal system enables energy-supplying nutrients (glucose) to re-enter the blood and to be returned directly to the heart for their subsequent distribution throughout the body.
How are the activities of the body controlled? 3132	The fundamental anatomy of the neuron (axon, neurilemma, dendrites, terminal arborization) illustrates the neuron's structural adaptability to transmit impulses along its length.

Reference Outline	Major Understandings and Fundamental Concepts
(1)polarity (nerve cell types)	The nervous system and glands help to regulate and coordinate all body activities.
(2)conduction (nerve tissue)	
(a)receptors to spinal cord and brain	Sensory nerves are adapted to receive messages and transmit the sensation to the spinal cord or brain.
(b)spinal cord, brain to muscles, glands	Motor nerves are structurally oriented to direct messages to muscles to cause movement.
(c)within spinal cord and brain	Associative nerve cells are structurally oriented within the brain and spinal cord to permit the interconnection between sensory and motor nerves.
(d)reflex arc	
(3)maintaining basic processes	
(a)some nerves automatically control such processes as:	
(1)respiration	
(2)heartbeat	
(3)digestion (peristalsis)	
(4)excretion	
(5)secretion	

Typical Problems and Related Learning Activities	Supplementary Information For Teachers
	Nerve cells are so joined end to end that they permit a message to travel along a nerve in one direction only.
	The orientation of neurons, together with the specificity of synaptic conduction, further identifies the final common pathway to be taken by the nerve impulse.
How are messages transmitted to the brain or spinal cord?	
3133	
3134	
	The transmission of impulses along nerves is considered an electrochemical phenomenon.
	Special nerve systems (sympathetic, parasympathetic) seem to be in sympathy with our basic fundamental needs. These systems usually send rhythmic messages to certain involuntary muscles, such as those located in the blood vessels, the digestive tube, certain skin glands, striated muscles which oppose gravity or are necessary for respiration, and cardiac muscles controlling heart action. Body temperature and protective actions are controlled by these nerves.
How do organs of the body adjust to changes in their environment?	
1126, A-15	
1125, 1127-28	

Reference Outline	Major Understandings and Fundamental Concepts
(4)areas of the brain	Special areas of the brain perform specialized functions. (differentiation and division of labor)
(a)thought processes (cerebrum)	The cerebrum functions in remembering, reasoning, and speaking. It is the control area for seeing, smelling, tasting, hearing, and touching.
(b)balance and muscle coordination (cerebellum)	The cerebellum receives messages from afferent nerves and the semicircular canals. These messages are integrated with motor messages transmitted to the muscles and result in smooth, coordinated movements. (The biceps contract at the same time that the triceps relax.)
(c)initiating automatic responses of heart and respiratory action (medulla)	The medulla oblongata controls involuntary acts, such as the heartbeat, respiration, and breathing.
c. nutrition and growth	
(1)diet (glucose, amino acids) vitamin B-complex, calcium, phosphorus	
d. personal care	The velocity of messages which are transmitted by nerves is seriously diminished by toxic agents such as chloroform, ether, curare, alcohol, and other narcotics and habit forming drugs. Depressants seriously impair the functions of all organs and systems which in turn are dependent upon nerve supply.
9. acquiring oxygen -	Respiration involves the taking in of oxygen and the giving off of products which are formed from oxidation in the body cells.

Typical Problems and Related Learning Activities	Supplementary Information For Teachers
How does the central nervous system coordinate body activities? A-29	
	Adequate sodium, potassium, calcium salts, and vitamin B-complex are dietary necessities for proper nerve function.
	The large air tube, the trachea, is constructed so as to stay open at all times. It will not "kink" with bending or twisting the neck, or collapse upon exhalation. 31

Reference Outline	Major Understandings and Fundamental Concepts
respiration	
a. structural adaptations	Special structures in the throat automatically open and close to prevent food from entering the trachea.
(1)nose and throat (2)larynx and trachea (3)lungs, pleura (4)chest cavity	
b. functional applications	
(1)cilia, mucous membranes	Epithelium cells lining the nose, throat, and trachea have special structural adaptations which filter and moisten inhaled air.
(a)beating action - protection (b)mucus, lubrication	
(2)air sacs	Air sacs are enveloped with numerous capillaries. This increases the surface area for the diffusion of oxygen into the blood stream.
(a)thin cell wall (b)increases surface area (c)diffusion of gases	*Diffusion, the spread of fluids and their dissolved substances, is an important method of conveying oxygen from the surface of a cell to its interior. Oxygen is transported to all cells in the body by red blood cells. Wastes (carbon dioxide, water, and some nitrogenous substances) are removed from body cells and are transported back to air sacs by the blood plasma and red blood cells.

Typical Problems and Related Learning Activities	Supplementary Information For Teachers
How is the voice produced? 2624	Involuntary muscles between "c" shaped cartilage rings of the trachea and bronchi afford great flexibility during respiratory movements.
How are the lungs structurally adapted to serve us? 1130, A-30	
What is ciliary action? A-31	The air tubes entering the lungs become smaller and more numerous in order to disperse air throughout the lungs.
	As air tubes become smaller, they loose their cartilage structure and become thin-walled and less rigid. Each tube ends in a very thin sac.
How do molecules diffuse through membranes? A-32, A-33	Osmosis is a type of diffusion which occurs through a semi-permeable membrane or barrier.

Reference Outline	Major Understandings and Fundamental Concepts
	Respiration in both plants and animals involves exactly the same gaseous exchange with the release of energy.
(3)chest movements	Breathing is an automatic physical act.
(a)inspiration - increasing volume of chest cavity - elevate ribs, depress diaphragm	As the volume of the chest cavity is increased, the internal air pressure is decreased and air rushes in inflating the lungs. Relaxation of the rib muscles and the diaphragm decreases the volume of the chest cavity resulting in increased internal air pressure and air is forced out.
(b)expiration - decreasing volume of chest cavity - relax rib muscles, relax diaphragm	
(c)breathing	
(1)exchange of gases (2)eliminates wastes (3)regulates body temperature (4)regulates body water content	
c. nutrition and growth	
(1)diet (2)adequate ventilation	

Typical Problems and Related Learning Activities	Supplementary Information For Teachers
	The lungs do not have any structural adaptations (muscles) for contracting. Inflation and deflation is passive and results from differences in internal and external pressures.
	Muscular adaptations, such as the dome-shaped diaphragm and the muscles between the ribs (intercostals), help to increase the volume of the chest cavity when these muscles contract.
How do our bodies obtain air? 1132, 2645, A-34	The diaphragm possesses circularly arranged muscle fibers which shorten and cause the diaphragm to flatten out upon contraction.
How many gallons of air do we breathe each minute? 2643	
How are gases exchanged and wastes eliminated through the breathing process? A-35	

Reference Outline	Major Understandings and Fundamental Concepts
d. personal care (1)avoid overeating, obesity (2)frequent "deep" breathing (3)nose breathing (4)avoid irritants when possible - occupational (coal dust) (5)smoking	
10. distribution of fluids (a)structural adaptations (1)the heart; a fist-sized pump	Circulation occurs in all living things, but more complex organisms have special adaptations for fluid distribution.
(a)muscle fibers (b)nerve supply (c)protective cover (d)chambers- number, size, location, chamber lining (e)valves - location	The heart is structurally adapted to receive blood at low pressure and to emit blood at high pressure for distribution throughout the body.
(2)heart movements (a)contraction (b)relaxation	The heart is a muscular pump which contracts rhythmically (and completely) due to messages from the medulla oblongata.
(3)the closed system of vessels (a)structures in the blood cycle aorta,	The circulatory system transports food and oxygen to all cells, through a series of structurally adapted semi-elastic tubes.

