NORTH HARRISON HIGH SCHOOL

SCIENCE RESEARCH GUIDE

North Harrison High School
1070 Highway 64 NW
Ramsey, IN 47166

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"The Ultimate Hands-on Experience"

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Introduction

Science is the study of the world around us. Through science, we discover how things work, and how to modify things around us. The work that is done through science must be made known to all. This is done by means of the science research presentation. Described in this booklet, you will find all you need to know in order to develop a proper science research report and project. By following the material outlined here, you should be well on your way to producing a top quality product and to learning how science is done.

Scientific Method

Scientists have a set procedure for finding out how the world works. It is called The Scientific Method. All scientists follow this method in their work. Since most of you have previously been exposed to scientific method, it is presented here as a short outline. The individual steps will be expanded on in future sections of this booklet.

A. Choose problem
1. Ask questions about problem
2. Do some general research

B. Form hypothesis (educated guess)
1. Do more detailed research
2. Plan experiment(s)

C. Experimentation
1. Set up control for comparison
2. Make complete lists of procedures and materials

D. Data Collection
1. Take careful notes and photographs
2. Set up graphs, charts & tables

E. Repeat Experiment (steps C and D)

F. Data Interpretation
1. Summarize results
2. Draw conclusions
3. Analyze

G. Prepare report, project and presentation

I. Experimental Project Design

A. Controlled experiments

By far, the most worthwhile and usable experiments are controlled experiments. These are experiments set up in duplicate in order to have a valid basis for comparing changes. In the controlled experiment, two setups are put together. (More, if more than one characteristic is being tested.) One setup -the control group- is not changed in any way from the regular, natural conditions. Any other setups -experimental groups - differ from the control in **only one** condition. For example, if I wish to find out which color of light provides the best growth conditions for a plant, I would have several setups. Each would have the same conditions, except for the color of light. I would have to use the same size and variety of plant, the same size pot, same soil type and amount, same water amount and frequency, same fertilization schedule, and same amount of light. My only change could be a regular white light for the control, and red, green, blue, etc., lights for the experimental group. There are some types of experiments in which a control is not possible. The important thing to remember with these is that you **can only test one condition, or variable, at a time**.

B. <u>Special Problems</u> (from *Intel International Science and Engineering Fair International Rules & Guidelines 2014* by Society for Science & the Public)

All forms referenced here may be found at http://www.societyforscience.org/document.doc?id=396

There are four broad categories of study that may cause some problems in a science research program. At the very least, International and Marian rules require that more care and paperwork be involved in these areas. While we are not trying to keep you from working in these areas, we do want to let you know that projects of these types do require more work and supervision.

1. Human Participants

<u>The effects of alcohol or any controlled or prescription substances on humans is not allowed.</u>

Student researchers must follow federal guidelines (Code of Federal Regulations 45 CFR 46) to protect the human research participant and the student researcher. When students conduct research with humans, the rights and welfare of the participants must be protected. Most human participant studies require preapproval from an Institutional Review Board (IRB) and informed consent/assent from the research participant.

Exempt Studies

(Do Not Require IRB Preapproval or Human Participants Paperwork)

Some studies involving humans are exempt from IRB pre-approval or additional human participant forms. Exempt projects for the Intel ISEF and affiliated fairs are:

- Student-designed Invention, Prototype, Computer Applications or Engineering/Design Project in which the student is the only person testing the invention, prototype or computer application and the testing does not pose a health or safety hazard. It is recommended that a Risk Assessment Form (3) be completed. The use of human participants (other than the student researcher him/herself) for this testing requires IRB review and approval. The Expedited Review process may be used for projects that involve human subjects to test a student designed intervention or prototype.
- Data/record review studies (e.g., baseball statistics, crime statistics) in which the data are taken from preexisting data sets that are publicly available and/or published and do not involve any interaction with humans or the collection of any data from a human participant for the purpose of the student's research project.
- Behavioral observations of unrestricted, public settings (e.g., shopping mall, public park) in which all of the following apply:
  a. the researcher has no interaction with the individuals being observed;
  b. the researcher does not manipulate the environment in any way, and
  c. the researcher does not record any personally identifiable data.
- Projects in which the student receives pre-existing/retrospective data in a de-identified/anonymous format which complies with both of the following conditions:
  a. the professional providing the data certifies in writing that the data have been appropriately de-identified before being given to the student researcher and are in compliance with all privacy and HIPAA laws, and
  b. the affiliated fair SRC ensures that the data were appropriately de-identified by review of the written documentation provided by the supervising adult(s).

Rules

1) The use of human participants in science projects is allowable under the conditions and rules in the following sections. Based upon the Code of Federal Regulations (45 CFR 46), the definition of a human participant is a living individual about whom an investigator conducting research obtains (1) data or samples through intervention or interaction with individual(s), and/or (2) identifiable private information. **These projects require IRB review and preapproval, and may also require documentation of written informed consent/assent/parental permission.** Examples of studies that are considered "human participant research" requiring IRB preapproval include:
   - Participants in physical activities (e.g., physical exertion, ingestion of any substance, any medical procedure)
   - Psychological, educational and opinion studies (e.g., surveys, questionnaires, tests)
   - Studies in which the researcher is the subject of the research (Expedited Review may be used.)
   - Behavioral observations that

a) involve any interaction with the observed individual(s) or where the researcher has modified the environment (e.g., posts a sign, places an object).

b) occur in non-public or restricted access settings (e.g., day care setting, doctor's office)

c) involve the recording of personally identifiable information

2) Student researchers must complete ALL elements of the Human Participants portion of the Research Plan Instructions and evaluate and minimize the physical, psychological and privacy risks to their human participants. See Risk Assessment below and the Risk Assessment Guide for additional guidance.

3) The research study should be in compliance with all privacy laws (e.g., Family Educational Rights and Privacy Act (FERPA) and Health Insurance Portability and Accountability Act (HIPAA)) laws when they apply to the project (e.g. the project involves medical information).

4) All research projects involving human participants, including any revisions, must be reviewed and approved by an Institutional Review Board (IRB) before the student may begin recruiting and/or interacting with human participants. The IRB must assess the risk and document its determination of risk on Form 4. After initial IRB approval, a student with any proposed changes in the Research Plan must repeat the approval process and regain approval before laboratory experimentation/data collection resumes.

5) Research conducted by a pre-college student at a Regulated Research Institution (e.g., university, college, medical center, government lab, correctional institution) must be reviewed and approved by that institution's IRB. A copy of the IRB approval for the entire project (which must include the research procedures/measures the student is using) and/or an official letter from the IRB attesting to approval is required. A letter from the mentor is not sufficient documentation of IRB review and approval.

6) Research participants must voluntarily give informed consent/assent (in some cases with parental permission) before participating in the study. Adult research participants may give their own consent. Research participants under 18 years of age and/or individuals not able to give consent (e.g. developmentally disabled individuals) give their assent, with the parent/guardian providing permission. The IRB will determine whether the consent/assent/parental permission may be verbal or must be written depending on the level of risk and the type of study, and will determine if a Qualified Scientist is required to oversee the project. See Risk Assessment below and the Risk Assessment Guide for further explanation of informed consent.

- Informed consent requires that the researcher provides complete information to the participant (and where applicable, parents or guardians) about the risks and benefits associated with participation in the research study, which then allows the participants and parents or guardians to make an informed decision about whether or not to participate.
- Participants must be informed that their participation is voluntary (i.e., they may participate or decline to participate, with no adverse consequences of nonparticipation or aborted participation) and that they are free to stop participating at any time.
- Informed consent may not involve coercion and is an on-going process, not a single event that ends with a signature.
- When written parental permission is required and the study includes a survey, the survey must be attached to the consent form.
- The student researcher may request that the IRB waive the requirement for written informed consent/parental permission in his/her research plan if the project meets specific requirements. See section on IRB waivers for more information about situations in which written parental permission and/or written informed consent can be waived by the IRB.

7) A student may observe and collect data for analysis of medical procedures and medication administration only under the direct supervision of a medical professional. This medical professional must be named in the research protocol approved by the IRB. Students are prohibited from administering medication and/or performing invasive medical procedures on human participants. The IRB must also confirm that the student is not violating the medical practice act of the state or country in which he/she is conducting the research.

8) Student researchers may NOT publish or display information in a report that identifies the human participants directly or through identifiers linked to the participants (including photographs) without the written consent of the participant(s) (Public Health Service Act, 42, USC 241 (d)).

9) All published instruments that are not in the public domain must be administered, scored and interpreted by a Qualified Scientist as required by the instrument publisher. Any and all use and distribution of the test must be in accordance with the publisher's requirements, including procurement of legal copies of the instrument.

10) Studies that involve the collection of data via use of the internet (e.g., email, web-based surveys) are allowed, but researchers should be aware that they can pose challenges in a) collecting anonymous data, b) obtaining informed

consent and c) ensuring that participants are of the appropriate age to give informed consent. See the Risk Assessment Guide and the Online Survey Consent Procedures.

11) After experimentation and before Intel ISEF competition, the Intel ISEF SRC reviews and approves previously-approved projects to ensure that students followed the approved Research Plan and all of the Intel ISEF rules.

12) The following forms are required:
   a. Checklist for Adult Sponsor (1), Student Checklist (1A), Research Plan, and Approval Form (1B)
   b. Human Participants Form (4) with applicable consents and survey(s)
   c. Regulated Research Institution Form (1C), when applicable
   d. Qualified Scientist Form (2), when applicable

IRB Waiver of Written Informed Consent

The IRB may waive the requirement for documentation of written informed consent/assent/parental permission if the research involves only minimal risk and anonymous data collection and if it is one of the following:

a) Research involving normal educational practices

b) Research on individual or group behavior or characteristics of individuals where the researcher does not manipulate the participants' behavior and the study does not involve more than minimal risk.

c) Surveys, questionnaires, or activities that are determined by the IRB to involve perception, cognition, or game theory and do NOT involve gathering personal information, invasion of privacy or potential for emotional distress.

d) Studies involving physical activity where the IRB determines that no more than minimal risk exists and where the probability and magnitude of harm or discomfort anticipated in the research are not greater than those ordinarily encountered in DAILY LIFE or during performance of routine physical activities.

If there is any uncertainty regarding the appropriateness of waiving written informed consent/assent/parental permission, it is strongly recommended that documentation of written informed consent/assent/parental permission be obtained.

Human Participant Involvement in Student-designed Invention, Prototype, Computer Application & Engineering/Design Projects

Student-designed invention, prototype, computer application and engineering/design projects that involve testing of the invention by any human participant require attention to the potential risks to the individual(s) testing or trying out the invention/prototype. To be considered for Exempt Status or Expedited Review, the data collected/feedback received must be a direct reference to the invention/prototype (i.e., personal data cannot be collected) and the testing may not pose a health or safety risk.

- Exempt Status can be used when the student researcher is the only person testing the invention/prototype. It is recommended that a Risk Assessment Form (3) be completed.
- Expedited Review can be used if the project includes participants other than the student researcher.
- Full IRB Review is necessary if the activities involved in testing of the invention or prototype are more than minimal risk and/or involve collection of personal information from participants.

Human Participant Risk Assessment

Projects involving no more than minimal risk and those with more than minimal risk are allowed under the following guidelines.

No more than minimal risk exists when the probability and magnitude of harm or discomfort anticipated in the research are not greater (in and of themselves) than those ordinarily encountered in everyday life or during performance of routine physical or psychological examinations or tests.

More than minimal risk exists when the possibility of physical or psychological harm or harm related to breach of confidentiality or invasion of privacy is greater than what is typically encountered in everyday life. Most of these studies require documented informed consent or minor assent with the permission of parent or guardian (as applicable).

1) Examples of Greater than Minimal Physical Risk
   a. Exercise other than ordinarily encountered in everyday life
   b. Ingestion, tasting, smelling, or application of a substance. However, ingestion or tasting projects that involve commonly available food or drink will be evaluated by the IRB which determines risk level based upon the nature of the study and local norms.
   c. Exposure to any potentially hazardous material.

2) Examples of Greater than Minimal Psychological Risk

   A research activity (e.g. survey, questionnaire, viewing of stimuli) or experimental condition that could potentially result in emotional stress. Some examples include: answering questions related to personal experiences such as sexual or physical abuse, divorce, depression, anxiety; answering questions that could result in feelings of depression, anxiety, or low self esteem; or viewing violent or distressing video images.

3) Privacy Concerns

The student researcher and IRB must consider whether an activity could potentially result in negative consequences for the participant due to invasion of privacy or breach of confidentiality. Protecting confidentiality requires measures to ensure that identifiable research data are not disclosed to the public or unauthorized individuals.

