SELECTING AN TOPIC FOR YOUR PROJECT.

In order for your to have a proper project you need to make 3 choices:

1. What **organism** will you use. 2. What **variable** will you test
3. What **interaction** you will measure to show the affect of the variable on the organism.

CHOOSING AN ORGANISM. The following is a suggested list of organisms you may choose for the specialization project, along with some suggestions for finding, cultivating and studying them. You may choose other organisms if you have special access. Since your study will be mainly done Nov-Jan. you must pick an organism that can be available during this time or cultive it indoors earlier. No vertebrates (except for some field observations) or pets are permitted. Use of cell or tissues (especially human) will only be allowed if you have access and supervision at a professional lab. No surveys of opinion are permitted and psychological studies of humans must have pre-approval.

A. BACTERIA. Bacteria are virtually everywhere. You may grow colonies of bacterial on sterile agar or in broth, or you may buy pure cultures from supply houses. Your teacher may be able to provide you with samples of some common bacteria types. You must become acquainted with techniques of sterilization, innoculation and incubation while doing your background report. No disease-causing bacteria or bacteria taken from nature may be used without professional supervision. This includes any bacteria taken from the human body. There are many harmless forms that can be identified by colony shape and color or chemical activity. Bacteria species are adapted to a wide variety of habitats and feed on virtually any organic substance. The school project room has an autoclave, incubator, petri dishes and innoculating loops.

B. FUNGI. Molds may also be cultivated from spores in the air or on surfaces, and grown on culture media. Your teacher also has some pure cultures that you may use. Common types are black bread molds (*Rhizopus*), blue-green molds (*Penicillium*) and orange bread molds (*Neurospora*). Water molds grow as a white fuzz on organic material submerged in water. Molds are noted for causing decay and often release antibiotics which kill some bacterial. Slime molds are unusual organisms that grow on logs in the forest, or purchased from supply companies. They are usually cultivated on oatmeal agar, but can sometimes be difficult to grow. They have a complex and unusual life cycle.

Commercial mushrooms may be grown if you purchase a kit and set up proper conditions. Wild mushrooms and toadstools are impossible to cultivate, but can be studied in the field in good weather. Some are very poisonous and should never be eaten. Extracts from them, if carefully handled, can be tested on other organisms.

Yeast are single-celled fungi that grow in any sugary media and produce alcohol and carbon dioxide waste. They reproduce rapidly by budding and are useful in studies of population growth and reaction to materials in their environment.

C. ALGAE. Algae are small photosynthetic orgnisms that are usually aquatic. Blue-green Algae (Actually cyano-bacteria) are very primitive. They have no cell nucleus; *Oscillatoria* is a common variety. Green algae have nuclei and can be unicellular, colonial or filamentous. Spirogyra is the best known genus. *Chlorella* may grow on tree trunks in humid areas. Diatoms are unicellular and shaped like needles, filaments or rods; they may glide across surfaces. Algae may be collected from ponds or streams and grown in aquaria exposed to sunlight. Algae should be collected from nature before it gets too cold. Pure cultures may be purchased from supply companies.

D. MOSSES & FERNS: These plants have complex life cycles and are easily transplanted from the woods or field but must be kept in moist environments. They grow very slowly and so growth-related experiments may be time-consuming. Both reproduce by spores at one state of their life cycle. Moss may persist in cold weather under snow cover and can be transplanted even in mid-winter. Ferns in particular may contain chemicals that have insect killing or repellant activity.

E. HOUSE AND GARDEN PLANTS: These may be grown indoors from seeds or cuttings or rescued from local flower gardens before the frost kills them. They may be grown in sand, soil or in water with proper minerals (hydroponics). Some, like sensitive plants and Venus fly traps have mobile leaves. Plants can be used for studies of photosynthesis, food production, tropisms, mineral requirements, effect of growth hormones, reaction to various chemicals and other environmental conditions. Changes in roots, stems, leaves or flowers can be noted. Cacti are interesting, but grow slowly. Bean plants are often over-used and are a joke at science fairs--"Here comes another bean-pot experiment." MANY GARDEN AND VAREITY STORES DO NOT SELL GARDEN PLANTS OR SEEDS IN WINTER. GET THEM NOW BEFGORE THEY ARE DISPOSED OF BY THE STORES. Mustard plants may be easily grown from seeds purchased in supermarket spice counters. The school greenhouse may be available for some of your experiments with plants, but you may also work at home.