Typical Problems and Related Learning Activities	Supplementary Information For Teachers
How are healthful air conditions maintained indoors? 2629-2640	
	Smoking irritates the respiratory system and interferes with efficient interchange of gases.
How is blood distributed throughout our bodies? A-36	The external heart is enveloped with a cover (pericardium) which protects and lubricates to diminish irritation and friction.
What can heart sounds tell us about our circulatory system? 1123, A-37	Internal chambers have smooth linings for free blood flow. The size or amount of muscle in each chamber is directly proportioned to the amount of work that chamber has to perform.
What structural adaptations help to keep our blood flowing in one direction? A-38, A-39	When upper chambers are relaxed, the lower chambers contract. When upper chambers contract, the lower chambers are relaxed. Valves are structural adaptations which prevent the back flow of blood between the upper and lower chambers, between the upper chambers and incoming blood vessels, and between the lower chambers and outgoing blood vessels.
How are the lungs and heart related in our circulatory system? 3118	

Reference Outline	Major Understandings and Fundamental Concepts
arteries, arterioles, capillaries, venules, veins, venacavae	
(b)adaptations of the vessels - diameters (relative), thickness of walls, muscular differences, valves	An increase in the size of an organism usually results in a corresponding elaboration of the circulatory system.
b. functional applications	
(1)muscle fibers (cardiac)	
(2)receiving chambers atria (auricles)	
(a)lining-smooth membrane	
(b)location	
(c)contract and relax	
(d)discharge of blood	
(3)discharging chambers ventricles	
(a)lining-smooth	
(b)location and capacity	
(c)contraction and relaxation	
(d)discharge of blood	

Typical Problems and Related Learning Activities	Supplementary Information For Teachers
What is the proper method of taking the pulse rate? 1124, 1125	The cardiac muscle fibers receive automatic nerve stimulation and react involuntarily as a unit. (See activity 3119.) The two receiving chambers of the heart, atria or auricles, are of about equal capacity. They contract completely and simultaneously and relax completely and simultaneously. (See activities 2125, A-27.) During contraction the valves to the lower chambers open and the valves from incoming blood vessels close. During relaxation the valves to the lower chambers close and the valves from incoming vessels open. (See activity A-39.) Blood is discharged from both chambers simultaneously and is directed to the lower chambers due to valve action. The left ventricle is about three times as muscular as the right ventricle due to the fact that it has to push blood throughout the body. The ventricles (completely) relax simultaneously and (completely) contract simultaneously.

Reference Outline	Major Understandings and Fundamental Concepts
(4) vessels transport blood away from the heart	
(a) accommodate increase in volume; pressure upon discharge lower chambers	The aorta and arteries have elastic tissue and several layers of involuntary muscle in their walls. This makes for greater adaptability caused by sudden distension of the vessel. Such vessels automatically return to their original diameters in preparation for the next surge.
(b) maintain blood supply to extremities	
(c) provide continuous supply to capillaries	All fluid exchange between the blood and the body cells is accomplished through small tubes (capillaries) whose walls are

Typical Problems and Related Learning Activities	Supplementary Information For Teachers
	During contraction the valves to the vessels leaving the heart open and the valves from the upper chambers close.
	During relaxation the valves to vessels leaving the heart close and valves from the upper chambers open.
	Blood is discharged from both ventricles simultaneously.
	The left chamber directs blood to the lungs while the right chamber pumps blood throughout the body.
	The blood leaves the heart under high pressure (systolic). The blood pressure drops when the lower chambers relax (diastolic) $\frac{120}{80}$ mm. Hg.
	The aorta is about 1¼ inches in diameter.
	Arteries become smaller and more profuse the farther they are from the heart. This permits greater distribution of blood. Arteries are further adapted since involuntary muscle layers and elastic tissue gradually disappear and the vessels become very thin-walled capillaries.
	A wave of blood is forced along the arteries because of automatic stimulation of involuntary muscles in the arterial wall.
What is the effect of temperature on capillary size? A-26	Capillaries are thin-walled non-muscular semipermeable tubes through which fluids are exchanged by osmosis.

Reference Outline	Major Understandings and Fundamental Concepts
	usually one cell layer thick. The lymph acts as a middle man between blood and cells.
(5)vessels transport blood toward the heart (a)increase in diameter (b)fewer muscles (c)valves in veins	Veins possess less elastic tissue and fewer layers of involuntary muscle within their cell walls than arteries do as veins are not required to withstand the high blood pressures that arteries are subject to. Veins have special adaptations to prevent the backflow of blood. (Arteries do not possess valves which would tend to impede the flow.) Veins increase in diameter as they return blood to the heart. (Reduced pressure in these large vessels is caused both by their increased volume and the effect of gravity against the blood itself.)
(6)composition of blood tissue (a)intercellular substance plasma (1)90% water (2)dissolved protein (3)dissolved nutrients (4)dissolved salts, gases, hormones, and antibodies	Blood is a tissue which is adapted to internally transport food, oxygen, and wastes.
(b)tissue cells (1)red blood cells (2)white blood cells (3)platelets	Blood is a tissue composed of different kinds of cells which are dispersed in a fluid (plasma).

Typical Problems and Related Learning Activities	Supplementary Information For Teachers
	Blood vessels transporting blood from the capillaries to the heart gradually increase in diameter and become increasingly muscular.
How can we locate some of the valves in our veins? A-38	Adaptations in the veins increase the pressure so that the blood enters the heart under higher pressure than it had upon leaving the capillaries. The increase in pressure is due to muscular massage, values in the veins, contractions of the spleen, and the more negative pressure of the (thoracic) chest cavity.
What is the composition of the blood? 3028 (demonstration)	

Reference Outline	Major Understandings and Fundamental Concepts
(7)functions of blood tissue (a)transport and exchange fluids (b)red blood cells transport oxygen and carbon dioxide (c)white blood cells protect and repair (d)platelets (blood clotting)	Red blood cells and platelets have chemical adaptations which insure the transportation of oxygen to body cells and provide a chemical mechanism for the formation of a blood clot. White blood cells are adapted for amoeboid-like movement which enables them to leave the capillary and seek out foreign organisms between other body cells. The plasma of blood tissue contains dissolved nutrients, wastes, salts, gases, and chemical regulators which are either being transported to or from body cells.
c. nutrition and growth	Chemical changes are constantly taking place in all of the life processes of every living thing. Most living things secure their energy by oxidizing (burning) foods within the cells. The amount of oxygen absorbed by cells (during cellular respiration) is directly proportional to the amount of energy released by the body. Waste products which result from cellular oxidation are primarily transported by the plasma to structures which are adapted for their excretion. All living things require oxygen in order to obtain energy from foods and to build new cell material (protoplasm). The blood transports all of the nutritive requirements necessary for each kind of tissue.

Typical Problems and Related Learning Activities	Supplementary Information For Teachers
	All substances involved in chemical changes which take place in an organism must be in solution.
What is a healthful diet? 2134, 2143	
	The basic constituents of all foods (carbohydrates, fats, proteins) are converted into simpler hexosis, fatty acids, and various amino acids for assimilation by the body.

Reference Outline	Major Understandings and Fundamental Concepts
d. personal care	Toxic substances which accumulate in the blood may be distributed to all tissues and result in impaired function or death.
(1) regular exercise and rest	
(2) avoid over-exertion and overweight	Alcohol which is taken internally may be transported by the blood and seriously diminish the effectiveness of nerve and muscle tissue.
(3) periodic check-ups	
(4) avoid use of drugs	Certain narcotics react chemically with some capillary walls so as to cause dilation of the vessel with subsequent loss in blood pressure, blood temperature and, in extreme cases, loss of plasma to the surrounding tissues.
(a) stimulants	Certain stimulants also affect some capillaries by constricting the vessel, thereby increasing the blood pressure and interfering with normal fluid exchange.
(b) depressants	As alcohol is not digested before it is transported to body cells, cells suffer the poisonous effects of raw alcohol until it can be chemically decomposed and eliminated from the body. Alcohol is considered to be a narcotic.
(5) avoid use of tobacco	The inhalation of tobacco smoke tends to constrict the capillaries of the upper respiratory passages resulting in localized increases in blood pressure.
11. body nutrition (cells)	Complex organisms have special adaptations for making food soluble and for reducing nutrients to simpler form.
a. structural adaptations	
(1) mouth	
(a) salivary glands	
(b) teeth	
(c) tongue	
(2) epiglottis, esophagus	

Typical Problems and Related Learning Activities	Supplementary Information For Teachers
What effects do some drugs have upon heartbeat? A-40	
What effect do certain stimulants have on the circulatory system? A-41	Certain pharmaceuticals classed as nasal decongestants employ the use of epinephrin or adrenalin-like substances for their vasoconstricting action on mucous membranes. Some caution should be observed to avoid prolonged use of these substances.
What should we know about smoking? 3130	
Where and how are foods digested? 2115, 2116, 3113, 3114, 3115, 1106	
Why is digestion necessary? A-42	