Risk level can be reduced by protecting confidentiality or collecting data that is strictly anonymous. This requires the collection of research in such a way that it is impossible to connect research data with the individual who provided the data.

4) Risk Groups

If the research study includes participants from any of the following groups, the IRB and student research must consider whether the nature of the study requires special protections or accommodations:

a. Any member of a group that is naturally at-risk (e.g. pregnant women, developmentally disabled persons, economically or educationally disadvantaged persons, individuals with diseases such as cancer, asthma, diabetes, AIDS, dyslexia, cardiac disorders, psychiatric disorders, learning disorders, etc.)

b. Special groups that are protected by federal regulations or guidelines (e.g. children/minors, prisoners, pregnant women, students receiving services under the Individuals with Disabilities Education Act (IDEA).

See the online Risk Assessment Guide and Online Survey Consent Procedures for more detailed information on risk assessment.

Sources of Information

1) *Code of Federal Regulation (CFR), Title 45 (Public Welfare), Part 46-Protection of Human Subjects (45CFR46)*
http://ohsr.od.nih.gov/guidelines/45cfr46.html

2) Dunn, C. M. and Chadwick, G. L., *Protecting Study Volunteers in Research: A Manual for Investigative Sites (*2002). Boston, MA: Thomson Centerwatch. ISBN 1-930624-36-0.
Can be purchased from: http://www.ahcpub.com/products_and_services/
NIH tutorial also provides similar information:
http://www.cancer.gov/clinicaltrials/learning/page3

3) NIH tutorial, "Protecting Human Research Participants"
http://phrp.nihtraining.com/users/PHRP.pdf

4) *Belmont Report*, April 18, 1979 http://ohsr.od.nih.gov/guidelines/belmont.html

5) *Standards for Educational and Psychological Testing.* (1999). Washington, DC: AERA, APA, NCME. To order call: (800) 628-4094. If outside US, call (717) 632- 3535, Ext. 8087
http://www.apa.org/science/standards.html

1) American Psychological Association
750 First Street, NE
Washington, DC 20002-4242
phone: 202-336-5500; 1-800-374-2721
http://www.apa.org

Information for students: http://www.apa.org/science/infostu.html

Information regarding publications: http://www.apa.org/publications/

7) Educational and Psychological Testing
Testing Office for the APA Science Directorate

phone: 202-336-5500
http://www.apa.org/science/testing.html

8) The Children's Online Privacy Protection Act of 1998 (COPPA) (15 U.S.C. §§ 6501–6506)
www.ftc.gov/privacy/coppafaqs.shtm

2. Vertebrate Animals

The following rules were developed to help pre-college student researchers adhere to the federal regulations governing professional scientists and to protect the welfare of both animal subjects and the student researcher. Health and well-being is of high priority when students conduct research with animal subjects.

The Society strongly endorses the use of non-animal research methods and encourages students to use alternatives to animal research. If the use of vertebrate animals is necessary, students must consider additional alternatives to reduce and refine the use of animals.

All projects involving vertebrate animals must adhere to the rules below AND to either Section A or Section B rules, depending on the nature of the study and the research site.

A project is considered a tissue study and not a vertebrate animal study if tissue is obtained from an animal that was euthanized for a purpose other than the student's project. (Documentation is required of the IACUC approval for the original animal study from which tissues are obtained.) In tissue studies, a student may observe the vertebrate study, but may not manipulate or have any direct involvement in the vertebrate animal experimental procedures.

Rules for ALL Vertebrate Animal Studies

1) The use of vertebrate animals in science projects is allowable under the conditions and rules in the following sections. Vertebrate animals, as covered by these rules, are defined as:
   - Live, nonhuman vertebrate mammalian embryos or fetuses
   - Tadpoles
   - Bird and reptile eggs within three days (72 hours) of hatching
   - All other nonhuman vertebrates (including fish) at hatching or birth.

   Exception: Because of their delayed cognitive neural development, zebrafish embryos are not considered vertebrate animals until 7 days (168 hours) post- fertilization.

2) Alternatives to the use of vertebrate animals for research must be explored and discussed in the research plan. The guiding principles for the use of animals in research include the following "Four R's":
   - Replace vertebrate animals with invertebrates, lower life forms, tissue/cell cultures and/or computer simulations where possible.
   - Reduce the number of animals without compromising statistical validity.
   - Refine the experimental protocol to minimize pain or distress to the animals.
   - Respect animals and their contribution to research.

3) All vertebrate animal studies must be reviewed and approved before experimentation begins. An Institutional Animal Care and Use Committee, known as an IACUC, is the institutional animal oversight review and approval body for all animal studies at a Regulated Research Institution. The local OR affiliated fair SRC serves in this capacity for vertebrate animals studies performed in a school, home or field. Any SRC serving in this capacity must include a veterinarian or an animal care provider with training and/or experience in the species being studied.

4) All vertebrate animal studies must have a research plan that includes:
   a. Justification why animals must be used, including the reasons for the choice of species, the source of animals and the number of animals to be used; description, explanation, or identification of alternatives to animal use that were considered, and the reasons these alternatives were unacceptable; explanation of the potential impact or contribution this research may have on the broad fields of biology or medicine.
   b. Description of how the animals will be used. Include methods and procedures, such as experimental design and data analysis; description of the procedures that will minimize the potential for discomfort, distress, pain and injury to the animals during the course of experimentation; identification of the species, strain, sex, age, weight, source and number of animals proposed for use.

5) Studies involving behavioral observations of animals are exempt from advance SRC review if ALL of the following apply:
   - There is no interaction with the animals being observed,
   - There is no manipulation of the animal environment in any way, and
   - The study meets all federal and state agriculture, fish, game and wildlife laws and regulations.

6) Students performing vertebrate animal research must satisfy U.S. federal law as well as local, state, and country laws and regulations of the jurisdiction in which research is performed.
7) Research projects which cause more than momentary or slight pain or distress are prohibited. Any illness or unexpected weight loss must be investigated and a veterinarian consulted to receive required medical care. This investigation must be documented by the Qualified Scientist, Designated Supervisor who is qualified to determine the illness or a veterinarian. If the illness or distress is caused by the study, the experiment must be terminated immediately.
8) No vertebrate animal deaths due to the experimental procedures are permitted in any group or subgroup.
   a. Studies that are designed or anticipated to cause vertebrate animal death are prohibited.
   b. Any death that occurs must be investigated by a veterinarian, the Qualified Scientist or the Designated Supervisor who is qualified to determine if the cause of death was incidental or due to the experimental procedures. The project must be suspended until the cause is determined and then the results must be documented in writing.
   c. If death was the result of the experimental procedure, the study must be terminated, and the study will not qualify for competition.
9) All animals must be monitored for signs of distress. Because significant weight loss is one sign of stress, the maximum permissible weight loss or growth retardation (compared to controls) of any experimental or control animal is 15%.
10) Students are prohibited from designing or participating in an experiment associated with the following types of studies on vertebrate animals:
   a. Induced toxicity studies with known toxic substances that could impair health or end life, including, but not limited to, alcohol, acid rain, pesticides, or heavy metals.
   b. Behavioral experiments using conditioning with aversive stimuli, mother/infant separation or induced helplessness.
   c. Studies of pain.
   d. Predator/vertebrate prey experiments.
11) Justification is required for an experimental design that involves food or fluid restriction and must be appropriate to the species. If the restriction exceeds 18 hours, the project must be reviewed and approved by an IACUC and conducted at a Regulated Research Institution.
12) Animals may not be captured from or released into the wild without approval of authorized wildlife or other regulatory officials. Fish may be obtained from the wild only if the researcher releases the fish unharmed, has the proper license, and adheres to state, local and national fishing laws and regulations. The use of electrofishing is permissible only if conducted by a trained supervisor; students are prohibited from performing electrofishing.
13) A Qualified Scientist or Designated Supervisor must directly supervise all research involving vertebrate animals, except for observational studies.
14) After initial SRC approval, a student with any proposed changes in the Research Plan of the project must repeat the approval process before laboratory experimentation/data collection resumes.

A. Additional Rules for Projects Conducted at School/Home/Field

Vertebrate animal studies may be conducted at a home, school, farm, ranch, in the field, etc. This includes:

- Studies of animals in their natural environment.
- Studies of animals in zoological parks.
- Studies of livestock that use standard agricultural practices.
- Studies of fish that use standard aquaculture practices.

These projects must be reviewed and approved by an SRC in which one member is either a veterinarian and/or an animal care provider/expert with training and/or experience in the species being studied.

1) These projects must adhere to BOTH of the following guidelines:
   a. The research involves only agricultural, behavioral, observational or supplemental nutritional studies on animals.
   AND
   b. The research involves only non-invasive and non- intrusive methods that do not negatively affect an animal's health or well-being.

All vertebrate animal studies that do not meet the above guidelines must be conducted in a Regulated Research Institutions. See Section B.

2) Animals must be treated kindly and cared for properly. Animals must be housed in a clean, ventilated, comfortable environment appropriate for the species. They must be given a continuous, clean (uncontaminated) water and food supply. Cages, pens and fish tanks must be cleaned frequently. Proper care must be provided at all times, including weekends, holidays, and vacation periods. Animals must be observed daily to assess their health and well-being. A Designated Supervisor is required to oversee the daily husbandry of the animals. Any of the following U.S. documents provide further guidance for animal husbandry:
   - *Federal Animal Welfare Regulation*
   - *Guide for the Care and Use of Laboratory Animals*

• *<u>Guide for the Care and Use of Agricultural Animals in Agricultural Research and Teaching</u>* (Ag-Guide)
• *<u>Quality Assurance Manuals</u> (for the appropriate species)*

3) The local or affiliated fair Scientific Review Committee must determine if a veterinarian's certification of the research plan and animal husbandry plans is required. This certification, as well as SRC approval, is required before experimentation and is documented on Vertebrate Animal Form 5A. A veterinarian must certify experiments that involve supplemental nutrition, administration of prescription drugs and/or activities that would not be ordinarily encountered in the animal's daily life.
4) If an illness or emergency occurs, the affected animal(s) must receive proper medical or nursing care that is directed by a veterinarian. A student researcher must stop experimentation if there is unexpected weight loss or death in the experimental subjects. The experiment can only be resumed if the cause of illness or death is not related to the experimental procedures and if appropriate steps are taken to eliminate the causal factors. If death is the result of the experimental procedure, the study must be terminated, and the study will not qualify for competition.
5) The final disposition of the animals must be described on Vertebrate Animal Form 5A.
6) Euthanasia for tissue removal and/or pathological analysis is not permitted for a project conducted in a school/home/field site. Livestock or fish raised for food using standard agricultural/aquacultural production practices may be euthanized by a qualified adult for carcass evaluation.
7) The following forms are required:
   a. Checklist for Adult Sponsor (1), Student Checklist (1A), Research Plan, and Approval Form (1B)
   b.. Vertebrate Animal Form (5A)
   c. Qualified Scientist Form (2), when applicable

B. Additional Rules for Projects Conducted in a Regulated Research Institution

All studies not meeting the criteria in Section A. but are otherwise permissible under Intel ISEF rules must be conducted in a Regulated Research Institution (RRI). A Regulated Research Institution within the U.S. is defined as a professional research/teaching institution that is regularly inspected by the USDA and is licensed to use animals covered by the Animal Welfare Act and may also be subject to U.S. Public Health Service Policy. Also included are all federal laboratories such as National Institutes of Health, Veteran's Affairs Medical Centers and the Centers for Disease Control. In addition, pharmaceutical and biotechnology companies and research institutions that utilize research animals that are not covered by the Animal Welfare Act but have an operational Institutional Animal Care and Use Committee and are in compliance with U.S. federal laws are included in this definition. For project conducted outside of the United States, a Regulated Research Institution would be a comparable research institution that adheres to country laws governing the care and use of vertebrate animals.

Some protocols permitted in a Registered Research Institution are not permitted for participation in the Intel ISEF; adherence to RRI rules is necessary but may not be sufficient.