F. WILDFLOWERS AND TREES. Most of these die or become dormant in winter, but some may be transplanted to terraria and studied under controlled conditions. Sometimes these are good fro studies of competition (weeds vs. flowers), or adaptation to extremes of physical environment. Many wild plants contain chemicals that may have anti-bacterial or insecticidal action or even inhibit the growth of other plants. If you want to extract these chemicals you should freeze or dry your plants before they are killed by winter. Trees are often too large for controlled experiments, but can be studied for their pattern of distribution relative to landscape, soil, slopes of hills etc. Additionally, bark and dried leaves may contain biologically active chemicals that can be tested on other plants or animals.

G. WATER PLANTS: Pet stores sell a variety of aquatic plants and some can be collected from ponds. They grow rapaidly and are often easy to maintain. One wild variety, duckweed, is a small plant with leaves that float on top of the water. It reproduces by budding. Aquatic plants are good for studies of gas production and utilization, as well as sources for cell studies. Techniques for studying gas production can be obtained from your teacher.

H. PROTOZOA: Protozoa are unicellular animal-like protists. Protozoa may be collected in ponds, stream, soil or cultivated from hay infusions. If pure cultures are desired they can be purchased from supply companies. You should investigate the physical conditions needed to cultivate them before obtaining the organisms. Many cultures will die off if not regularly transferred to new media. Common types are *Ameba, Paramecium, Euglena, Vorticella.* Hay infusion cultures will change rapidly as physical conditions change with new species replacing those that disappear. Many are known to react to light, gravity, temperature or chemicals in their environment. Their populations can be studied by sampling techniques.

I. HYDRA. Hydra is a Cnidarian that feeds using stinging tentacles. Its food is small water crustaceans and large protozoa. They can be found in pond water and easily transferred to new containers. Microscopes are needed for close observation. Collection must take place before cold water begins, but they can be purchased from supply companies.

J. WORMS. Nematodes are small roundworms that are very abundant in soil, but are very small and difficult to identify due to the plain external appearance. Vinegar eeels may be cultivated by putting a small amount of soil into vinegar and are very hardy. Many worms are parasitic and difficult and sometimes dangerous to study.

Flatworms (Platyhelminthes) are mostly parasitic, but a free-living form is planaria. It can be purchased or obtained (in warm weather) in ponds using raw meat on a string as pait. They feed on raw liver and survive well if their container is kept clean of excess food. They have remarkable powers of regeneration if cut apart.

Segmented Worms (Annelids) (Earthworms mostly) can be purchased at a bait store or collected from soil. They can be kept in containers of proper media, but must be kept cool and must have access to air pockets in the soil. They have complex internal organs and some powers of regeration. Their skin is very thin and will absorb many substances applied to the skin. Tubiflex is a small fresh-water segmented worm that forms tubes in mud at the bottom of ponds. They can be purchased in pet stores and are easy to maintain as they tolerate polluted conditions.

K. BRINE SHRIMP: (*Artemia*) ("Sea Monkeys"). These can be grown from eggs in salt water. Some magnification is needed for easy study.

L. SOW BUGS (PILL BUGS, ROLLY-POLLEYS ETC.): These terrestrial crustaceans can survive in jars or terraria if conditions are kept constantly moist (keep a lid on the container). They eat paper towels as well as other organic food. They move fairly rapidly at times and can be used from some stimulus-response studies and do reproduce rapidly by laying eggs. It is necessary to change paper frequently to remove their wastes. There are about 3 local species that can be distinguished by anatomy, but must be collected before winter. They live under bark chips, rocks, logs and damp ground vegetation.

M. CRAYFISH. These are fresh-water crustaceans that are common in any small stream. They can be kept in well-aerated aquaria. They are territorial and may fight if crowded. Females maintain eggs on their abdomens and may carry their young for a time. Frequent cleaning of their container is vital to maintaining crayfish.

N. WATERFLEAS. (Daphnia or Cyclops). These small aquatic crustaeans are found in fresh water ponds and can be collected for purchased. They feed on algae, bacteria and small protozoa. Media formulas are available. Under a microscope their heartbeat can be observed.

O. INSECTS. These are the most abundant arthropods, but many die or go dormant in winter months. Mealworms are larval grain beetles that can be purchased in pet stores and kept in oatmeal with an occasional piece of apploe for moisture. They have complete metamorphosis. Ant colonies may be purchased, but ants won't be shipped during the winter. These colonies do not have queens and may often die out after a time. Crickets may be kept in escape-proof containers, but males will fight to the death if kept together. They can be obtained from pet stores and bait shops, but often these do not live long. Fruit flies may be grown and bred in culture media in small jars. They come in a number of mutant forms and are easy to use for genetic and behavior studies. Any biting or stinging insect should be avoided. Other insects may be approved if available during the period of your study.