Reference Outline	Major Understandings and Fundamental Concepts
(3)stomach (valves) (4)small and large intestines (a)glands (b)villi	
b. functional applications	The mouth contains structures which function to increase the surface area of solid foods.
(1)digestion in the mouth (a)mastication (b)lubrication (c)tongue (d)salivary glands	Digestion of food begins in the mouth. Salivary glands secrete chemical solutions which accelerate the dissolving of carbohydrates.
(2)non-digestive applications (a)epiglottis	
(b)esophagus	
(c)stomach	
(3)digestion (dissolving food in the stomach)	Food is digested or changed into soluble form by the action of chemical accelerators called enzymes.
(4)digestion in the small intestine	The digestion of food and the absorption of dissolved nutrients into the blood stream occur

Typical Problems and Related Learning Activities	Supplementary Information For Teachers
How does chewing prepare food for digestion? A-43 How are carbohydrates acted upon by the saliva? 3434, 3435, A-44	The epiglottis covers the trachea and functions automatically to direct food into the esophagus and prevent food from entering the trachea. The lower portion of the gullet (esophagus) contains longitudinal and transverse muscle fibers which automatically constrict the tube and force food downward to the stomach. Circular (sphinctre) valves at the entrance and exit of the stomach function automatically to allow small amounts of food to enter and leave the stomach. These adaptations prevent regurgitation and keep food in the stomach long enough for partial digestion of proteins.
How is food broken down into soluble substances by certain chemicals in the body? 2119, 2120, A-45	Longitudinal and transverse muscle fibers of the stomach provide involuntary motion. Glands in the stomach wall secrete chemicals to help dissolve protein. Involuntary muscle fibers are oriented lengthwise and circularly throughout the walls of the small

Reference Outline	Major Understandings and Fundamental Concepts
	primarily in the small intestine.
	Osmosis is a type of diffusion through a semipermeable membrane in which the rate of flow is greater from the more dense to the less dense media until an equilibrium has been established.
	The surface area of the small intestine is determined by its length and the finger-like projections called villi.
	Each villus is especially adapted to perform the absorption of fats (fatty acids, amino acids, and glucose) into the blood stream for distribution to the body cells.
(5)retaining body moisture	
c. nutrition and growth	Most living things secure their energy by oxidizing (burning) foods within the body.
	Carbohydrates and fats are energy-producing foods, but fats yield more than twice as much energy per unit weight as carbohydrates.
	Proteins are used to build and repair body cells and to yield energy upon oxidation.
	Water helps to dissolve food, helps to regulate the temperature of the body, and helps in transporting wastes.
d. personal care	Some narcotics and some stimulants inhibit peristalsis and hunger pains. There is a danger of nutritive deficiencies resulting from the indiscriminate use of drugs.

Typical Problems and Related Learning Activities	Supplementary Information For Teachers
	intestine in order to provide automatic motion of food substances in one direction.
How does digested food enter the blood? 3116, 3117, 2122-2133, A-46	
	The large intestine absorbs moisture and aids in digestion by bacterial action. The movement of wastes through the large intestine is an automatic process.
What effect does diet have upon body growth and functioning? 2134-2143, A-47	

Reference Outline	Major Understandings and Fundamental Concepts
12. eliminating wastes	The skin is adapted to eliminate wastes such as moisture and nitrogenous substances.
a. structural adaptations (1)skin (2)lungs (3)kidneys (4)large intestine	
b. functional applications (1)sweat glands	The large surface area of the skin exposed to the environment helps in the elimination of wastes.
(2)respiration	The large number of air sacs in the lungs afford a large surface area from which gaseous wastes (carbon dioxide and water vapor) diffuse into the external environment. *Some of the wastes produced by ordinary cellular respiration stimulate other cells of the body to work faster. (carbon dioxide - a respiratory stimulant)
(3)the kidneys	The kidneys remove most of the fluid wastes of the body.
c. nutrition and growth (1)balanced diet	A well-balanced diet supplies the body with the proper proportion of all the nutrients. The basic seven plan for good nutrition insures a well-balanced diet. The energy value of foods is measured in calories. One calorie is the amount of heat needed to raise the temperature of one gram of water one degree centigrade.

Typical Problems and Related Learning Activities	Supplementary Information For Teachers
How are wastes eliminated through the skin? A-48	An increased respiration rate (due to increased muscular activity) aids in regulating body temperature and in the elimination of wastes.
How do the kidneys aid in the elimination of wastes? A-49, A-50	The kidneys are structurally adapted to filter water, urea, and other nitrogeneous wastes from the blood and to maintain the correct water balance in the body.

Reference Outline	Major Understandings and Fundamental Concepts
	Diet refers to the variety of foods that are usually eaten.
d. personal care (1)bathing (2)cosmetics (3)water intake	
III. Developing Beneficial Patterns of Behavior	
A. Inborn automatic behavior	Every animal comes into the world possessing certain inherited behavior patterns which function automatically and serve for its protection.
1. simple reflex action	Simple reflexes are inborn reactions which are unlearned and independent of intelligence. Simple reflexes which serve to protect us are usually beneficial to the human race as well as to the individual. Reflexes are important in controlling the everyday vital functions of the organism.
2. instincts	Instincts are inborn patterns of behavior.
B. Acquired (learned) automatic behavior	Conditioning is the changing or modification of behavior patterns due to an association between different kinds of stimuli. Unwarranted fears and prejudices are encouraged by certain kinds of conditioning.
1. habits	Habits are responses to stimuli which become automatic as a result of constant repetition.
a. reasons for habit formation b. habit formation-a process c. beneficial nature of habits d. harmful nature of habits	Habits may be helpful or harmful.

Typical Problems and Related Learning Activities	Supplementary Information For Teachers
Why is the daily bath important in the elimination of wastes?	
1107	
How may we condition or bring about changes in the behavior of animals?	
3149, 3152	

Reference Outline	Major Understandings and Fundamental Concepts
2. voluntary acts - a desired response	*Voluntary or willful acts involve some kind of intelligence. Such acts include memory, reasoning ability, speed of recognizing symbols, space perception, and possibly others.
	*Intelligence may be described partially as an ability to solve problems in situations new to the individual.
3. habits involving narcotics and drugs	In certain abnormal conditions and under medical supervision, narcotics may be used to alleviate pain. We must be on guard however, against the danger of habit formation.
a. stimulants accelerate cell activity	
b. depressants (narcotics) depress cell activity	Long continued use of narcotics or alcohol produces severe, permanent damage to the human body.
(1)alcohol	
(2)tobacco	

Typical Problems and Related Learning Activities	Supplementary Information For Teachers
How does the study of animal behavior help us understand our own behavior? 3146, 3148	Certain ill effects involving accelerated cell activity results from the use of stimulants such as benzedrine and cocaine. These ill effects include: accelerated heartbeat, elevated blood pressure, the constriction of certain blood vessels, decreased glandular secretion, the dilation of the pupils, the ciliary muscles are affected so that the eyes are accommodated for far vision, and an induced hyperexcitability.
How may the unwise use of various substances endanger our safety and health? 1137-1141	Depressants such as opium, heroin, morphine, codeine, barbiturates, bromides, marihuana, and alcohol depress cell activity and generally involve loss of memory, distorted reaction time, poor vision, and paralysis. Alcohol temporarily increases the heart rate, depresses the force of the heartbeat, induces rapid pulse, dilates blood vessels in the skin, causes perspiration but lowers blood temperature, slows reaction time, decreases cerebration, and decreases coordination. Tobacco affects the circulatory system, temporarily increases the blood pressure, interferes with efficient gaseous exchange in the air sacs, and diminishes sensory discrimination of taste and smell.

Appendix - Learning Activities

A-1. Binocular Vision

(a) To demonstrate that man possesses binocular vision, or that two images are combined in normal vision, hold a pencil about 12 inches in front of the eyes while looking at a distant object. Then look quickly at the pencil and note the double image of the distant object.

(b) To stress the advantage of binocular vision, have members of the class hold two pencils, one in each hand, at arms length and about 3 feet apart. Have them close one eye and try to bring the rubber tips of the pencils together. Now have them try again using two eyes.

A-2. Sense of Hearing

Hearing is an extremely important sense whose value is easily demonstrated. Blindfold one student and have him hold the end of his finger firmly in one ear. Place four or five other students in different positions about 10 feet away and click coins together at short intervals so the sound is just audible. Ask the student being tested to point in the direction from which he thinks the sound is coming. Let him remove the finger and try again; notice how much better he can now locate the source of the sound.

This demonstration will point out that good hearing in both ears is a protective device. This is a good occasion to discuss ear injury and ear hygiene.