1) The Institutional Animal Care and Use Committee (IACUC) or the comparable animal oversight committee must approve all student research projects before experimentation begins. Such research projects must be conducted under the responsibility of a principal investigator. The local and regional SRC must also review the project to certify that the research project complies with Intel ISEF Rules. This local and regional SRC review should occur before experimentation begins, if possible.
2) Student researchers are prohibited from performing euthanasia. Euthanasia at the end of experimentation for tissue removal and/or pathological analysis is permitted. All methods of euthanasia must adhere to current American Veterinarian Medical Association (AVMA) Guidelines.
3) Research projects that cause more than momentary or slight pain or distress to vertebrate animals that is not mitigated by approved anesthetics, analgesics and/or tranquilizers are prohibited.
4) Research in nutritional deficiency or research involving substances or drugs of unknown effect is permitted to the point that any clinical sign of distress is noted. In the case that distress is observed, the project must be suspended and measures must be taken to correct the deficiency or drug effect. A project can only be resumed if appropriate steps are taken to correct the causal factors.
5) The following forms are required:
   a. Checklist for Adult Sponsor (1), Student Checklist (1A), Research Plan, and Approval Form (1B)
   b. Regulated Research Institution Form (1C)
   c. Vertebrate Animal Form (5B)
   d. Qualified Scientist Form (2)
   e. PHBA Risk Assessment Form (6A) –for all studies involving tissues and body fluids.
   f. Human and Vertebrate Animal Tissue Form (6B) – for all studies involving tissues and body fluids.

Sources of Information for Animal Care and Use

1) Laboratory Animals, Institute of Laboratory Animal Research (ILAR), Commission on Life Sciences, National Research
http://dels.nas.edu/ilar

2) Guide for the Care and Use of Laboratory Animals, 8th Edition (2011)
http://grants.nih.gov/grants/olaw/Guide-for-the-Care-and-Use-of-Laborato...
www.nap.edu/catalog.php?record_id=12910

3) *Guidelines for the Care and Use of Mammals in Neuroscience and Behavioral Research* (2003), Institute for Laboratory Animal Research (ILAR).
To order these ILAR publications contact:
National Academies Press
500 Fifth Street, NW
Lockbox 285
Washington, DC 20055
phone: 888-624-8373 or 202-334-3313
fax: 202-334-2451; http://www.nap.edu

4) Federal Animal Welfare Act (AWA)
7 U.S.C. 2131-2157
Subchapter A - Animal Welfare (Parts I, II, III)
http://www.nal.usda.gov/awic/legislat/awicregs.htm
Above document is available from:
USDA/APHIS/AC
4700 River Road, Unit 84
Riverdale, MD 20737-1234
email: ace@aphis.usda.gov
Tel: (301) 734-7833
Fax: (301) 734-4978
http://awic.nal.usda.gov

5) *Guide for the Care and Use of Agricultural Animals in Agricultural Research and Teaching (Agri-Guide)*
Federation of Animal Science Societies (FASS)
1800 S. Oak Street, Suite 100
Champaign, IL 61820-6974
phone: (217) 356-3182
email: fass@assochq.org
http://www.fass.org

6) *Guidelines for the Use of Fish in Research* (2004), American Fisheries Society.
www.fisheries.org
www.fisheries.org/afs/docs/policy_16.pdf

7) Euthanasia Guidelines
AVMA Guidelines on Euthanasia (June 2007)
American Veterinary Medical Association.
www.avma.org/KB/Policies/Documents/euthanasia.pdf

Sources of Information for Alternative Research and Animal Welfare

1) The National Library of Medicine provides computer searches through MEDLINE:
Reference & Customer Services
National Library of Medicine
8600 Rockville Pike
Bethesda, MD 20894
1-888-FIND-NLM or 1-888-346-3656
(301) 594-5983; email: custserv@nlm.nih.gov
http://www.nlm.nih.gov
www.ncbi.nlm.nih.gov/sites/entrez

2) National Agriculture Library (NAL) provides reference service for materials that document a) Alternative Procedures to Animal Use and b) Animal Welfare.
Animal Welfare Information Center
National Agriculture Library
10301 Baltimore Avenue, 4th Floor
Beltsville, MD 20705-2351
phone: (301) 504-6212, fax: (301) 504-7125
email: awic@nal.usda.gov
http://www.nal.usda.gov/awic

3) Institute of Laboratory Animal Resources (ILAR) provides a variety of information on animal sources, housing and handling standards, and alternatives to animal use through annotated bibliographies published quarterly in ILAR Journal.
ILAR
The Keck Center of the National Academies
500 Fifth Street, NW, Keck 687
Washington, DC 20001
phone: (202) 334-2590, fax: 202-334-1687
email: ILAR@nas.edu
http://dels.nas.edu/ilar/

Quarterly bibliographies of Alternatives to the Use of Live Vertebrates in Biomedical Research and Testing may be obtained from:
Specialized Information Services
NLM/NIH
2 Democracy Plaza, Suite 510
6707 Democracy Blvd., MSC 5467
Bethesda, MD 20892-5467
Ph: 301-496-1131; Fax: 301-480-3537
Toll Free: 1-888-FIND-NLM or 1-888-346-3656
Email: tehip@teh.nlm.nih.gov
http://www.sis.nlm.nih.gov;
http://toxnet.nlm.nih.gov/altbib.html

5) John's Hopkins Center for Alternatives to Animal Testing (CAAT) has worked with scientists since 1981 to find new methods to replace the use of laboratory animals in experiments, reduce the number of animals tested, and refine necessary tests to eliminate pain and distress.
email: caat@jhsph.eduhttp://caat.jhsph.edu/

3. Potentially Hazardous Biological Agents

Rules for use of microorganisms (including bacteria, viruses, viroids, prions, rickettsia, fungi, and parasites), recombinant DNA (rDNA) technologies or human or animal fresh/frozen tissues, blood, or body fluids.

Research using microorganisms (including bacteria, viruses, viroids, prions, rickettsia, fungi, and parasites), recombinant DNA (rDNA) technologies or human or animal fresh/frozen tissues, blood, or body fluids may involve potentially hazardous biological agents. Students are permitted to do some research projects with potentially hazardous biological agents meeting the conditions and rules described below which were designed to protect students and to ensure adherence to federal and international biosafety regulations and guidelines.

When dealing with potentially hazardous biological agents, it is the responsibility of the student and all of the adults involved in a research project to conduct and document a risk assessment (Form 6A) to define the potential level of harm, injury or disease to plants, animals and humans that may occur when working with biological agents. The risk assessment determines a biosafety level which in turn determines if the project can proceed, and if so, the laboratory facilities, equipment, training, and supervision required.

All projects involving microorganisms, recombinant DNA technologies and human or animal fresh/frozen tissues, blood or body fluids must adhere to the rules below AND, depending on the study, to the additional rules in Section A, B or C.

Rules for ALL Studies with Potentially Hazardous Biological Agents

1) The following types of studies involve BSL-1 organisms and are exempt from prior SRC review and require no additional forms:
   a. Studies involving baker’s yeast and brewer’s yeast, except when used with rDNA studies.
   b. Studies involving Lactobacillus, *Bacillus thuringiensis,* nitrogen-fixing, oil-eating bacteria, and algae-eating bacteria introduced into their natural environment. (Not exempt if cultured in a petri dish environment.)
   c. Studies involving water or soil not concentrated in media conducive to their microbial growth. (Please review all rules below to ensure that there are not more specific rules that may apply.)
   d. Studies of mold growth on food items if the experiment is terminated at the first evidence of mold.
   e. Studies of slime molds and edible mushrooms.
   f. Studies involving *E. coli* k-12 which are done at school and are not recombinant DNA studies.

2) The following types of studies are exempt from prior SRC review, but require a Risk Assessment Form 3:
   a. Studies involving protists, archaea and known non-pathogenic microorganisms.
   b. Research using manure for composting, fuel production, or other non-culturing experiments.
   c. Commercially-available color change coliform water test kits. These kits must remain sealed and must be properly disposed.
   d. Studies involving decomposition of vertebrate organisms (such as in forensic projects).
   e. Studies with microbial fuel cells.

3) Prior review and approval is required for the use of potentially hazardous microorganisms (including bacteria, viruses, viroids, prions, rickettsia, fungi, and parasites), recombinant DNA (rDNA) technologies or human or animal fresh/frozen tissues, blood, or body fluids:
   a. An affiliated fair SRC, an IBC or an IACUC must approve all research before experimentation begins. The initial risk assessment determined by the student researcher and adults supervising the project must be confirmed by the SRC, IBC or IACUC.
   b. Experimentation involving the culturing of potentially hazardous biological agents, even BSL-1 organisms, is prohibited in a home environment. However, specimens may be collected at home as long as they are immediately transported to a laboratory with the BSL containment determined by the affiliated fair SRC.
   c. Research determined to be at Biosafety Level 1 (BSL-1) must be conducted in a BSL-1 or higher laboratory. The research must be supervised by a trained Designated Supervisor or a Qualified Scientist. The student must be properly trained in standard microbiological practices.
   d. Research determined to be a Biosafety Level 2 (BSL-2) must be conducted in a laboratory rated BSL-2 or above (commonly limited to a Regulated Research Institution). The research must be reviewed and approved by the Institutional Biosafety Committee (IBC) if the Regulated Research Institution requires the review. The research must be supervised by a Qualified Scientist. For a high school BSL-2 laboratory, the SRC must review and approve.
   e. Students are prohibited from designing or participating in an experiment associated with the following types of PHBA studies:
      - BSL-3 or BSL-4 Research
      - Culturing CRE (Carbapenem Resistant Enterobacteriacae)

f. Insertion of antibiotic resistance markers for the clonal selection of bioengineered organisms is permitted. Students may not genetically engineer organisms with multiple drug resistance traits for the intended purpose of investigation of the pathology or treatment of antibiotic-resistant infections. Insertion of antibiotic-resistance traits or selection of organisms expressing traits that may affect the ability to provide effective treatment of infections acquired by humans, animals, or plants is strictly prohibited.

g. Laboratory studies culturing known MRSA (Methicillin-resistant *Staphylococcus aureus*), VRE (Vancomycin-resistant enterococci) and KPC (Klebsiella pneumonia) must have a written justification for usage and be conducted at a Regulated Research Institution with a minimum BSL-2 laboratory with documented IBC Committee review and approval. Students are prohibited from culturing CRE (Carbapenem Resistant Enterobacteriacae).

h. Extreme caution must be exercised when selecting and sub-culturing antibiotic-resistant organisms. Studies using such organisms require at least BSL-2 containment.

i. Naturally-occurring plant pathogens may be studied (not cultured) at home, but may not be introduced into a home/garden environment.

j. The culturing of human or animal waste, including sewage sludge, is considered a BSL-2 study.

k. All potentially hazardous biological agents must be properly disposed at the end of experimentation in accordance with their biosafety level. For BSL 1 or BSL 2 organisms: Autoclave at 121 degrees Celsius for 20 minutes, use of a 10% bleach solution (1:10 dilution of domestic bleach), incineration, alkaline hydrolysis, biosafety pick-up and other manufacturer recommendations are acceptable.

l. Any proposed changes in the Research Plan by the student after initial local or affiliated fair SRC approval must undergo subsequent SRC or IBC review and approval before such changes are made and before experimentation resumes.

4) The following forms are required:

- Checklist for Adult Sponsor (1), Student Checklist (1A), Research Plan, and Approval Form (1B)
- Regulated Research Institution Form (1C) - when applicable.
- Qualified Scientist (2), when applicable
- Risk Assessment (3), when applicable
- PHBA Risk Assessment Form (6A), when applicable
- Human and Vertebrate Animal Tissue Form (6B) – for all studies involving tissues and body fluids.

A. Additional Rules for Projects Involving Unknown Microorganisms

Studies involving unknown microorganisms present a challenge because the presence, concentration and pathogenicity of possible agents are unknown. In science fair projects, these studies typically involve the collection and culturing of microorganisms from the environment (e.g. soil, household surfaces, skin.)

1) Research with unknown microorganisms can be treated as a BSL-1 study under the following conditions:

a. Organism is cultured in a plastic petri dish (or other standard non-breakable container) and sealed. Other acceptable containment includes two heavy-duty (2-ply) sealed bags.

b. Experiment involves only procedures in which the Petri dish remains sealed throughout the experiment (e.g., counting presence of organisms or colonies).

c. The sealed Petri dish is disposed of via autoclaving or disinfection under the supervision of the Designated Supervisor.

2) If a culture container with unknown microorganisms is opened for any purpose, (except for disinfection for disposal), it must be treated as a BSL-2 study and involve BSL-2 laboratory procedures.

B. Additional Rules for Projects Involving Recombinant DNA (rDNA) Technologies

Studies involving rDNA technologies in which microorganisms have been genetically modified require close review to assess the risk level assignment. Some rDNA studies can be safely conducted in a BSL-1 high school laboratory with prior review by a knowledgeable SRC:

1) All rDNA technology studies involving BSL-1 organisms and BSL-1 host vector systems must be conducted in a BSL-1 laboratory under the supervision of a Qualified Scientist or Designated Supervisor and must be approved by the SRC prior to experimentation. Examples include cloning of DNA in *E. coli* K-12, *S. cerevesiae,* and *B. subtilis* host-vector systems.