P. SPIDERS: Spiders may be maintained in wooden boxes with glass fronts to ease web-making observations. Black interiors also make their webs more visible. High humidity must be maintained, especially in the winter. All spiders are somewhat poisonous and bites may be swolen. Avoid the two deadly species--black widow and brown recluse.

Q. CENTIPEDES AND MILLIPEDES: These may be maintained in terraria. Centipides are carnivorous, millipedes gegetarians. Centipedes move rapidly and escape precautions should be maintained. Moist environments are essential for cultivation.

R. SNAILS AND SLUGS: These mollusks can be found in ponds or moist areas and are easy to maintain in aquaria and terraria. Pond snails eat algae from the sides of fish tanks using rasping "jaws." They lay small eggs and snail embryology can be observed microscopically. Slugs can be collected and maintained in small plantic containers that are kept cool and moist.

S. MARINE ORGANISMS. These are salt-water creatures and require a salt-water aquarium. This is more difficult to maintain than fresh-water aquaria and can be expensive. You may use them if you can for a variety of salt-water invertebrate studies.

SELECTING A VARIABLE

The variable is the factor being tested on the organism. It is important that your experiment contains one and only one variable unless you have multiple experimental groups. The control group is not subject to the variable. You need to select one variable that your background research or previous knowledge leads you to believe will have some effect on your organism. **DO NOT PICK A VARIABLE AT RANDOM.** The following are some of the variables you may select:

A. LIGHT VARIATION: Almost all organisms are affected to some degree by available light. Green plants require light of particular wavelengths (colors) to produce their food by photosynthesis. Phototaxis, is an adaptive behavior pattern in which animals move in response to light stimuli. Some plants will grow towards a light source or react to changes in light intensity, duration and wavelength. Some of these effects are so well-known that they are trite and should be avoided. Plants in the dark WILL die. Both plants and animals may change their chemical activity or behavior when day and night time periods are altered (circadian rhythms).

B. INTERACTION BETWEEN SPECIES: All organisms interact with other species. In some cases, it is as simple as preditor vs prey. Other relationships are symbiotic and involve cooperation between species. Less obvious, but important, is competition for limited natural resources. Weeds, for instance, may outcompete garden plants for growing space and soil nutrients. Some organisms also release toxins that kill other species trying to grow in their space.

C. DISTRIBUTION: All species have ideal habitats that they prefer. Field studies can determine the distribution and habitats of a variety of species. The physical characteristics of environments can be compared to the types of species found there. Maps can be made of the distribution of wild plants. In a forest, there may be vertical variation in habitats. In a pond, physical conditions change with depth. Field studies can, however, be difficult in cold weather. Field studies, though, may only involve a comparison of areas and may not have to be a controlled experiment.

D. POPULATION: Interesting studies can be done concerning the increase of decrease in populations of a species in various environments. Changes can be recorded on a graph as a "growth curve." Background information on population studies can be obtained from Ecology books.

E. INTELLIGENCE AND LEARNING: Animals of almost any variety can be tested for learning ability. Simple mazes (T-shaped for simple organisms) that involve rewards of food or preferred environment can be used. In any maze-running experiment a large number of trials are needed to determine learning. Experiments in memory retention and the ability of organisms to solve simple problems can also be done. The strength of organisms can also be measured by simple experiments involving pulling or lifting small weights.

F. PRECEPTION: All animals and even some plants and microbes detect signals from the environment through their senses. Most common are through the senses of sight, hearing, smell, taste and touch. Each species is adapted to be most sensitive to those stimuli that meet their greatest needs or present danger. Studies can be conducted to determine which stimuli animals can detect and the degree of sensitivity of these animals. Plant movement in response to stimuli are called tropisms; similar actions of animals are called taxis. Avoid obvious or absurd interactions (Nearly everyone knows plants grow towards sunlight and playing music to or talking to plants probably does not affect their growth.) The ability of animals to navigate under unusual conditions may also be interesting. (Ants follow trails for formic acid back to their nests).

Some organisms have the ability to sense stimuli beyond the normal range of humans. Examples would be ultraviolet light (some insects), magnetic fields (some bacteria and migratory birds), electric fields (electric eels, perhaps worms and some plants). Mild electric currents can cause muscle contraction or reaction in animals. Balance is another sense known in humans and which is certainly present in many organisms.