A-3. Inheritance of Taste Ability

It is difficult to find many human traits that are inherited and that are not affected by environment. One trait is the ability to taste a harmless substance called phenylthiocarbamide.

Papers that have been soaked in this substance are called PTC papers. Taster papers can be obtained from the American Genetics Association, 1507 M Street N.W., Washington 5, D.C. at a very nominal price.

About 7 out of 10 persons, on chewing up a bit of the paper will taste a very bitter substance. Some will taste it as sweet, salt, or sour. The remaining 3 of 10 will taste nothing but the paper that has been impregnated with the substance.

A-4. Sensitivity of Skin to Touch

Nerve endings sensitive to touch are more abundant in the skin over some parts of the body than others. The density of these nerve endings can be determined by using a pair of dividers such as are used in mechanical drawing.

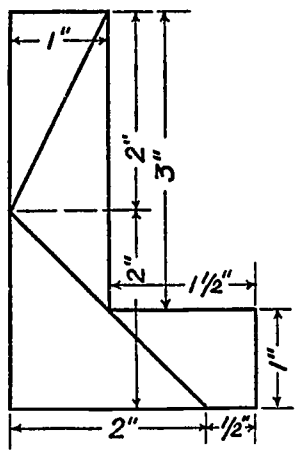
With careful teacher supervision pupils should work in pairs on this activity, switching roles when the data has been completed for one person. The subject should be blindfolded so that his interpretation of touch will not be influenced by sight.

The back of the subject's hand should be touched lightly with the two points of the divider about one-fourth inch apart. Repeat, decreasing the distance until the two points feel as one. The closest distance that the two points can be recognized as two should be recorded. Do this on the skin of other parts of the body, such as the palm of the hand or fingertip. The closer together the points can be distinguished as two points, the closer together are the touch-sensitive nerve endings.

A-5. Trial-and-Error Learning

An interesting simple exercise illustrating the improvement that comes through repetition of trial-and-error learning follows.

Give each pupil four pieces of cardboard cut as indicated in the diagram below. At a signal, each pupil will begin to arrange the scrambled pieces to form the letter L. Each pupil should keep a record of the time required. As soon as each pupil has completed the task, he should rescramble the pieces and put them together again. When he has completed this ten times, he should make a line graph of his data.



The typical graph will show marked improvement in time in early trials, with improvement tapering off in later trials.

A-6. Learning Under Distraction

Memorization constitutes a type of learning. Duplicate limerick number 1 below and provide each pupil with a copy, face down. On signal, have pupils turn the papers over and memorize the limerick. Allow 2 minutes for this, keeping the room absolutely quiet. At the end of this time, have pupils write the limerick from memory. Score the number of words correct.

Appendix - Learning Activities

Distribute limerick number 2 and repeat the procedure, playing music on a radio or phonograph during the memorization period. Score the number of words correct.

Distribute limerick number 3 and repeat the procedure. This time rap on the desk with a ruler, sound a buzzer or bell, and make other disturbing noises. Score the number of words correct.

Other distracting situations may be set up for the memorization period of limerick number 4.

It is interesting to determine the class average of correct words for each situation. In a discussion following this activity the desirability of quiet conditions for study can be brought out.

Limerick 1

There was a young lady, whose nose
Continually prospers and grows
  When it grew out of sight
  She exclaimed in a fright
"Oh! Farewell to the end of my nose!"

Edward Lear

Limerick 2

There was a young lady named Bright,
Who traveled much faster than light.
  She started one day
  In a relative way
And returned on the previous night.

Limerick 3

There was a young lady of Norway
Who casually sat in a doorway;
  When the door squeezed her flat
  She exclaimed, "What of that?"
This courageous young lady of Norway.

Edward Lear

Limerick 4

There was a young lady of Niger
Who smiled as she rode on a tiger;
  They returned from the ride
  with the lady inside,
And the smile on the face of the tiger.

A-7. Importance of Understanding to Learning

(a) Provide each pupil with a copy of the three lists of words printed below. Instruct them to read each list 3 times, cover it and write the words in the list on a separate sheet of paper in the correct order. When completed, pupils should score their own papers, allowing 1 credit for each correct item.

List A	List B	List C
Zod	table	ecology
Gid	vegetable	deals
Nur	short	with
Deh	before	living
Hif	write	things
Kep	school	and
Joz	mother	their
Zub	time	relations
Kol	walk	to
Woj	morning	environment

Since the items in list A are all nonsense syllables, scores will be poorest here. The letter combinations in list B are all familiar words. Scores will be better here, but many points will be deducted because of improper order. The third list, being a sentence, has something to tie the words in order, and scores will be highest here. This should emphasize the importance of being sure pupils really understand material presented in class before being asked to study.

(b) As a variation of the above, and to emphasize the same facts, try the following. On the blackboard list the words in the following two columns. Cover the list so the pupils cannot see them.

Column A	Column B
no	leaped
in	in
mistake	the
water	pool
what	on
there	a
leaped	dare
pool	what
a	a
the	mistake
a	no
dare	water
on	there

Uncover the words of column A and direct pupils to memorize the list of words in correct order. Have pupils raise their hands when they have memorized the list and record the time.

After this has progressed for 5 minutes, or until all have memorized the list, whichever is less, uncover the words in column B. Direct the pupils to memorize the words in this list which of course are the same words but in an order that makes sense. Memorization will take place in much less time, since column B makes sense and column A is meaningless.

A-8. Uniqueness of the Individual

Each individual human is different from every other human because each has a different combination of experiences. This causes each of us to have different reactions to the same situation.

Read the following list of words to the members of the class, or have the list duplicated. Ask each pupil to write after the word the first word that comes to his mind. It is unlikely that two pupils will have the same list of response words.

table	country	family	school
religion	books	snake	mirror
hat	house	desk	shade
dog	shoe	lemon	diamonds

A-9. Simple Reflexes in Humans

Pupils can work in pairs to demonstrate many simple reflexes that occur in humans. It should be noted that in each case there is a stimulus and a specific response. Pupils should keep records.

(a) Iris Reflex. Have one member of the pair keep his eyes closed for 1 minute with his hand over them. At the end of this time, he should look at his partner, opening his eyes. It will be noted that the pupils, considerably dilated as a result of the time spent in darkness, will quite suddenly contract, as the iris expands in response to the stimulus of light.

(b) Patellar Reflex. Have one member of the pair sit with crossed legs so that one leg swings freely. The other partner should strike smartly just below the kneecap with the edge of the hand. If the stimulus is applied at the proper place, the leg will invariably swing outward.

(c) Sneeze Reflex. With a hair or a piece of thread, tickle the inside of a nostril. Teacher should demonstrate.

(d) Blinking Reflex. Have one pupil hold a piece of clear plastic in front of his face. Have the other student throw a loosely wadded ball of paper at him, aiming at the eye. Blinking will invariably result, even though the student knows that he is protected by the piece of clear plastic.

It should be noted that the blinking that one does normally when at rest is also a reflex, the stimulus for which is the sensation of dryness that results from the evaporation of the tear fluid covering the eyeball.

As a result of this series of demonstrations, it should be evident to pupils that reflexes are involuntary, rapid, and often protective in nature.

A-10. The Nature of a Habit Response

After long practice, habit responses tend to become unconscious and uncontrolled. As a result of long and constant repitition they have become automatic. This can be demonstrated with a simple exercise.

Dictate the following passage rapidly after instructing pupils not to dot the i's or cross the t's.

"Terrible Tabby is a tiny kitten. Indians often trapped rabbits. The thirteenth fairy was wicked. The little letters on the sign in the window were painted pink. The third tree to the right is a fir. The rain drifted earthward from the trees. The noises of the night filled the air. Time and tide wait for no man."

The habit of dotting i's and crossing t's is so deeply ingrained that most pupils will be unable to control it.

A-11. Anatomy of the Human Eye

Using a dissectable eye model (available from biological supply houses) show pupils the structure of the eye such as the cornea, iris, crystalline lens, scleroid and choroid coats as well as the retina. Point out that the iris actually has a hole in it (the pupil). Discuss the aqueous and vitreous humor fluids, and the origin of the ciliary body of the aqueous humor. Tell about glaucoma of the eye. Trace the path of light rays through the lens to show how the image becomes inverted before it falls on the retina.