2) Commercially available rDNA kits using BSL-1 organisms may be conducted in a BSL-1 laboratory under the supervision of a Qualified Scientist or trained Designated Supervisor and must be approved by the SRC prior to experimentation.

3) An rDNA technology study using BSL-1 agents that may convert to BSL-2 agents during the course of experimentation must be conducted entirely in a BSL-2 facility.

4) All rDNA technology studies involving BSL-2 organisms and/or BSL-2 host vector systems must be conducted in a Regulated Research Institution and approved by the IBC prior to experimentation.
5) Propagation of recombinants containing DNA coding for human, plant or animal toxins (including viruses) is prohibited.

C. Additional Rules for Projects with Tissues and Body Fluids, including Blood and Blood Products

Studies involving fresh/frozen tissue, blood or body fluids obtained from humans and/or vertebrates may contain microorganisms and have the potential of causing disease. Therefore, a proper risk assessment is required.

1) *The following types of tissue do not need to be treated as potentially hazardous biological agents:*
   a. Plant tissue (except those known to be toxic or hazardous)
   b. Plant and non-primate established cell lines and tissue culture collections (e.g., obtained from the American Type Culture Collection). The source and/or catalog number of the cultures must be identified in the Research Plan.
   c. Fresh or frozen meat, meat by-products, pasteurized milk or eggs obtained from food stores, restaurants, or packing houses.
   d. Hair, hooves, nails and feathers.
   e. Teeth that have been sterilized to kill any blood- borne pathogen that may be present.
   f. Fossilized tissue or archeological specimens.
   g. Prepared fixed tissue.
2) Research involving human and/or non-human primate established cell lines and tissue culture collections (e.g., obtained from the American Type Culture Collection) must be considered a BSL-1 or BSL-2 level organism as indicated by source information and treated accordingly. The source and/or catalog number of the cultures must be identified in the Research Plan.
3) If tissues are obtained from an animal that was euthanized for a purpose other than the student's project, it may be considered a tissue study. Use of the tissues obtained from research at a Regulated Research Institution requires documentation of the IACUC approval for the original animal study. Use of tissues obtained from agricultural/aquacultural studies require prior SRC approval.
4) If the animal was euthanized solely for the student's project, the study must be considered a vertebrate animal project and is subject to the vertebrate animal rules for studies conducted at a Regulated Research Institution. (See vertebrate animal rules.)
5) The collection and examination of fresh/frozen tissue and/or body fluids, (not including blood or blood products; see rule 8) from a non-infectious source with little likelihood of microorganisms present must be considered Biosafety level 1 studies and must be conducted in a BSL-1 laboratory or higher and must be supervised by a Qualified Scientist or trained Designated Supervisor.
6) The collection and examination of fresh/frozen tissues or body fluids or meat, meat byproducts, pasteurized milk or eggs NOT obtained from food stores, restaurants, or packing houses may contain microorganisms. Because of the increased risk from unknown potentially hazardous agents, these studies must be considered biosafety level 2 studies conducted in a BSL-2 laboratory under the supervision of a Qualified Scientist.
7) Human breast milk of unknown origin, unless certified free of HIV and Hepatitis C and domestic unpasteurized animal milk are considered BSL-2.
8) All studies involving human or wild animal blood or blood products should be considered a Biosafety level 2 study and must be conducted in a BSL-2 laboratory under the supervision of a Qualified Scientist. Studies involving domestic animal blood may be considered a BSL-1 level study. All blood must be handled in accordance with standards and guidelines set forth in the OSHA, 29CFR, Subpart Z. Any tissue or instruments with the potential of containing blood-borne pathogens (e.g. blood, blood products, tissues that release blood when compressed, blood contaminated instruments) must be properly disposed after experimentation.
9) Studies of human body fluids, where the sample can be identified with a specific person, must have IRB review and approval, and informed consent.
10) Any study involving the collection and examination of body fluids which may contain biological agents belonging to BSL-3 or -4 is prohibited.
11) A project involving a student researcher using their own body fluids (if not cultured)
   a. can be considered a BSL-1 study
   b. may be conducted in a home setting
   c. must have IRB review if the body fluid is serving as a measure of an effect of an experimental procedure on the student researcher (e.g. student manipulates diet and takes a blood or urine sample). An example of a project not needing IRB review would be collecting urine to serve as a deer repellent.
   d. must receive prior SRC review and approval prior to experimentation.

12) Studies involving embryonic human stem cells must be conducted in a Registered Research Institution and reviewed and approved by the ESCRO (Embryonic Stem Cell Research Oversight) Committee.

Potentially Hazardous Biological Agents Risk Assessment

Use this information to complete PHBA Risk Assessment Form 6A

Risk assessment defines the potential level of harm, injury or disease to plants, animals and humans that may occur when working with biological agents. The end result of a risk assessment is the assignment of a biosafety level which then determines the laboratory facilities, equipment, training, and supervision required.

Risk assessment involves:

- Assignment of the biological agent to a risk group
  - Studies involving a known microorganism must begin with an initial assignment of the microorganism to a biosafety level risk group based on information available through a literature search.
  - The study of unknown microorganisms and the use of fresh tissues relies on the expertise of the supervising adult(s).
- Determination of the level of biological containment available to the student researcher to conduct the experimentation. (See "Levels of Biological Containment" for details.)
- Assessment of the experience and expertise of the adult(s) supervising the student.
- Assignment of a biosafety level for the study based on risk group of biological agent, level of biological containment available and the expertise of the Qualified Scientist or Designated Supervisor who will be supervising the project.

Documentation of review and approval of study prior to experimentation:

- If a study is conducted at a non-regulated site (e.g. school), the SRC reviews the Research Plan.
- If the study was conducted at a Regulated Research Institution, and was approved by the appropriate institutional board (e.g. IBC, IACUC), the SRC reviews the institutional forms provided and documents SRC approval (Form (6A)).
- If a PHBA study was conducted at a Regulated Research Institution but the institution does not require review for this type of study, a letter from an institutional representative stating that review was not required must be obtained. The SRC must review the study and document approval on Form 6A that the student received appropriate training and the project complies with Intel ISEF rules.

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Classification of Biological Agents
Risk Groups

Biological agents, plant or animal, are classified according to biosafety level risk groups. These classifications presume ordinary circumstances in the research laboratory, or growth of agents in small volumes for diagnostic and experimental purposes.

BSL-1 risk group contains biological agents that pose low risk to personnel and the environment. These agents are highly unlikely to cause disease in healthy laboratory workers, animals or plants. The agents require Biosafety Level 1 containment. Examples of BSL-1 organisms are: *Agrobacterium tumifaciens, Micrococcus leuteus, Neurospora crassa, Bacillus subtilis.*

BSL-2 risk group contains biological agents that pose moderate risk to personnel and the environment. If exposure occurs in a laboratory situation, the risk of spread is limited and it rarely would cause infection that would lead to serious disease. Effective treatment and preventive measures are available in the event that an infection occurs. The agents require Biosafety Level 2 containment. Examples of BSL-2 organisms are: *Mycobacterium, Streptococcus pneumonia, Salmonella choleraesuis.*

BSL-3 risk group contains biological agents that usually cause serious disease (human, animal or plant) or that can result in serious economic consequences. Projects in the BSL-3 group are prohibited.

BSL-4 risk group contains biological agents that usually produce very serious disease (human, animal or plant) that is often untreatable. Projects in the BSL-4 group are prohibited.

Levels of Biological Containment

There are four levels of biological containment (Biosafety Level 1–4). Each level has guidelines for laboratory facilities, safety equipment and laboratory practices and techniques.

BSL-1 containment is normally found in water-testing laboratories, in high schools, and in colleges teaching introductory microbiology classes. Work is done on an open bench or in a fume hood. Standard microbiological practices are used when working in the laboratory. Decontamination can be achieved by treating with chemical disinfectants or by steam autoclaving. Lab coats are required and gloves recommended. The laboratory work is supervised by an individual with general training in microbiology or a related science.

BSL-2 containment is designed to maximize safety when working with agents of moderate risk to humans and the environment. Access to the laboratory is restricted. Biological safety cabinets (Class 2, type A, BSC) must be available. An autoclave should be readily available for decontaminating waste materials. Lab coats, gloves and face protection are required. The laboratory work must be supervised by a scientist who understands the risk associated with working with the agents involved.

BSL-3 containment is required for infectious agents that may cause serious or potentially lethal diseases as a result of exposure by inhalation. Projects in the BSL-3 group are prohibited.

BSL-4 containment is required for dangerous/exotic agents that pose high risk of life-threatening disease. Projects in the BSL-4 group are prohibited.

Sources of Information

American Biological Safety Association: ABSA Risk Group Classification – list of organisms
http://www.absa.org

American Type Culture Collection
http://www.atcc.org

Bergey's Manual of Systematic Bacteriology website – follow the links for resources and microbial databases for a collection of international websites of microorganisms and cell cultures: www.bergeys.org/resources.html

Biosafety in Microbiological and Biomedical Laboratories (BMBL) - 4th Edition. Published by CDC-NIH,
www.cdc.gov/biosafety/publications/bmbl5/BMBL.pdf

World Health Organization
Laboratory Safety Manual-3rd Edition
http://www.who.int/csr/resources/publications/biosafety/Biosafety7.pdf

Canada – Agency of Public Health – list of non-pathogenic organisms
www.phac-aspc.gc.ca/lab-bio/index_eng.php
www.phac-aspc.gc.ca/lab-bio/res/index-eng.php

Microorganisms for Education Website – list of organisms
http://www.science-projects.com/safemicrobes.htm

NIH Guidelines for Research Involving Recombinant DNA Molecules. Published by National Institutes of Health.
http://osp.od.nih.gov/office-biotechnology-activities/oba/index.html

OSHA – Occupational Health and Safety Administration
http://www.osha.gov

4. Hazardous Chemicals, Activities or Devices

(Includes DEA-controlled substances, prescription drugs, alcohol & tobacco, firearms and explosives, radiation, lasers, etc.)

The following rules apply to research using hazardous chemicals, devices and activities. These include substances and devices that are regulated by local, state, country, or international law, most often with restrictions of their use by minors such as DEA-controlled substances, prescription drugs, alcohol, tobacco, firearms and explosives. Hazardous activities are those that involve a level of risk above and beyond that encountered in the student's everyday life.

These rules are intended to protect the student researcher by ensuring proper supervision and the consideration of all potential risks so that the appropriate safety precautions are taken. Students are required to meet all standards imposed by Intel ISEF, school, local, and/or regional fair(s).

Rules for ALL Projects Involving Hazardous Chemicals, Activities and Devices

1) The use of hazardous chemicals and devices and involvement in hazardous activities require direct supervision by a Designated Supervisor, except those involving DEA-controlled substances, which require supervision by a Qualified Scientist.
2) The student researcher must conduct a risk assessment in collaboration with a Designated Supervisor or Qualified Scientist prior to experimentation. This risk assessment is documented on the Risk Assessment Form 3.
3) Student researchers must acquire and use regulated substances in accordance with all local, state, U.S. federal and country laws. For further information or classification for these laws and regulations, contact the appropriate regulatory agencies.
4) For all chemicals, devices or activities requiring a Federal and/or State Permit, the student/supervisor must obtain the permit prior to the onset of experimentation. A copy of the permit must be available for review by adults supervising the project and the local and affiliated and the ISEF Scientific Review Committee in their review prior to competition.
5) The student researcher must minimize the impact of an experiment on the environment. Examples include using minimal quantities of chemicals that will require subsequent disposal; ensuring that all disposal is done in an environmentally safe manner and in accordance with good laboratory practices.
6) The following forms are required:
    a. Checklist for Adult Sponsor (1), Student Checklist (1A), Research Plan and Approval Form (1B)
    b. Regulated Research Institution Form (1C), when applicable
    c. Qualified Scientist Form (2), when applicable
    d. Risk Assessment Form (3)

Additional Rules for Specific Regulated Substances

There are additional rules for the following regulated substances:

A. DEA-controlled Substances
B. Prescription Drugs
C. Alcohol & Tobacco
D. Firearms and Explosives

A. DEA-Controlled Substances

The U.S. Drug Enforcement Administration (DEA) regulates chemicals that can be diverted from their intended use to make illegal drugs. Other countries may have similar regulatory bodies; students outside of the U.S. must adhere to their own country's drug regulatory agency requirements in addition to U.S. DEA regulations. DEA-controlled substances and their schedule number are at the DEA website under Sources of Information. It is the responsibility of the student to consult this list if there is a possibility that substances used in experimentation could be regulated.