G. RADIATION: Radiation can affect the health of organisms and can cause mutations. Sources of radiation are, of course, difficult to obtain. X-rays can be used if you have contacts with a dentist or X-ray technician that can help you. Avoid deadly exposure levels and do not handle radioactive materials without professional help. Weak ultraviolet radiation can be obtained from "black" or "party" lights. Microwave ovens generate radiation that heats water molecules, but boiled organisms are well known to usually just die. Microwaves should be used sparingly.

H. CHEMICALS: Over-the counter medication or household chemicals may be used on organisms as long as cruelty or rapid death is not the goal. Remember that small organisms require proportionally small amounts of drugs to achieve an equivalent dose that a human might utilize. Prescription drugs, alcohol or tobacco may only be used with written permission of your parents. Under no circumstances should illegal drugs be used in any study. Many plants contain active chemicals in the leaves, stems or roots. Dried plants or water extracts of plants can be tested for anti-bacterial, insecticidal or herbicidal activity. Acids and bases vary in their pH levels and can be used as a variable. The affect of acid rain on plants has been overdone. Avoid this or come up with a new variation. Heavy metals (like Mercury or Arsenic) may be toxic. Avoid these or use under careful supervision. Antiseptics and anti-bacterial chemicals are known to kill household and common bacteria. Salt tends to dehydrate organisms but in smaller amounts is a known mineral requirement.

I. FOOD: It is obvious that if you underfeed an organism it will become unhealthy; if you overfeed it may become fat. Such experiments should be avoided. You can, however, vary the diet of animals in more subtle ways with additives or delections. Interesting work may also involve food preferences of animals. Plants, of course, make their own food. Adding large biochemical molecules to soil of plants is unwise (they probably won't absorb it and it will probably rot and kill the roots and stick up your house). Plants do require specific minerals from the soil, carbon dioxide in the air and produce sugar and/or starch as a food product.

J. TEMPERATURE: All organisms have an ideal temperature range in which they function well. Variation of the temperature can be used, within reason, as a variable. Bacteria and molds are very tolerant of temperature changes and may become dormant when conditions are not ideal.

K. SOIL TYPE: Plants vary in which types of soil they find ideal. Soils may be compact or loose in composition (clay to loam to sandy) and may vary in mineral and organic content. Soil pH is also critical to some plants.

INTERACTIONS (THINGS YOU CAN MEASURE)

In any study you conduct, it is important to collect numerical data and use charts, graphs, tables and maps to display shuch data. Subjective evaluation should be avoided except in special cases. **All measurements must be in the metric system.**

A. GROWTH: Growth may be measured by periodic weighing or the organism. The growth is the difference between initial weight and final weight. Growth in plants can also involve measuring height, stem diameter, number of leaves etc. At the end of a plant or invertebrate experiment biomass can be determined by drying the organism in an oven to remove water and thus measuring only biochemical mass. Organisms can also be heated in a crucible to very high temperature to measure only mineral content.

Animal growth can be determined by environmental conditions, levels of strss, amount and quality of food, and growth hormones. Plant growth is influenced by light levels and type, nutrients, carbon dioxide, temperature and growing space. Plants also produce and react to specific growth hormones. (gibrellins and auxins). Plant growth can be modified by pruning especially removal of terminal or axial buds.

B. MOVEMENT: In response to stimuli animals may move towards or away from the stimulus and may increase the rate of their movement. Levels of movement can also vary with the time of day. This can be measured by timing how long an organism takes to move a specified distance (ex. 8 cm/min). Movemeent can be sampled if you can't observe it constantly. Mechanical and electronic counting devices may be used, as well as video cameras.

Plants move slowly in response to light, gravity, watr and even touch. Measuring angles of growth, particularly of stems, roots and leaves can be done.

C. POPULATION: Many factors can increase and decrease the reproductive and death rates of grops of organisms. You may count them directly or measure population by sampling part of their environment. (How many paramecia in a field of view under a microscope). Bacteria cells are difficult to count, but colonies that grow from a single bacterium are easily counted.

D. MORTALITY: Mortality is the death rate of an organism subject to some negative factor. For Bacteria failure of colonies to grow is a reflection of death of the original cell. Kill zones may be measured on petri dishes around wells containing various chemicals. Foods like milk, fruit and vegetables may rot or spoil at different rates, depending on conditions.

E. ASSOCIATION: Some animals avoid contact with members of their own species; others seek it out. This can be determined by measuring local densities of individuals (Ex: Are Earthworms equally distributed in soil or are they often found close together? Do species of plants tend to form clusters in the forest?)