A-12. The Eye and Common Defects

There are numerous methods and models for illustrating the normal and abnormal eye. A simple and effective arrangement can be assembled easily. A wire figure or piece of very coarse wire screen is illuminated from behind and used as the object. A convex lens casts its image on a translucent screen. The fact that the distances must be out of proportion to make a suitably large image does not destroy the validity of the demonstration. The object, lens, and screen rest on a board which can be turned toward the class to permit viewing the image, or broadside to show the relative positions of the parts.

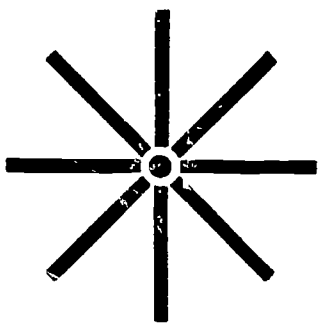
The image is first focused to show the normal eye. The object position is changed to show need for accommodation. With the image initially in focus, the screen is moved away from the lens to show the blurred image resulting from the eye structure typical of nearsightedness. Moving the object nearer the lens restores image clarity, emphasizing the meaning of the term "nearsighted." With the image out of focus, correction is made by adding a diverging lens. It is interesting to borrow glasses from members of the class for this correction, and in the average high school age group a lens can be found to do the trick.

Farsightedness and its correction can be demonstrated by the same general procedure, after moving the "retina" closer to the lens.

Astigmatism is shown by substituting an astigmatic lens for the original spherical convex lens. When suitably oriented, it can be shown to have two focal lengths, one for the vertical wires in the screening, and one horizontal. The effect of rotating the lens at right angles to the first, and the effect of rotating this correcting lens is shown.

A-13. Simple Methods of Detecting Astigmatism

If there is an irregularity of the cornea of the eye, the refraction of light by the cornea will be more diffuse. This condition is known as astigmatism. Draw a chart similar to the one in the diagram and be certain each segment is exactly the same shade of black. If the pupil will rotate the chart in his hand the normal eye sees all the segments in a rather gray shade as the chart is slowly rotated.



A-14. Nearsightedness and Farsightedness

Have the pupils place their books at a comfortable reading distance from their eyes. A distance of 14 to 16 inches is usually considered normal. Call attention to the fact that the eye lens is capable of accommodation (changing shape to maintain focus). Mention the fact that the lens is convex and has the ability to bring light rays to focus.

Ask a nearsighted student to remove his glasses and, after feeling the lenses, report to the class on which part of the lens feels the thickest and which feels thinnest. It will be a concave lens, thinnest at the center. Similarly, have a farsighted

pupil tell the class about the lenses in his glasses; they will be convex and thinnest at the sides.

Explain how a concave lens "spreads out" rays of light that were brought to a focus in front of the retina, whereas a convex lens finishes the bending started by an eye lens that formed an image behind the retina.

A-15. Convex Lens - Description of Image

Procedures for qualitative investigations of the image produced by a lens are described in texts and laboratory manuals. These are easily adapted for either demonstration or individual pupil experiment.

Determination of the focal length is probably best done by forming the image of a distant object, such as a tree branch. Despite its greater distance, use of the sun as an object is not desirable because of the dazzling brilliance of its image, and the distracting smoldering of the screen.

For formation of the images to be studied, a candle flame is suitable as an object. Of course, any of the commercial illuminated objects can be used.

The effect of object distance on image nature and size can be demonstrated by holding a large convex lens so that it magnifies print for the class. The distance is gradually increased with a resulting increase in size of the virtual image, until inversion takes place as the focal point is passed. Continued increase of object distance results in decreasing the size of the real inverted image. Side to side motion of the viewer's head can show, by parallax, the position of the virtual image behind the object, and of the real image, in front of the lens.

A-16. Convex Lens - Size and Distance of Image

A convenient object for a quantitative experiment involving object and image sizes, if not otherwise available, can be made by cutting a rectangular hole 2 or 3 cm. on a side in a card, and mounting the card against an operating, frosted bulb, incandescent lamp. Stretching a piece of thread across this opening, held with cellophane tape, provides a sharp object to assist with focusing. A convex lens is used to cast the image on a screen, and object and image distances and sizes are measured, and their proportionality demonstrated

The measured distance can be used to compute the focal length of the lens, and this figure compared with the focal length measured directly.

A-17. Anatomy of the Human Ear

Plaster or plastic models of the ear are available from

many biological supply houses. It is best to have the dissectable type that will show all the main structures.

One of these models will point out very clearly such parts as the auditory meatus, tympanic membrane, malleus, incus, stapes, eustachian tube, cochlea, organ of corti, and the auditory nerve.

A-18. Function of Semicircular Canals

Seat a person on a revolving stool. Arrange the other members of the class in a ring around the subject. Have the person on the stool close his eyes while he is rotated about 25 times. Then have him open his eyes and walk slowly to the back of the room. Have several pupils ready to catch him in the event he starts to fall.

During the time he was being rotated, the fluid in the horizontal semicircular canal began to circulate inside the canal. This takes a number of rotations because of the inertia of the fluid in the canal and the relative lack of friction between the fluid and the sides of the canal. When the person was no longer being rotated, the fluid continued to circulate in the canal, for the same reasons that made it slow to start. The nerve endings in the canal continue to send the same impulses to the brain that they did during the rotation of the fluid (endolymph) in the canals.

A-19. Taste Areas of the Tongue

The only substances to which the tongue is sensitive are salt, sweet, sour, and bitter. Certain areas of the tongue are sensitive to each. To determine what areas of the tongue are sensitive to which taste, prepare the following solutions:

5 per cent sugar solution (sweet)
2 per cent table salt solution (salt)
1 aspirin dissolved in half-glass of water (bitter)
5 per cent vinegar solution (sour)

Wipe the tongue dry with a clean paper tissue so that saliva will not transfer the substances from place of application to other parts of the tongue.

After dipping a cotton-tipped applicator in the sugar solution touch it to the inside rim of the container to remove any excess solution. Touch it to the tip, middle, and back of the tongue and determine on which areas of the tongue the characteristic sweet taste can be detected. Record the results on an outline drawing of the tongue.

Rinse the mouth, dry the tongue, and repeat using the salt solution and another cotton-tipped applicator.

Using the same method, determine what areas of the tongue are sensitive to bitter and sour. Be sure to rinse the mouth after each solution, dry the tongue, and use a fresh applicator.

A-20. Identification of Food by Taste Alone

Prepare small peeled cubes of raw apple, carrot, onion, potato, celery, and turnip. Other foods may be added.

Pupils should work in pairs in this activity, switching roles when the data has been completed for one pupil. The "taster" should be blindfolded. Have the "taster" hold his nose tightly. Using tweezers place food samples on his tongue, one at a time. Ask him to identify each food by taste alone. Record his responses on a chart. Some foods can be identified by taste alone, but most of these suggested here are usually misidentified.

A-21. Organization of Cells

The organization of cells into tissues, organs, and organ systems to form an organism can be demonstrated very well with a frog. Live frogs are usually available in most localities in the fall and are readily collected on the edges of ponds and swampy places.

(a) The live frog is an independent, functioning organism. Have the pupils observe the activities of a frog in a half inch or so of water in a battery jar. Such things as breathing movements, reactions to touch, and blinking movements can readily be observed.

(b) This makes a good laboratory lesson in the technique of careful observation and recording. Have the pupil record everything he can observe about the structure or behavior of the frog during a 15-minute period. At the end of the observation period a discussion will probably reveal many items missed by some groups that others observed. This experience can be used to good advantage to bring out the necessity of great care and completeness in observation and recording.

(c) After a frog has been in water for a day or so, films of epidermis will be seen in the water. These can be picked out and passed to pupils as examples of tissue. The cells making up a tissue can be seen if a bit of the epithelium is spread out in two or three drops of water on a microscope slide. Cover with a cover slip and examine under the low and high powers of the microscope. The structure of the cells can be seen better if dilute methylene blue stain is used on the microscope slide instead of water.

A-22. Coordination of Tissues in Organs (demonstration)

An important concept in the study of complex organisms, is that of the coordinated functioning of many different tissues in an organ. This may be illustrated by means of a dissected chicken leg.

Remove the skin from the complete leg (thigh, drumstick, and foot) of a freshly killed chicken. Separate the individual muscles and tendons to the toes by carefully cutting the connective tissue between them. The muscles of the thigh can be removed completely, leaving only the thigh bone.