1) All studies using DEA-controlled substances must be supervised by a Qualified Scientist who is licensed by the DEA (or other international regulatory body) for use of the controlled substance.
2) All studies using DEA Schedule 1 substances must have the research protocol approved by DEA before research begins. Schedule 2, 3 and 4 substances do not require protocol approval by DEA.

B. Prescription Drugs

Prescription drugs are drugs regulated by federal or country laws and are available only through a pharmacy to protect against inappropriate or unsafe use. Special precautions must be taken in their use for a science project as follows:

1) Students are prohibited from administering prescription drugs to human participants.
2) A veterinarian must supervise student administration of any prescription drugs to vertebrate animals.

C. Alcohol and Tobacco

The U.S. Alcohol and Tobacco Tax and Trade Bureau (TTB) regulates the production of alcohol and distribution of alcohol and tobacco products. Many such products are restricted by age for purchase, possession and consumption.

1. The Designated Supervisor is responsible for the acquisition, usage and appropriate disposal of the alcohol or tobacco used in the study.
2. Production of wine or beer by adults is allowable in the home and must meet TTB home production regulations. Students are allowed to design and conduct a research project, under direct parental supervision, involving the legal production of the wine or beer.
3. Fermentation studies in which minute quantities of ethyl alcohol are produced are permitted.
4. Students are prohibited from conducting experiments where consumable ethyl alcohol is produced by distillation. However, students are allowed to distill alcohol for fuel or other non-consumable products. To do so, the work must be conducted at school or a Regulated Research Institution and follow all local and country laws. See the Alcohol and Tobacco Tax and Trade Bureau (TTB) website for details.

D. Firearms and Explosives

The U.S. Bureau of Alcohol, Tobacco, Firearms and Explosives (ATF), along with state agencies, regulates the purchase and use of firearms and explosives. A firearm is defined as a small arms weapon from which a projectile is fired by gunpowder. An explosive is any chemical compound, mixture or device, the primary purpose of which is to function by explosion. Explosives include, but are not limited to, dynamite, black powder, pellet powder, detonators, and igniters.

The purchase of a firearm by a minor is generally unlawful. The use of a firearm, without proper state certification, is illegal. Students should check the training and certification requirements of individual states and countries.

1) Projects involving firearms and explosives are allowable when conducted with the direct supervision of a Designated Supervisor and when in compliance with all federal, state and local laws.
2) A fully assembled rocket motor, reload kit or propellant modules containing more than 62.5 grams of propellant are subject to the permitting, storage and other requirements of federal explosive laws and regulations.
3) Potato guns and paintball guns are not firearms unless they are intended to be used as weapons. They must be treated as hazardous devices.

E. Drones

Projects involving unmanned aircraft systems (UAS)/drones must follow all state, Federal, and country laws. See the Federal Aviation (FAA) for more details

Guidance for Risk Assessment

Please find below guidance on conducting risk assessment when using the following:

A. Hazardous Chemicals
B. Hazardous Devices
C. Radiation

A. Hazardous Chemicals

A proper risk assessment of chemicals must include review of the following factors:

Toxicity – the tendency of a chemical to be hazardous to health when inhaled, swallowed, injected or in contact with the skin.

Reactivity — the tendency of a chemical to undergo chemical change.

Flammability — the tendency of a chemical to give off vapors which readily ignite when used under normal working conditions.

Corrosiveness — the tendency of a chemical, upon physical contact, to harm or destroy living tissues or physical equipment.

When assessing risk, the type and amount of exposure to a chemical must be considered. For example, an individual's allergic and genetic disposition may have an influence on the overall effect of the chemical. The student researcher must refer to Material Safety Data Sheets provided by the vendor (MSDS) to ensure that proper safety precautions are taken. Some MSDS sheets (e.g., Flinn) rank the degree of hazard associated with a chemical. This rating may assist students and adult sponsors in determining risk associated with the use of a chemical.

A risk assessment must include proper disposal methods for the chemicals used in an experiment. The Flinn Catalog (referenced in the Sources of Information section) provides information for the proper disposal of chemicals. If applicable, the student researcher must incorporate in the research plan disposal procedure required by federal and state guidelines.

Environmentally Responsible Chemistry

The mission of environmentally responsible (green) chemistry is to avoid the use or production of hazardous substances during a chemical process. The principles of green chemistry are described on the EPA website in the Sources of Information section.

The following principles must be incorporated into the research plan:

- Waste prevention
- Use of the safest possible chemicals and products
- Design of the least possible hazardous chemical syntheses
- Use of renewable materials
- Use of catalysts in order to minimize chemical usage
- Use of solvents and reaction conditions that are as safe as possible
- Maximization of energy efficiency
- Minimization of accident potential

B. Hazardous Devices

The documentation of risk assessment (Form 3) is required when a student researcher works with potentially hazardous/dangerous equipment and/or other devices, in or outside a laboratory setting that require a moderate to high level of expertise to ensure their safe usage. Some commonly used devices (Bunsen burners, hot plates, saws, drills, etc.) may not require a documented risk assessment, assuming that the student researcher has experience working with the device. Use of other potentially dangerous devices such as high vacuum equipment, heated oil baths, NMR equipment, and high temperature ovens must have documentation of a risk assessment. It is recommended that all student designed inventions also have documentation of a risk assessment.

C. Radiation

A risk assessment must be conducted when a student's project involves radiation beyond that normally encountered in everyday life. Non-ionizing radiation includes the spectrum of ultraviolet (UV), visible light, infrared (IR), microwave (NW), radiofrequency (RF) and extremely low frequency (ELF). Ionizing radiation has enough energy to remove tightly bound electrons from atoms, thus creating ions. Examples include high frequency UV, X-Rays, and gamma rays.

Lasers usually emit visible, ultraviolet or infrared radiation. Lasers are classified into four classes based upon their safety. Manufacturers are required to label Classes II – IV lasers.

Class I lasers – those found in CD players, laser printers, geological survey equipment and some laboratory equipment. There are no known risks associated with using a Class I laser.

Class II lasers – found in laser pointers, aiming and range-finding devices. These pose a risk if the beam is viewed directly over a long period of time.

Class III lasers – found in higher-powered laser pointers, printers and spectrometers. They are hazardous devices which can cause eye damage when the beam is viewed directly even for a short period of time.

Class IV lasers – high powered lasers used in surgery, research, and industry. They are extremely hazardous and can cause eye and skin damage from both direct and indirect exposure. The beam is also a fire hazard.

Projects involving radionuclides (radioisotopes) and X-rays must involve a careful examination of the risks associated with the study. Depending upon the level of exposure, radiation released from these sources can be a health hazard. A risk assessment must take into account the time of exposure, distance and shielding involved in the study.

1) A study of natural radiation that is no more than than encountered in everyday life is exempt from the following requirements.

2) All studies may not exceed the dose limits set by the Nuclear Regulatory Commission of 0.5 mrem/hr or 100 mrem/year of exposure.

3) If the voltage needed in the study is >10 kvolts, a risk assessment must be conducted. The study may be done at home or school, and SRC preapproval is not required.

4) A study using 10-25 kvolts must have a risk assessment conducted and must be preapproved by the SRC to assess safety. Such a study must be conducted in a metal chamber using a camera only, not direct view through glass. A dosimeter or radiation survey meter is required to measure radiation exposure.

5) All studies using > 25 kvolts must be conducted at an institution with a Licensed Radiation Program and must be preapproved by the Institutions' Radiation Safety Officer or the Committee which oversees the use of ionizing radiation to ensure compliance with state and federal regulations.

Sources of Information

General Lab/Chemical Safety
Safety in Academic Chemistry Laboratories, *volumes 1 and 2*, 2003. Washington, DC: American Chemical Society.
Order from (first copy free of charge):
American Chemical Society
Publications Support Services
1155 16th Street, NW
Washington, DC 20036
phone: (202) 872-4000 or 1-800-227-5558
email: help@acs.org,
www.acs.org/education

Howard Hughes Medical Institute as a resource for working with cell cultures, radioactive materials and other laboratory materials.
www.hhmi.org/resources/

Environmental Protection Agency (EPA) website for green chemistry: http://www.epa.gov/greenchemistry

Material Safety and Data Sheets (MSDS)
http://www.flinnsci.com/msds-search.aspx/
A directory of SDS sheets from Flinn Scientific Inc. that includes a ranking of hazard level and disposal methods
www.ilpi.com/msds/index.html - A listing of numerous sites that have free downloads of SDS sheets

Pesticides
National Pesticide Information Center
http://npic.orst.edu/ingred/products.html
Describes the various types of pesticides and the legal requirements for labelling. Provides links and phone numbers to get additional information.
Environmental Protection Agency
http://iaspub.epa.gov/apex/pesticides/f?p=PPLS:1
A database of product labels. Enter the product name or company name to view the approved label information of pesticides which are registered with the agency.

DEA Controlled Substances
Drug Enforcement Agency website:
www.justice.gov/dea/index.htm
Controlled Substance Schedules – a list of controlled substances :
www.deadiversion.usdoj.gov/schedules/

Alcohol, Tobacco Firearms and Explosives
Alcohol and Tobacco Tax and Trade Bureau
www.ttb.gov

Bureau of Alcohol, Tobacco, Firearms and Explosives
http://www.atf.gov

Radiation
Radiation Studies Information (CDC)
www.cdc.gov/nceh/radiation/default.htm

CDC Laboratory Safety Manuals
www.cdc.gov/biosafety/publications/index.htm

Occupational Safety and Health Administration
http://www.osha.gov

Safety and Health Topics:
www.osha.gov/SLTC/
www.osha.gov/SLTC/reactivechemicals/index.html
www.osha.gov/SLTC/laserhazards/index.html
www.osha.gov/SLTC/radiationionizing/index.html
11) U.S. Nuclear Regulatory Commission
Material Safety and Inspection Branch
One White Flint North
11555 Rockville Pike
Rockville, MD 20852
phone: 301-415-8200; 800-368-5642
www.nrc.gov

C. Putting It All Together

1. **Topic Proposal**

a. **General Areas of Interest**. Choose the area in which you are most interested. Science Fair categories are broken up as follows:

Please visit our website at **http://www.societyforscience.org/isef/project_categories** for a full description and definition of the Intel ISEF categories (subcategories may adjust):

ANIMAL SCIENCES
Animal Behavior
Cellular Studies
Development
Ecology
Genetics
Nutrition and Growth
Physiology
Systematics and Evolution
Other
BEHAVIORAL & SOCIAL SCIENCES
Clinical & Developmental Psychology
Cognitive Psychology
Neuroscience
Physiological Psychology
Sociology and Social Psychology
Other
BIOCHEMISTRY
Analytical Biochemistry
General Biochemistry
Medicinal Biochemistry
Structural Biochemistry
Other
BIOMEDICAL AND HEALTH SCIENCES
Cell, Organ, and Systems Physiology
Genetics and Molecular Biology of Disease
Immunology
Nutrition and Natural Products
Pathophysiology
Other
BIOMEDICAL ENGINEERING
Biomaterials and Regenerative Medicine
Biomechanics
Biomedical Devices
Biomedical Imaging
Cell and Tissue Engineering
Synthetic Biology
Other
CELLULAR AND MOLECULAR BIOLOGY
Cell Physiology
Cellular Immunology
Genetics
Molecular Biology

Neurobiology
Other
CHEMISTRY
Analytical Chemistry
Computational Chemistry
Environmental Chemistry
Inorganic Chemistry
Materials Chemistry
Organic Chemistry
Physical Chemistry
Other
COMPUTATIONAL BIOLOGY AND BIOINFORMATICS
Computational Biomodeling
Computational Epidemiology
Computational Evolutionary Biology
Computational Neuroscience
Computational Pharmacology
Genomics
Other
EARTH AND ENVIRONMENTAL SCIENCES
Atmospheric Science
Climate Science
Environmental Effects on Ecosystems
Geosciences
Water Science
Other
EMBEDDED SYSTEMS
Circuits
Internet of Things
Microcontrollers
Networking and Data Communications
Optics
Sensors
Signal Processing
Other
ENERGY: CHEMICAL
Alternative Fuels
Computational Energy Science
Fossil Fuel Energy
Fuel Cells and Battery Development
Microbial Fuel Cells
Solar Materials
Other
ENERGY: PHYSICAL
Hydro Power
Nuclear Power
Solar
Sustainable Design
Thermal Power
Wind
Other

ENGINEERING MECHANICS
Aerospace and Aeronautical Engineering
Civil Engineering

Computational Mechanics
Control Theory
Ground Vehicle Systems
Industrial Engineering-Processing
Mechanical Engineering
Naval Systems
Other
ENVIRONMENTAL ENGINEERING
Bioremediation
Land Reclamation
Pollution Control
Recycling and Waste Management
Water Resources Management
Other
MATERIALS SCIENCE
Biomaterials
Ceramic and Glasses
Composite Materials
Computation and Theory
Electronic, Optical, and Magnetic Materials
Nanomaterials
Polymers
Other
MATHEMATICS
Algebra
Analysis
Combinatorics, Graph Theory, and Game Theory
Geometry and Topology
Number Theory
Probability and Statistics
Other
MICROBIOLOGY
Antimicrobial and Antibiotics
Applied Microbiology
Bacteriology
Environmental Microbiology
Microbial Genetics
Virology
Other
PHYSICS AND ASTRONOMY
Atomic, Molecular, and Optical Physics
Astronomy and Cosmology
Biological Physics
Computational Physics and Astrophysics
Condensed Matter and Materials
Instrumentation
Magnetics, Electromagnetics and Plasmas
Mechanics
Nuclear and Particle Physics
Optics, Lasers, and Masers
Quantum Computation
Theoretical Physics
Other

PLANT SCIENCES
Agriculture/Agronomy

Ecology
Genetics and Breeding
Growth and Development
Pathology
Plant Physiology
Systematics and Evolution
Other

ROBOTICS AND INTELLIGENT MACHINES

Biomechanics
Cognitive Systems
Control Theory
Machine Learning
Robot Kinematics
Other

SYSTEMS SOFTWARE

Algorithms
Cybersecurity
Databases
Human/Machine Interface
Languages and Operating Systems
Mobile Apps
Online Learning
Other

TRANSLATIONAL MEDICAL SCIENCE

Disease Detection and Diagnosis
Disease Prevention
Disease Treatment and Therapies
Drug Identification and Testing
Pre-Clinical Studies
Other

b. Once you have chosen an area, begin to narrow it down further and further until you have a single topic of focus. This topic becomes your problem, and should be in question form.

c. Library research will aid you in narrowing your topic. You must use the library to complete this project. Unfortunately, the Marian Library is not sufficient to provide all the resource information you will need. Also, do not be afraid to contact professors at IUSB, Notre Dame, or St. Mary's for help with developing your ideas. They are a valuable resource for equipment, as well.

d. Research resources

(1) Check with local school corporations regarding equipment, resource staff, moneys available, release time, recognition and emotional supports.

(2) Get topic ideas from hobbies, personal interests, items in newspapers or magazines.

(3) Get reference materials from school, public, or university libraries; or teacher advisor materials.

(a) -write letters

(b) -use interlibrary loans

(c) -do computer searches

(d) -study previous student papers

(e) -use computer Internet services

(4) Telephone hospitals, universities, businesses, or professionals with questions. Start a file of addresses and numbers.

(5) Consult science catalogs to develop a list of materials and costs. Develop a budget.

(6) Read professional pamphlets, fliers and magazines. Note research grants available for students.

(7) Visit hospitals, universities and laboratories. Learn research techniques.

e. When you have chosen your problem, complete and turn in Preliminary Discussion of Research Proposal form by stated due date (See Appendix A).

2. **Topic Suggestions**

a. Due to previous overuse, lack of cohesive experimentation, or simply because they are too simple for a high school level project, the following topics **MAY NOT** be used:

1. The Effect of Colored Light on Plants
2. The Effect of Various Household Chemicals on Plants
3. Mold Growth
4. "How Simple is That Sugar?"
5. Dreams
6. Acid Rain Effects and the Use of Limestone to Remediate Them
7. Cancer in Plants – Crown Gall Disease and the Use of *Agrobacterium tumefaciens*
8. The Effects of Fertilizers on Plants
9. Hydroponics
10. The Effect of Music on Plants
11. The Effect of Pollution on Plants
12. Cigarette Smoke/Lung Cancer
13. Bacterial Growth on Surfaces
14. "Microbes Cause Infection" (The Apple Thing)
15. The Effect of Different Substances on the Melting Time of Ice
16. Chromatography of Inks and Drink Mixes
17. What Type of Insulation Works Best?
18. Which Substance Cleans Teeth Best?
19. The Effectiveness of Baseball Bats – Wood vs. Aluminum
20. The Decomposition/Biodegradation of Paper in Different Soil Types
21. Crystal Growth
22. Are Clothes Fireproof?
23. Battery Life
24. The Effect of Video Games on the Cardiovascular System
25. Personality Types
26. The Effect of Color on Food Preference
27. Which cereal will best support a colony of mealworms?
28. Do earthworms respond to colored light?
29. Which color light will attract the most insects?
30. What food do birds prefer in an outdoor feeder?
31. Will planaria regenerate faster in different pHs?
32. Can an evergreen be rooted from cuttings?
33. Will snails keep algae off the sides of an aquarium?
34. What type of soil do cacti thrive in?
35. Planaria regeneration studies
36. Will controlling root growth produce a Bonsai tree?
37. Antacids neutralizing stomach acid
38. The effect of salt water on plants
39. Different detergent effects on stains or different cloth types
40. Color of light on solar panels
41. The effect of caffeine on plants
42. pH of local water sources

b. These Project Ideas may be used as a **starting point** to develop your own ideas:

1. Do insects have internal parasites?
2. Will aspirin change the pulse rate of an organism?
3. How will insects respond to pressure changes?
4. Can cockroaches truly survive extreme environmental conditions?
5. Will green mold on oranges inhibit bacterial growth?
6. Why might more insects be found in a field than in a forest?
7. Polytetrafluoroethylene – health risks?
8. Mussels as filters
9. Cholesterol control using roaches
10. Will a DC current have any effect on an ant colony?
11. Will a strong magnetic field have an influence on insects?
12. Effects of nutrient enrichment on algae growth
13. Crayfish dominance hierarchies
14. What soil pH is preferred by earthworms?
15. How will earthworms respond to low direct current in the soil?
16. Do pesticides injure earthworms?
17. Do land snails or slugs prefer light or dark?
18. Effect of electrode materials on fuel cell efficiency
19. Can an invertebrate survive in a sealed, balanced environment?
20. Will invertebrates show up on infrared film?
21. Does a mild soap solution affect invertebrates?
22. Is wasp nest paper more durable than manmade paper?
23. What food preferences do spiders have?
24. What is the intelligence level of invertebrates?
25. Does protective coloration really protect insects?
26. Will aquatic organisms do better in hard or soft water?
27. Will a strong magnetic field confuse aquatic organisms?
28. What color of light do aquatic organisms prefer?
29. Are aquatic organisms drawn towards sound vibrations?
30. Dinoflagellates as test organisms for metal toxicity
31. Can frog development be changed due to manipulation of their eggs?
32. Artificial light for solar cell charging
33. Will colored lights affect the mood of an animal?
34. Do animals other than dogs hear/react to dog whistles?
35. Does soft water really use less soap to clean than hard water?
36. Which natural water in our area has the highest pH and why?
37. Algae bioluminescence as a light source
38. Can you copper plate silverware using DC or battery current?
39. Do insecticides affect organisms other than their intended targets?
40. Do plants affect the amount of humidity around them?
41. Do tree types affect soil pH?
42. What uses can be made of Bernoulli's Principle?
43. Can you transmit your voice over a light beam?
44. Would rollers beneath buildings help in an earthquake?
45. What device can show how steady a student's hand is?
46. Is it physically possible to copper plate insects/leaves/twigs/etc.?
47. Can you construct and program a robot to perform a practical duty?

48. What device can show how strong a student’s grip is?
49. What are the advantages of the geometric shape of wasp and bee nests?
50. Will a heat cable in the soil speed plant germination and growth?
51. Will marigolds control nematodes in the soil?
52. What is the salt tolerance level of common plants?
53. Harnessing fuel from algae
54. Capsaicin as an antibacterial agent
55. Do plants grow better in volcanic ash?
56. Do germinating seeds give off heat?
57. Bioactivity of Triclosan
58. Will fungi mycelium grow in nutrient gel?
59. Will fungi remove dyes from water/soil?
60. Does magnetism affect germination or growth of plants?
61. How does ultraviolet light affect most plants?
62. What is the best type of soil for mushroom growth?
63. Will mildew attack all types of cloth fibers the same?
64. Does chlorine pollution affect plant growth?
65. Are plants affected by extremes in air pressure?
66. What sources were used for ancient pigments?
67. What sources were used for ancient medicines?
68. What effects do “antibacterial” products have on septic systems?
69. What good are air pumps in shoes?
70. Do natural weed killers exist?
71. Can toxic chemicals (like lead) be removed from the environment using natural sources?
72. How strong are synthetic polymers?
73. What additives can strengthen concrete?
74. Does kernel color affect germination rate in corn?
75. *Pseudomonas* and *Penicillium* for bioremediation
76. Does creatine affect earthworm movement?
77. Does earwax have antibacterial properties?
78. Can Aloe vera function as a sunscreen?
79. Is there a functional use for discarded Chitin? (Crab leg shells, etc.)
80. Development of slime molds on mulch.
81. Is there a functional use for eggshells?
82. Is there a chemical way to separate the inner membrane from an eggshell?
83. Do individual Hydra cells segregate from each other in a mixed cell aggregate?
84. Will green and brown Hydra cells mixed in an aggregate separate from each other?
85. Effect of caffeine on seed growth after UV exposure
86. Allelopathy of different tree species
87. Biodiesel Fuel
88. Artificial Neural Networks in computers
89. Fungal degradation of compact disks
90. Cell phones and radar guns effect on *Drosophila* mutation
91. Wheelchair modifications
92. Liquid bandages
93. Antibiotic effects of plant extracts or herbs

94. Use of straw to control algae
95. Phytoremediation of water
96. Does ‘clean-up’ by perpetrator compromise DNA evidence?
97. Effects of toxic water plants on invertebrates
98. Lichens as pollutant indicators
99. Soil tests on roadsides where evergreens are dying
100. Natural larvicides like herbs on mosquitoes and Daphnia
101. Road salt effects on freshwater invertebrates
102. Arsenic percolation in playgrounds
103. Sarcodine bioremediation
104. Hydroponic phytofiltration
105. Antidepressants on crayfish
106. Pillbug pheromones
107. Effect of alcohol on cell cultures
108. Herbal mold retardants
109. Antioxidant effects on *C. elegans*
110. Alfalfa fire retardation capability
111. Acrylamide effects on cell cultures/DNA
112. Naturally colored silk
113. Non carbon dioxide car exhaust material – effects on plants
114. Facial recognition using ‘Faces’ program or sketch artists
115. Sulfur bioremediation
116. Antibiotic effects of honey
117. Cancer cell cultures – reactions to lycopene, etc.
118. Fungal bioremediation
119. Soundproofing insulation
120. Effects of chemicals on a spider’s web construction ability
121. Styrofoam as a strength enhancer for concrete
122. Chromatographic analysis of air or water pollution
123. Sodium benzoate as a fungus control
124. Nanoparticle delivery systems
125. Herbal remedy effects on worms
126. Protein variations in honey
127. Tannins as metal cleaners
128. Aloe vera as a termite pesticide
129. Natural antacids (*Solanum nigrum*)
130. Sunscreen effectiveness – silver nitrate and spectrophotometry
131. Peltier Effect – replacing freon in car air conditioning
132. Phytoremediation using ribbon ferns
133. Heavy metals vs. water plants
134. Phytopurification of drinking water
135. Acid rain vs. *Spirogyra*
136. Phytoremediation of ammonia
137. Spices as pesticides
138. Fish oils vs. breast cancer
139. Tea vs. cholesterol
140. Vitamin E vs. UV mutation
141. Lichens vs. *Staph.*
142. Natural vs. artificial sweeteners – *Drosophila* preference

143. Light wavelength effects on *Drosophila* reproduction
144. Plastic manufacture without petroleum
145. Using eggshells as a calcium supplement source
146. Ethanol production in grasses
147. Saliva as a pH buffer
148. Kudzu as a pesticide
149. Mycoremediation of oil-contaminated soil
150. *Rhue chalepensis* as a pesticide
151. Effects of tea on plant growth
152. UV absorbance of sunscreens in pool water
153. Celery extract as a coolant
154. Oil extraction from seeds
155. Measuring flood potential through soil porosity
156. Microbial fuel cells – construction and energy sources

3. Background Information

a. Understanding **Science Journal Articles**

(1) All research scientists wish to publish. They are interested that the science community learns about their research findings. Since there are thousands of research projects going on each day, the reports must be technical, exact and concise.