If the dissection is done carefully, it will be possible to demonstrate that the contraction of individual muscles of the leg moves specific toes by means of tendon connections to bones. The antagonistic action of muscles can be demonstrated by pulling alternately the tendons on the front and back of the foot. The function of connective tissues in holding tendons in place and the lever action of bones can be demonstrated.

Between the muscles of the leg will be found a tough white cord about the thickness of a string. This is the main nerve supplying motor neuron endings to each muscle cell in the leg.

Emphasize through class discussion the role of nerve impulses in producing muscle contraction as well as controlling the function of the digestive and circulatory systems. The point to be illustrated is the coordination of many cells and tissues in producing movement in a given part of the animal body.

A-23. Microscopic Structure of Muscle

(a) Striated Muscle Cells. Pupils can make excellent microscopic preparations of striated muscle cells from the leg muscle of frogs. Freshly killed or preserved material may be used. From a block of muscle about one-fourth inch long remove a shred about the size of a heavy thread. Place this in a drop or two of water on a microscope slide and tease it apart into the smallest possible shreds with two dissecting needles. Add a cover slip and examine under the microscope. The light will have to be greatly reduced in order to see the striations.

To see the nuclei of these cells remove the cover slip and add a few drops of dilute methylene blue stain. Allow the stain a few minutes to penetrate the cells before replacing the cover slip.

Small pieces of beef or other vertebrate muscle can also be used in the same manner to show the similarity of muscle cells. The muscle cubes can be stored indefinitely in 10 per cent formalin.

(b) Smooth Muscle Cells. Bits of muscle tissue from the stomach or intestinal wall of a frog can be handled in the

same way as above to show the structure of smooth muscle cells.

A-24. Energy-supplying Nutrients are Stored in Liver and Muscle Cells

Excess carbohydrates are stored in the liver and muscles of animals in the form of glycogen. The presence of glycogen in liver can be shown in the following way.

Cut about a one-half inch cube of liver into small pieces and grind with sand in a mortar. Add water, place in an evaporating dish and boil for about 20 minutes, adding water if necessary. Note the appearance of opalescence in the liquid. While the solution is still boiling, acidify with two or three drops of acetic acid, then filter. To 5 cc. of the filtrate in a test tube, add 5 to 10 drops of iodine solution and 2 or 3 drops of 10 per cent sodium chloride solution. A reddish, port wine color indicates the presence of glycogen.

(The effect of diet on the glycogen content of the liver can be determined by using livers from laboratory rats that have been overfed, kept on a normal diet, and starved for several days.)

A-25. Control of Breathing

The rate of breathing is controlled by the effect of blood carbon dioxide content on a control center in the medulla of the brain. If the breath is held for some time, the content of carbon dioxide in lung air is increased. By osmotic equilibrium, this increases the amount of blood carbon dioxide.

Count the number of respirations per minute as you are sitting still. Hold the breath as long as possible. Exhale, and immediately count the number of respirations made during the next minute.

The number of respirations during the minute following holding the breath will be greater than it was during the preceding minute.

A-26. Effect of Temperature on Capillary Size (demonstration)

Anesthetize a frog and spread out the web of a hind foot for microscope examination. After examining the capillaries in the web, put a small piece of ice on the foot. Observe again and note any changes in blood flow and/or size of the capillaries.

Remove the ice and after the foot returns to room temperature, drop some water warmed to 100°F. on it. Examine again and compare circulation and capillary size with the conditions you observed at room temperature and when the foot was chilled.

A-27. Heartbeat Rate of Frog (demonstration)

Pith a frog. Put the frog on its back on a wax-lined dissecting tray and pin down the extended legs, inserting the pins at an angle so that the legs will not slip up on the pins. Pick up the abdominal skin at the base of the hindlegs and snip a small opening with scissors. Cut the original incision to the outer base of each hindleg to make two large skin flaps.

Pick up the abdominal muscle at the base of the hindlegs and snip a small opening. A large abdominal vein is just under the body wall. This must not be cut. Cut the abdominal muscle to the lower jaw, keeping the point of the scissors up against the underside of the abdominal muscle so the organs underneath will not be damaged. At the pectoral region it is necessary to cut through bare bone.

Make lateral cuts through the abdominal muscle from the vertical incision to correspond with similar incisions in the skin. Pin back the skin, abdominal muscles, and pectoral region so that the internal organs are exposed.

The heart is surrounded by a membrane called the pericardial sac. Carefully cut this membrane, exposing the three-chambered heart. Notice how the deep red auricles contract, forcing blood into the ventricle. The ventricle then contracts, changing from a dark red color to a pale pink when it contracts to force the blood into the aorta.

This demonstration is invaluable in showing the two-step nature of heart contraction. If the heart and other internal organs are kept moist with Ringer's solution and no major blood vessels have been cut, this demonstration can be kept set up and the heart beating for 5 or 6 hours.

A-28. Effect of Temperature on Frog's Heartbeat Rate (demonstration)

Pith a frog and dissect it to observe the heartbeat as in activity A-27. After you have determined the rate of heartbeat at room temperature, flood the heart with a dropper-full of Ringer's solution heated to 100°F.

Chill some Ringer's solution by putting it in a bottle in a refrigerator or by immersing it in a bottle in some ice water until it is chilled to about 40°F. Compare the heartbeat rate under hot and chilled Ringer's solution with that of the heartbeat at room temperature.

A-29. Animal Coordination by Central Nervous System (demonstration)

The fact that an animal's activities are controlled by the central nervous system can be demonstrated with an earth-

worm. When an earthworm is crawling on a damp surface, cut it swiftly with a sharp razor blade into anterior and posterior halves. The anterior half, containing the central nervous system, will soon regain coordination and continue crawling. The posterior half will writhe but not crawl.

A-30. Structure of the Alveolus

A Florence flask may be used to represent an alveolus if capillaries are drawn on it with a glass-marking pencil. A still more effective model is constructed by gluing string to the outside of the flask. The string may be painted or stained red to represent capillaries.

A-31. Action of Ciliated Epithelium (demonstration)

The action of the cilia in moving material along the surface of the tissue can be demonstrated by using the throat cavity of a frog. Destroy the brain and spinal cord of the frog by pithing. This should be done before the beginning of class.

Cut the jaw at the corners of the mouth with scissors, removing the lower jaw and tongue completely. Pin the frog on its back in a dissecting tray. Drop a few fine particles of cork or sawdust on the dorsal surface of the throat. They will be seen to move slowly as a result of ciliary action. If the preparation is kept moist with a 1 per cent salt solution, ciliary action will continue for several hours.

A-32. Diffusion of Materials into a Cell (demonstration)

The diffusion of materials such as water and digested food into a cell can be demonstrated by means of an artificial cell which is constructed as follows.

Prepare some colorless gelatin and pour it into a cellophane or plastic bag placed in a transparent plastic refrigerator box. As the gelatin begins to harden, whip it a little in the bag to make it frothy. Embed a marble near the center to represent the nucleus. Tie the bag and place the lid on the box.

In order to represent diffusion, add a gram or two of cornstarch to the gelatin while it is being dissolved. After the cell is completed, place the plastic bag and its contents into a beaker containing Lugol's iodine solution.

The diffusion of the dissolved iodine molecules into the cell will be indicated by the appearance of the characteristic black color of iodine and starch inside the plastic bag. The fact that the starch molecules, being in suspension rather than in solution, do not diffuse through the plastic is indicated by the fact that the iodine does not become black in color.

A-33. Diffusion of Gases through Cell Membrane

Prepare an artificial cell as in activity A-32, but use colorless phenolphthalein solution instead of water to prepare the gelatin. (Phenolphthalein turns red in an alkaline medium, such as ammonium hydroxide.)

Remove the plastic bag and its contents from the refrigerator box and suspend it over a beaker in which there is some ammonium hydroxide. The ammonia molecules will soon diffuse through the plastic, turning the gelatin of the artificial cell red. This can be compared to the diffusion of oxygen into a cell.

A variation of this is to put phenolphthalein solution in a test tube, the end of which is covered with uncoated or non-waterproof cellophane. This is inverted over a bottle of ammonium hydroxide. The appearance of ammonia molecules in the test tube will be apparent in a few moments.

A-34. Function of Atmospheric Pressure in Breathing

The fact that it is the atmospheric pressure that forces air into the lungs can be demonstrated using pupils themselves.

Have pupils close their mouths and with the fingers of one hand close their nostrils. Instruct them to expand their chests as they usually do in taking a deep breath. Then tell them to open their mouths suddenly.

The effect is noisy and startling. The atmospheric pressure in the air around the body being greater than the pressure in the lungs causes a sudden inrush of air to satisfy the partial vacuum created by the breathing movements of the chest. This, with the following relaxation of the muscles causing exhalation, constitutes breathing. It is thus possible to make a dead animal having lungs breathe. The problem which science has not yet succeeded in solving is "to restart the respiratory process in the cells, once it has stopped."

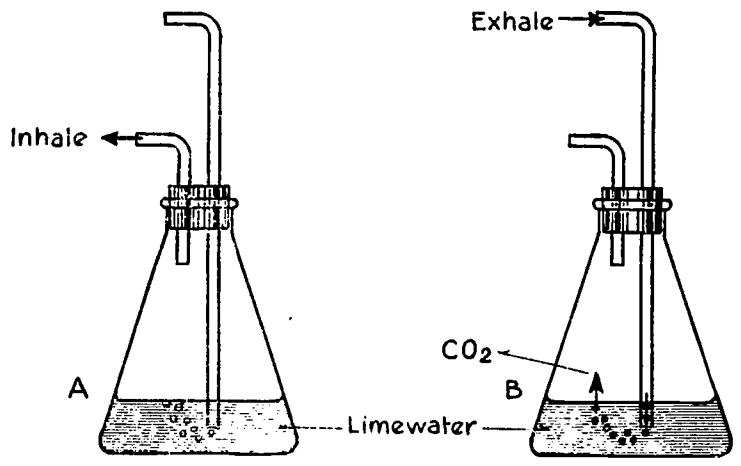
A-35. Carbon Dioxide Given Off by Lungs

Set up the apparatus as shown in the diagram below and put about three-fourths inch of limewater in each flask. (Limewater turns milky in the presence of carbon dioxide.)

Inhale through the lower tube of flask A and exhale through the upper tube of flask B. This will cause the air to go through limewater before entering your lungs and again after leaving them. Continue inhaling and exhaling through the limewater for 1 minute.

The limewater in the flask into which you exhale will quickly become very milky, while that in the other flask will

become only very slightly milky if at all. This is a controlled experiment situation that indicates clearly that the carbon dioxide in exhaled air comes from some body process.



A-36. Vertebrate Heart (demonstration)

Blood is forced through the circulatory systems of vertebrate animals by a heart of two chambers (fish), three chambers (amphibians and reptiles), or four chambers (birds and mammals). Obtain a specimen heart of each class of vertebrate. A butcher shop or super market will be able to supply hearts of fish, birds, and mammals.

Bisect each heart to expose the chambers and valves between chambers. Mount dissected specimens on glass plates in jars of formalin.

A-37. Heart Sounds

Most pupils have never heard heart sounds. Many high school biology laboratories have stethoscopes and they may be purchased from supply houses. However, pupils can fabricate a stethoscope from a small glass funnel, a glass "T" or "Y" tube, and some rubber tubing. Slip a piece of rubber tubing 3 or 4 inches long over the tip of the funnel. Insert the "T" or "Y" tube into the other end of the short piece of rubber tubing and attach longer pieces of tubing to both arms of the "T" or "Y" tube. By placing the funnel firmly against the chest over the heart and the ends of the tubing in the ears, heart sounds can be heard.

The familiar "lubb" and "dupp" sounds that pupils will hear represent the sound of valves closing. The first of the pair, or "lubb," represents the closing of the semilunar valves at the bases of the aorta and pulmonary artery as the ventricle expands to receive blood. The second, or "dupp," represents the closing of the bicuspid and tricuspid valves between the auricles and ventricles as the ventricle contracts. The closing of these valves prevents the backward flow of blood into the auricles and insures that it proceeds out the arteries.

A-38. Locating Valves in Veins

The prominent veins in the forearm are useful in pointing out to pupils the location of valves in veins. Each pupil can do this simple procedure himself.

Let the arm hang at the side and pump the fist open and closed to make the veins stand out. This muscle activity squeezes the veins within the arm, forcing a greater part of the blood in the arm to return to the heart through the superficial veins.

With the arm still at the side and the veins prominent, make a tight fist. Place a finger on a prominent vein near the elbow and with some pressure slide it toward the wrist, holding it near the wrist. This will force the blood out of the vein and prevent the blood from entering in the usual way. The vein will be empty and collapsed from the finger up to the first valve, since blood cannot flow backward down the arm in the vein past the valves. When the pressure of the finger is released, it will be seen that the vein quickly fills from the bottom up.

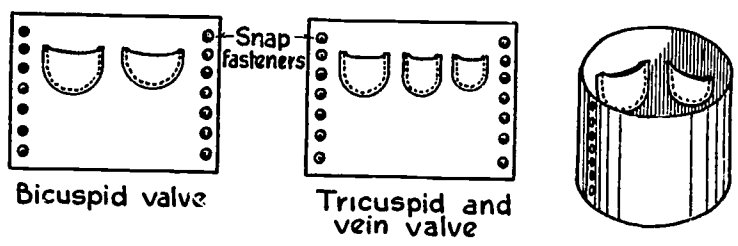
A-39. Model of the Heart and Vein Valves

A simple model to illustrate the structure of the bicuspid and tricuspid valves of the heart as well as the valves found in veins can be made from a piece of transparent plastic such as used for shower curtains.

Sew pockets cut from the same materials as shown in the diagram below. Snap fasteners sewn along the edges enable the plastic to be rolled into a tube.

By forcing a hand and arm through the tube it is simple to demonstrate that a liquid flowing in one direction presses the pockets against the wall, allowing for easy passage. Inserting the hand from the other direction, it can be shown that the pockets bulge into the lumen of the tube, effectively preventing liquid flow.

This apparatus also shows the difference between the bicuspid and tricuspid valves, as well as the nature of valves in veins.



A-40. Effect of Drugs on Heartbeat

The effect of digitalis, adrenalin, and other drugs on heartbeat can be shown using a frog heart.

Expose the beating heart of a pithed frog.

(a) Digitalis. Digitalis is a drug frequently used to strengthen the action of weak heart muscles. With an eye dropper, put several drops of digitalis directly on the heart. If the digitalis is obtained in the form of a tablet, dissolve the tablet in a little water and use several drops of the solution. The action of the heart muscle will gradually become slower and much deeper in both contraction and relaxation.

(b) Adrenalin. Adrenalin is sometimes used to restart heart action that has stopped. Its normal function when released by the adrenal glands is to increase the rate of heartbeat.

Rinse the digitalis off the frog heart by flooding with water. When heart action has returned to normal, add several drops of adrenalin. A sudden increase in the heartbeat rate will be noted.

Point out the relationship between the effects noted and the medical uses of adrenalin. These include the stimulation of weak hearts as well as starting hearts beating again after they have stopped.

A-41. Effect of Adrenalin on Capillaries (demonstration)

The hormone adrenalin causes capillaries in skeletal muscles and connective tissues to enlarge or dilate. At the same time it causes capillaries of the skin and mucous membranes to contract. This contraction is shown very well in the frog.

Anesthetize a frog and spread out the web of a hind foot for microscopic examination. After examining the capillaries in the web, put several drops of a 1:1000 adrenalin solution on it. After allowing several minutes for the adrenalin to penetrate the tissues, examine again and compare capillary size with the original observation.

A-42. Necessity for Digestion

Starch is insoluble in water, whereas sugar is soluble. To show this mix 5 gm. of starch in 100 cc. of water and 5 gm. of dextrose (not sucrose) in another 100 cc. of water, stirring well. Put a small amount of the starch mixture in a test tube with iodine to confirm the fact that it is starch. Confirm the dextrose mixture with Benedict's solution and heat.

Set up two funnels for filtering and filter some of each mixture into separate flasks. Test some of each filtrate for the presence of the original material in the mixture.

The starch filtrate should be negative for starch, since the mixture is a suspension rather than a solution, and will not pass through the filter paper. The sugar, being in solution, should be present in the filtrate in as great a concentration as it was originally.

Most foods, like starch, are insoluble and cannot enter a cell through its membrane any more than they can pass through the filter paper. The chemical process by which foods are changed into soluble materials is digestion.

A-43. Effect of Particle Size on Rate of Digestion (demonstration)

Hard-boil an egg and remove the white. Separate this in two portions, equal by weight. Chop one portion finely and the other in coarse pieces. Place both portions in tubes containing equal parts of 1 per cent pepsin solution and 1 per cent hydrochloric acid (artificial gastric juice). Leave in a warm place overnight. The next day pour the artificial gastric juice off each and dry the remaining egg white on paper towels. Weigh each portion.