(2) When reading a science journal article (one written for scientists, not the general public), you should follow these steps. (See 'How to Do a Literature Search' in Appendix A.)

(a) <u>Photocopy the article</u> - include the bibliographic information so you don't forget where you got the article.

(b) Read the article through once. Then take a break.

(c) Read the article a second time, <u>detailing main points with a highlighter</u>.

(d) Look for the researcher's hypothesis, the methods used, and the results. You should be able to identify:

i) Title of article and author(s).

ii) Hypotheses used.

iii) Focus of experiment. (What type organism, chemical, process, equation, etc.)

iv) Control and experiment groups.

v) Procedural steps with emphasis on measurements and units.

vi) Test types used (if standard).

vii) Results

viii) Category of research.

b. **Writing the Background Literature Summary**

(1) A background literature summary is simply a bibliography that includes a paragraph or two summarizing the main points of each entry. This is very similar to the process of making notecards for a term paper in English.

(2) An annotation (single entry) begins with the author's name in reversed order, followed by the title of the article in quotations, then the periodical is capitalized and underlined. The volume, page, and date are given as well. Skip a line after the reference information to begin text.

Sample Annotation

Bernstein, Neil P., 'Vegetational History of Mentor Marsh.' The Ohio Journal of Science. May 1981. Vol. 81, no. 3, pp.105-108.

Mentor Marsh is a remarkable wetland on the south shore of Lake Erie, east of Cleveland. It possesses a diverse number of plant species, several of which are not found elsewhere in Ohio Lake Erie wetlands...

--Points should be summarized in one (1) to two (2) paragraphs.

c. **How to find Research**

(1) Research material comes in many forms. This includes: journals, the Internet, books, magazines, texts, manuals, encyclopedias, people (written or interviewed), videos, audio tapes, etc. Most research for a science project will be found in a library. In this area, there are many libraries to choose from. Here is a list, from least helpful to most helpful.

(a) Marian Library - limited science research information.

(b) Public Library branches

i) Elkhart
ii) Mishawaka
iii) South Bend main libraries.

(c) IUSB Schurz Library

(d) Notre Dame Hesburgh Library

(2) These libraries usually have all research material referenced on computer. In the appendix, you will find information regarding the IUSB reference system. The process is extremely similar for Notre Dame and the public libraries.

(3) Notre Dame has split its scientific libraries between various buildings. Besides the main library building, you may need to find:

(a) Fitzpatrick Hall - Engineering library on first floor.

(b) Galvin Life Sciences Building--Life Science library on first floor.

(c) Nieuwlands Hall - Chemistry/Physics Library on second floor.

Maps of the Notre Dame Campus are available online.

4. **Writing the Hypothesis** (See also page 50)

a. A hypothesis is an educated guess that attempts to answer your problem question. When forming your hypothesis, clarity of wording is extremely important. It should be brief, concise and narrowed in scope. A hypothesis should cover only one variable. You may have more than one hypothesis involved in your project.

b. A hypothesis should be stated as an answer to your problem question. It should begin with the word 'that'.

c. Examples

(1) That the longevity of *Drosophila melanogaster* is inversely proportional to the concentration of DDT added to the food media during the egg-larvae stage of metamorphosis.

(2) That the inter-nodal stem growth during the first weeks following seed germination of *Zea mays* is directly proportional to the concentration of nitrogen in the hydroponic solution.

(3) That there will be no significant physiological differences between male and female lab rats when exposed to a sound frequency of 5,000 cps at a decibel level of ninety.

5. **The Outline**

Before you begin experimentation, you need to plan your process step-by-step. The outline you make is different from the outline form you are familiar with. The Science Project outline is a form required for all projects by the International Science Fair Committee. It is more accurately called the Research Plan (see Form IA). This plan must be completed in full with all signatures, and turned in, in duplicate, by the stated due date. ***Note: For the following sections 5-9, see also descriptions under: E. Writing the Science Research Paper.**

6. **Materials and Methods** (See also page 51)

a. An important part of your science project is a detailed list of all materials used. The purpose of listing your materials is so that anyone who wishes to re-do your project can gather the same materials you used. In the world of Science research, scientists commonly repeat others' work to verify their findings and set up new modifications. It is important that your materials list be <u>as specific as possible</u>, including brand names and measurements where applicable. To be more accurate, you may wish to include the materials used solely for your backdrop (paper, pen, computer, etc.) under a separate heading.

b. **Make sure to use only Metric (S.I.) measurements when gathering data.**

c. As you can see from Form 1A, a list of methods or procedures is needed before you begin your experimentation. Scientists refer to this list as the protocol of the experiment. It is necessary so that others may repeat your project. This list should be as detailed as possible, but may always be modified along the way.

7. **Data Collection**

This is the meat of your project. Be accurate, precise, and complete. **All measurements should be in metric units!!!!!** Your data should include the following:

a. Timetable - How often did you collect data? When did you start? When did you stop?

b. Accuracy - How accurate were your observations and measurements? Did you estimate? What did you compare non-numerical data to? Make every attempt to convert data to a measurable scale, i.e., Numbers.

c. Reporting - <u>All data must be reported. It should all be recorded in a project databook (in ink!)</u> Any data that does not fit your project's intent should not be removed. Any mistakes should be changed by crossing- out, not erasing. Data applicable to your project's intent must also be reported in the form of charts, tables and/or graphs. Use a computer program for this purpose.

d. Photographic Evidence - <u>Take pictures from start to finish!!!</u> This ill be your only way to verify that you actually performed your experiment. Remember to end experimentation with enough time left before the due date to get your pictures developed. The one hour developing is very expensive. You may want to take duplicate pictures on separate rolls of film. Developing places have lost film in the past. With two rolls of film at different developers, you have a better chance. **All pictures must be included with the final project. Pictures of people must be accompanied by a signed release form (Form 4B) for each person in the photograph.**

8. **Report on Results** (See also page 51)

This section is where your collected data is presented. It should include all the information outlined above.

9. **Discussion Section** (See also page 52)

The purpose of this section is to relate collected data to your problem. It is here that you explain if your hypotheses were supported by data or not, and how.

10. **Conclusions** (See also page 52)

This section reviews hypotheses and shows how general trends in data relate to them. The average person should be able to look at only your problem, hypotheses, and conclusions and understand what your project was all about. Conclusions should also include:

a. <u>Sources of Error</u> - What could possibly have caused any errors or inconsistencies in your data? Inaccuracy of measurements, human error, skipping a data point, too long or too short a time between data points, etc. can all be sources of error. List all that apply to your project and explain each.

b. <u>Further Study</u> - Include what could be done in the future to improve or continue your study.

D. <u>Backdrop Design</u>

1. **Title** - Your title should be short and to the point. It should identify the focus of your project. You may wish to use your problem, hypothesis, or a restatement of either as the project's title. It does not have to be in question form. Here are some helpful hints on titles:

a. The title should be large, with big, easy-to-read letters. <u>It should not, however take up most of your backdrop</u>.

b. <u>Stenciled letters should have spaces connected and filled in</u>.

c. Do not use fancy style lettering of any kind. <u>Use block letters only</u>.

d. **Center** the title at the top of the display.

e. Use <u>only one color</u> for the title, preferably one of high contrast to the background.

f. Computer-printed titles are fine.

2. **Construction**

a. Your backdrop must stand by itself. Poster board will wilt over time, and is not acceptable for a backdrop. Wire hangers, rulers, dowels and tinker toys will also make for very poor backdrop supports. Your best bet is to use corrugated cardboard, fiber board, foam board, pegboard, wood or some kind of plastic/metal framework. The easiest thing to do is to purchase a Showboard type type tri-fold display board. These are available through your teacher. Professional quality backdrops will be made available to projects advancing to competitions.

b. Size limitations for a project display are:

(1) 76 cm (30 in) deep

(2) 122 cm (48 in) wide

(3) 274 cm (108 in) high - tables are usually 76 cm (30 in) high

c. <u>Presentation of Clear Information</u>--Your backdrop must contain all information pertinent to your project. It is basically the only thing most people will see. The following sections should be included on your backdrop:

(1) **Title**

(2) **Problem**

(3) **Hypothesis**

(4) **Materials**

(5) **Procedure**

(6) **Results** (Graphs, tables, etc.) - make sure each is clearly labeled.

(7) **<u>Photographs</u>** - a minimum of six for the final project – **Must have caption and credit**

(8) **Discussion**

(9) **Conclusions/Unanswered questions/Sources of error**

(10) **Bibliography** (a minimum of six references excluding encyclopedias)

(11) **Abstract**

d. Each of the above sections (except for title) should have its own heading. These can be purchased, or made yourself. This allows a viewer to locate the section of your project that is most interesting to them.

e. Information should flow smoothly. The above list is pretty much in order of how the information should be presented. Remember, since we read from left to right, your information should flow from left to right as well. With the title in the top center, the left side of the board should hold the Problem, Hypothesis, Materials, and Procedure. The center of the board should display the Results and the Photographs. All other information should be on the right. You do not have to set it up this way of it does not fit. Use your own judgment. The important thing is that your information flows from start of project to end of project.

3. **Appeal**

a. Besides presenting your information, your board's purpose is to attract attention. It should be visually stimulating without being obnoxious or painful. When in a room full of projects, yours should say 'look at me first' through its visual appeal.

b. Different methods to increase visual appeal.

(1) Bright colors. (Caution! - colors that are too bright give people headaches, and they will not want to look at your project. Also, don't use too many different colors.)

(2) Pictures, photographs, drawings, graphs, tables, illustrations, etc.

(3) Balance - too much open space or overcrowding is bad.

(4) Matting - border each set of information with construction paper or matte-board.

(5) Clear lettering

(6) Heading labels

(7) Typed information

c. Hint: Use Excel, Deltagraph, ChemDraw, Super Paint, Lightning Paint, etc. for illustrations. Most computers include some type of drawing or graphing program.

4. **Display Rules** (non-backdrop related)

a. The following things **<u>may not</u>** be displayed:

(1) Living organisms (plants, animals, microbes, etc.)

(2) Dried plant materials (unless sealed in acrylic or other similar material)

(3) Taxidermy specimens

(4) Preserved animals

(5) Soil or waste samples

(6) Chemicals (including water) unless integral to an <u>enclosed</u> apparatus

(7) Human or animal parts or body fluids

(8) Human or animal food

(9) Sharp items

(10) Poisons, drugs, controlled substances, hazardous substances or devices

(11) Dry ice

(12) Flames or flammable material

(13) Tanks that have contained combustible materials unless certified as having been purged with CO_2

(14) Batteries with open top cells

(15) Awards, medals, business cards, advertisements, etc.

(16) Photographs or visual presentations depicting vertebrate animals in other-than-normal conditions (i.e. surgery, dissection, autopsy, or lab techniques).

(17) Personal photographs, accomplishments, acknowledgments, addresses, phone or fax numbers, E-mail or web-site addresses.

(18) All hazardous substances or devices (poisons, firearms, drugs, weapons, ammunition, lasers, etc.)

(19) Glass or glass objects unless integral and necessary to the project

Items Allowed at Project or in Booth BUT with the Restrictions Indicated

(1) Soil, sand, rock, and/or waste samples **if permanently encased in a slab of acrylic**

(2) Postal addresses, World Wide Web and e-mail addresses, telephone numbers, and fax numbers **of Student Investigator only**

(3) Photographs and/or visual depictions **if:**

a. They are not deemed offensive or inappropriate by the Scientific Review Committee, the Display and Safety Committee, or Science Service. This includes, but is not limited to, visually offensive photographs or visual depictions of invertebrate or vertebrate animals, including humans. The decision by any one of the groups mentioned above is final.
b. Credit lines of their origins ("Photograph taken by..." or "Image taken from...") are attached. (If all photographs being displayed were taken by the Student Investigator or are from the same source, one credit line prominently displayed is sufficient.)
c. They are from the Internet, magazines, newspapers, journals, etc., and credit lines are attached. (If all photographs/images are from the same source, one credit prominently displayed is sufficient.)
d. They are photographs or visual depictions of the Student Investigator.
e. They are photographs of human subjects for which signed consent forms are at the project or in the booth. (Human Subjects Form 4 or equivalent photograph release signed by the human subject must be included in the paperwork and must be properly checked on the Intel ISEF Official Abstract and Certification.)