The egg white in smaller pieces has a much larger surface area exposed to enzyme activity than that in large chunks. There will be more egg white left in the portion left in large pieces, indicating less digestion than in the portion chopped finely. Relate this information to the advisibility of chewing food thoroughly.

A-44. Digestion of Starch by Saliva (demonstration)

(a) Put 1 gm. of starch in 1,000 cc. of hot water. Heat and stir until an opalescent paste results. Fill two tubes with the paste and hold against the light so that the opalescence can be observed.

Add a few drops of saliva to one tube and an equal quantity of water to the other. Shake both tubes thoroughly. After a few minutes, hold both up to the light. The one with the saliva will shortly become quite clear due to the digestion of the saliva to dextrin and maltose, a reducing sugar.

Add a few drops of iodine to some of the material from each tube. The characteristic black color of iodine and starch will be seen only in the tube lacking the saliva.

Test some of the material from each tube with Benedict's solution. Sugars will be found present only in the tube containing the saliva.

(b) Prepare a little starch suspension in each of two test tubes. Test the contents of one tube for the presence of sugar, using Benedict's solution.

Put about a half-inch of starch suspension in a third test tube and add an equal amount of saliva. This tube and its contents should be held in the hand for 10 minutes to keep it warm and allow the enzyme ptyalin in saliva to decompose the starch to sugar. The sugar in this case is maltose. The tube should be kept in motion while being held in order to insure constant mixing of the saliva and starch suspension.

Divide the saliva and starch mixture into two portions in two test tubes and test one portion for the presence of starch and the other for the presence of sugar.

A sample of saliva should also be tested for the presence of starch and sugar.

It will be expected that the original sample of starch will show the presence of starch and the absence of sugar. The mixture of starch and saliva will still show some starch present at the end of 10 minutes, as well as some sugar. The saliva should be negative for both starch and sugar.

(c) Sprinkle a few grains of starch in a drop of water on a microscope slide. Add a drop or two of Lugol's iodine solution, which will color the starch grains black in the characteristic indication of starch.

Add a bit of saliva to the mixture of starch, water, and iodine on the microscope slide. In a matter of a half hour or so, the grains of starch should lose their color and disappear, as they are changed to sugar and dissolve in the liquid. The presence of the iodine does not seem to interfere with the action of the saliva enzyme.

A-45. Gastric Digestion of Protein (demonstration)

Artificial gastric juice can be made from equal parts of a 1 per cent solution of pepsin and 1 per cent hydrochloric acid. Egg white is a fairly pure source of protein, the nutrient whose digestion is started in the stomach.

Fill a 6-inch length of 2-mm. or 3-mm. glass tubing with raw egg white by drawing it up into the tube with your mouth. Coagulate the egg white in the tube by holding it in a beaker of boiling water. With a file, cut the tube containing the coagulated egg white into four pieces of approximately equal length. Put the tubes in bottles containing the following materials so that both ends of the tubes are covered.

Bottle 1. Equal parts of 1 per cent pepsin solution and 1 per cent hydrochloric acid (artificial gastric juice)

Bottle 2. 1 per cent pepsin solution

Bottle 3. 1 per cent hydrochloric acid

Bottle 4. Water

Stopper all bottles and leave in a warm place overnight. There will be considerable egg white gone from each end of the tube in artificial gastric juice, indicating that the egg white has been changed to some soluble substance. The fact that pepsin functions best in an acid medium will be indicated by a much smaller amount of digestion in the tube in the pepsin alone. The fact that it is the pepsin and not the acid which functions as the enzyme will be indicated by the lack of any digestion in the tube in the acid alone. The tube in the bottle of water serves as an additional control.

A-46. Structure of Villus (demonstration)

(a) Many fine and relatively inexpensive plaster and vinyl models of the villi are available from most biological supply houses.

(b) Paint a network of capillaries on the outside of a test tube and insert a smaller tube inside to represent the structure of a lacteal within a villus.

A-47. The Body's Need for Food (demonstration)

(a) Food as a Fuel. Demonstrate the fact that fat produces heat energy when burned. A piece of cotton or string placed in an evaporating dish with some melted butter or bacon fat will act as a wick and allow the fat to burn. A butter candle can be made by forming a pat of butter around a piece of string for a wick.

(b) Food for Control of Body Activities. Vitamins are the major nutrients involved in insuring proper functioning of the organism. The effect of vitamin C deficiency is the easiest to show in a short time by using young guinea pigs. (Rats, mice, and hamsters cannot be used for this, since they are capable of synthesizing vitamin C in their own tissues.)

Select young guinea pigs about half grown and divide them into groups in separate cages. Feed each a basic diet consisting of:

Rolled oats	35.0 gm.
Wheat bran	30.0 gm.
Dry peas (finely ground)	30.0 gm.
Fresh butter (melted and thoroughly mixed with other ingredients)	4.5 gm.
Salt (sodium chloride)	0.5 gm.

This diet is deficient in vitamin C, although complete in all other nutrients. Feed this same diet to the control group with the addition of orange or tomato juice or fresh whole leaves of cabbage as a source of vitamin C.

The animals should have available a constant supply of clean water, preferably provided by a drinking tube. Remove all uneaten food each day and provide fresh.

Weigh the animals daily and chart the weight of all animals on a single multiple-line graph, using different colors for the experimental and control groups. Keep records of the condition of skin, fur, teeth, and gums. Feel the joints to see if they are inflamed; if they are, the animal will fidget and may squeal when its joints are felt. Signs of scurvy should be pronounced in the experimental animals in 3 weeks.

After the symptoms of scurvy have been well established in the experimental group of animals, add to their diet the same source of vitamin C as used with the control group. Be sure to indicate this on the record charts. In a relatively short time the animals of the experimental groups should be as healthy as the control group.

A-48. Excretion of Water through Skin of Vertebrate

Much water is excreted through the skins of vertebrates. This can be demonstrated with two live frogs and two battery jars or quart jars.

Weigh one of the jars when empty and with one of the frogs in it. Subtraction will determine the weight of the frog. Do the same with the other jar and frog.

Add one inch of water to the jar with the first frog and cover it with screening so that the frog cannot escape. Put the second frog in its jar without water and cover it with screening.

After 24 hours reweigh the frogs by the same method as originally used. Compare these weights with the original weight of the frogs.

The results which you obtain account for the fact that frogs are confined to relatively wet environments.

A-49. Kidneys of Vertebrates

In vertebrates, dissolved wastes are removed from the blood as it streams through the kidneys.

The kidneys in vertebrates are paired, and in the dorsal body wall. In fish they extend almost the entire length of the body cavity on either side of the backbone. They are very

difficult to remove because of their thinness. The kidneys of other vertebrates are more easily removed from the animal.

An attractive display can be prepared by mounting on glass plates in jars of 10 per cent formalin the dissected speciments of the kidneys of fish, amphibians, reptiles, birds, and mammals. Include the major blood vessels that bring blood to the kidneys and those that remove blood. It may be necessary to include some of the surrounding tissues in the case of the fish kidneys.

Pig, beef, lamb, and chicken kidneys may be obtained at the butcher shop. One kidney can be bisected longitudinally and both halves mounted on a single plate to show both internal and external structure.

A pig kidney sectioned longitudinally shows the major regions of the kidney as illustrated in many textbooks.

A-50. Ammonia in Urea (demonstration)

The action of the enzyme urease, which transforms urea into ammonia, can be demonstrated simply. Urea and urease are available from biological supply houses. Dissolve a small amount of urea in water and pour this solution into two beakers. Add a small amount of the indicator phenolphthalein to each beaker. When you add a few crystals of urease to one beaker, pupils will notice an immediate color change to red. This occurs because the solution is changed to alkaline by the ammonia that is formed.

A-51. Cytoplasmic Movement in Cells

The cytoplasm in living, active cells is a dynamic moving material. This movement, called cyclosis, may be observed in Elodea leaf cells.

Mount a leaf from the growing tip of a plant, rightside up, in a drop of warm water on a microscope slide. Add a cover slip. Focus on the upper layer of cells near the midrib and look for movement of chloroplasts. This will require the high power of the microscope.

Movement may be speeded up with a warming light. In reality, the chloroplasts are not moving under their own power, but are being carried along with the movement of the cytoplasm in which they are suspended.