(4) Any apparatus with unshielded belts, pulleys, chains, or moving parts with tension or pinch points **if for display only and not operated**

(5) Class II lasers **if** :

a. The output energy is <1 mW and is operated only by the Student Investigator
b. Operated only during the Display and Safety inspection and during judging
c. Labeled with a sign reading **"Laser Radiation: Do Not Look into Beam"**
d. Enclosed in protective housing that prevents physical and visual access to beam
e. Disconnected when not operating

(6) Class III and IV lasers if for display only and not operated

(7) Any apparatus producing temperatures that will cause physical burns if adequately insulated.

c. **Restrictions**

(1) Vacuum tubes or ray-generating devices must be shielded.

(2) Pressurized tanks must be secured.

(3) Apparatus producing temperatures that cause physical burns must be insulated.

(4) High-voltage equipment must be shielded with a grounded metal box.

(5) Wiring, switches, and metal parts must be insulated and have overload safety factors.

(6) Electric circuits for 125/220-volt AC must have a maximum of nine foot cord approved by Underwriters Laboratories.

(7) Electrical connections in 125/220-volt circuits must be soldered or made with UL approved connectors and insulated. (Maximums are 500 watts @130 VAC/60 hertz or 250 watts @ 220 VAC/60 hertz.)

(8) Bare wire and exposed switches may be used only in circuits of 12 volts or less.

(9) Handouts must be limited to one copy of the official abstract.

d. **Necessities** -Besides your backdrop you should also include:

(1) Your project databook or journal where you have recorded all data, procedures, etc.

(2) Abstract.

(3) Research paper, if required.

(4) <u>All required forms, surveys, tests, etc.</u> It would be best to attach folders with pockets onto the back of your display board to hold the above materials.

E. Writing the Science Research Paper

***It is important to note that various competitions require specific formats for papers. The rules provided by these organizations will supercede or enhance the rules provided here as applicable.**

1. General Hints

a. Drafts and Rewrites

(1) Writing is difficult. Writing sensible sentences, paragraphs, and entire papers is nearly impossible on first attempts. All published authors write a first draft and then revise and rewrite it, usually several times. You must do the same.

(2) To make the job as easy as possible, the work should be broken down into sections (as an outline). Work on each section separately, and put the final copy of each section on an individual sheet. Do not put page numbers on until each section has been revised, proofread and assembled correctly.

b. Clarity and Concise Writing

(1) The use of needless and confusing words and phrases must be avoided. Information must be presented clearly with an absence of wordiness. Examples:

Wordy	Concise
at this time	that
due to the fact	that
because during the time	that
while for the reason	that because
goes under the name of	is called
if conditions are such	that if
in the event	that if
it is often the case	that often
often it would appear	that apparently
serves the function of	being is
it was discovered by Jones	that Jones discovered

(2) After completing your drafts, slowly read over your paper, eliminate excess words, and re-phrase awkward passages. Have someone else proofread it and do the same. Then have someone else read it aloud to you. Listen to see if it makes sense. If not, change it again.

(3) Remember the "Ten Rules" from English class:

1. Always write in third person.
2. Run-on sentences and fragments are never permitted.
3. Sentences must agree in number and gender.
4. A paragraph should contain at least five sentences.
5. Each paragraph should contain only one idea.
6. Spelling and proper punctuation always count.
7. Never abbreviate or use contractions.
8. Avoid clichés.
9. Never use the word THERE …Ever!
10. OF is not the same as HAVE. A LOT is not a word.

c. Paper and Writing Types

(1) If you choose to hand write your report, (**which is not preferred**), use lined paper, or typewriter paper under which you have place lined paper as a guide.

(2) Use unpunched paper when possible. Be sure that it is good quality and standard size. Do not use recycled paper for reports! Never use paper torn from a binder. Paper torn from spiral bound notebooks is unacceptable, even if the edges are cut off. Do not use colored paper.

(3) Do your best to use a typewriter or, better yet, a computer. Make sure that the ribbon prints dark letters. Clearly correct errors. Use as little correction fluid as possible, that is, retyping is better than white-out.

(4) Use one side of the paper only. If hand-written, use only black ink.

d. **Format**

(1) Number all pages in the upper right corner. Do not use periods after the number. Place your last name in front of the number.

(2) Make at least two copies (both are turned in) of your research paper. (It is much easier to do this if you use a computer and store the paper on a disk.)

(3) Reports will average about 5,000 words or 20 double-spaced type written pages.

(4) Double space the body of the paper. Use 12 point type. Choose from following fonts: HELVETICA, TIMES NEW ROMAN, COURIER NEW.

(5) Indent paragraphs five spaces.

(6) Leave four line spaces between a section and the next heading, if putting more than one section on a page. If only one section is on a page, center that section on the page.

(7) Leave two line spaces between the heading and the start of a section.

(8) Standard format:

(a) Title
(b) Abstract
(c) Introduction
(d) Problem
(e) Hypotheses
(f) Materials
(g) Methods or Procedures
(h) Results (including data, graphs, etc.)
(i) Statistical Analysis
(j) Discussion of Results
(k) Summary and Conclusions (w/ sources of error)
(l) Works Cited
(m) Appendix (optional)

2. **Sections of the Research Project and Paper** - in detail

a. TITLE - Every scientific paper must have a title. The most important aspect about the title is that it be self-explanatory. That is, the reader should be able to tell, just by reading the title, what you have done without having to read the paper itself, A title, such as A BIOLOGY RESEARCH PROJECT, for example, tells the reader nothing. The reader has no idea whether your work involved an animal or a plant, or what you were measuring or testing. An example of a good title would be: THE EFFECTS OF LIGHT AND TEMPERATURE ON THE GROWTH OF THE BACTERIUM *ESCHERICHIA COLI*. In this example, the title explains what the worker has done; he has manipulated two environmental factors (light and temperature) to determine what the effects will be on the growth of a specific organism (*E. coli*). There are some exceptions to this guideline in which the author does not state all of the factors that were manipulated. The following title would be acceptable; EFFECTS OF VARIOUS CHEMICALS ON THE GROWTH OF *E. COLI*. In this case, the complete title would be too long. The same guideline applies if more than one organism is involved. For example; EFFECTS OF LIGHT AND TEMPERATURE ON THE GROWTH OF SEVERAL SPECIES OF BACTERIA. The researcher would, of course, include the names of the several bacteria in the text of the paper.

b. INTRODUCTION - The introductory section of the paper contains basic theory concerning the problem along with information on related investigations. The researcher states the purpose of the investigation, that is, the specific question(s) s/he is attempting to answer. S/He also describes relevant information he has been able to locate concerning the problem, including any research that has been done on the problem in the past. This is usually accomplished by a literature search in the library. All background information the researcher has gathered from textbooks and journals must, of course, be appropriately referenced. Any time a researcher mentions factual information in his paper that is not information he personally obtained (via his own experiments or observation) the researcher must include a reference to indicate the source of that information. This is referred to as 'citing the reference'. The first rule to remember when citing references in a science research report, is that footnotes are not used for this purpose. Footnotes are only used when additional explanation may be needed about data given on that page. If you have stated some factual information that needs to be cited, put the last name of the author of the source of that information in parentheses at the end of the statement. It should be followed by the page number it is found on. Example: Some birds eat only insects and obtain all the water they need from the insects they eat. (Smith, p.490) The Introduction Section will usually be the largest section of the report. In most cases, at least 75 % of this section would have been stored on a disk containing the initial proposal. It should be written in past tense and usually contains three (3) to five (5) double-spaced typewritten pages. The last paragraph ties together the introductory section with the remainder of the paper. It clearly states why the investigation is being performed. The following paragraph demonstrates this important element of a paper.

(Taken from Kim McIntosh's research paper)

Aedes albopictus is a major vector (i.e., carrier and possible transmitter) of arboviruses (i.e., viruses that can replicate in both vertebrates and arthropods) and dengue fever virus in other countries. They are also easily infected by parasites, some of which currently have not been found to harm humans or other animals (O'Meara, p. 169). As a result of these factors, the potential for *Aedes albopictus* "to become a major vector of arboviruses of public health importance may increase" (O'Meara, p. 171). Other aspects that increase the possibility for *Aedes albopictus* as a vector are its tendencies to bite a wide variety of species and the proximity of its environment to areas of human habitation (Stevens, p. 10A). Since *Aedes albopictus* has the ability to live in varied climates and temperatures, some scientists feel that they will begin spreading to the northern regions of the United States. *Aedes triseriatus* is the most common mosquito found in Indiana. Since *Aedes albopictus* dominated this mosquito in Florida, it would probably do the same in Indiana. Therefore, discovering how *Ascogregarina taiwanensis*, the common parasite in *Aedes albopictus*, affects the mosquito's size, and in turn its reproduction rate, may be a potentially effective way to control these mosquitoes if they migrate north as expected.

c. <u>PROBLEM</u> – Make a clear statement of not less than 4 sentences explaining the subject/question you are investigating. This section should end with a question.

d. <u>HYPOTHESIS(ES) TESTED</u> - This section, although very important, will likely be brief. Clarity of wording is extremely important. The following examples will demonstrate good form. Note that the hypotheses were not taken from the same research project.

(1) That the longevity of *Drosophila melanogaster* is inversely proportional to the concentration of DDT added to the food media during the egg-larvae stage of metamorphosis.

(2) That the inter-nodal stem growth during the first weeks following seed germination of *Zea mays* is directly proportional to the concentration of nitrogen in the hydroponic solution.

(3) That there will be no significant physiological differences between male and female lab rats when exposed to a sound frequency of 5,000 cps at a decibel level of 90.

e. MATERIALS AND METHODS - In these sections (which should be separate), the researcher explains HOW and WHERE he did his work. He describes his experimental design, experimental apparatus, methods of gathering data and the type of control. If any work was done outdoors in a natural habitat, the researcher describes the exact location and explains when he did his work. If any specimens were collected for study, their locations must be recorded and a time reference given. The basic rule to follow is that the procedural steps and materials section should be detailed and clear enough that any interested reader could duplicate the experiment if he wished. A second rule to review is that these sections should be written in the past tense.

(1) The following two procedural steps are poorly written.

(a) First pour six petri dishes full of agar, then inoculate them with fungus.

(b) I put the dishes in an oven and then looked at them the next day.

(2) The following steps would be acceptable

(a) Six petri plates were prepared with TSA agar and inoculated with the fungus *Aspergillus flavus*. (From microbiology department, Notre Dame).

(b) The inoculated plates were then placed in an incubator at 40°C for 24 hours.

(3) Generally it is not necessary to describe equipment, unless it is specifically built for your project. In such a case it would be necessary to describe in detail, perhaps in the appendix, the equipment. Sometimes a sketch is included.

f. RESULTS - When a researcher presents his data to the scientific world he tries to make that data as easily understandable as possible. He puts that data into a form that easily shows the reader any correlations, relationships or patterns that are important. Two widely used methods for doing this are tables and graphs. A table is the most efficient method of presenting numbers. The table classifies the data, and its organization should be self-evident. Because the numbers in a table usually could be arranged in several different ways, it is desirable to try several different forms and select the one that will demonstrate the results to the reader most effectively. All tables should have a title and all columns on the table should be properly identified. Although the table may be the most effective way of presenting the findings, it may not be the clearest to understand or the easiest in which to detect a trend. Where space is not a problem, as in this paper, both graphs and tables containing the same data are often used. Usually one variable is dependent on a second variable. Mathematical examination shows that one is a function of the other, or that $y=f(x)$. The length of a growing animal varies with time, not vice versa. The absorption of light by a solution depends on the concentration of the solute. Either you control the factor and measure its effect or you observe the relationship with some uncontrollable factor, like time. In either case, the effect goes on the vertical axis and the independent variable goes on the horizontal axis. For both tables and graphs, where the data are expressed in inconveniently large or small numbers, it is often best to indicate in the heading that all entries contain a common factor. Line graphs should be used for Continuous Data (i.e. growth). Bar graphs should be used for discontinuous data.

The degree of significance should also be determined and noted using some test of significance, such as **Student-t**, **Z**, **N**, **ANOVA**, **Chi-square**, etc. (See section G.) Where appropriate, the formula for linear regression and the value for the correlation coefficient should be included on the graphs and/or tables.

g. DISCUSSION OF RESULTS - The results mean nothing unless they are related to the problem. The main purpose of your report is to communicate your findings, however, if the reader sees no significant trend in your findings and if the trends are not identified, the whole project and paper have been a waste of time. The data in the results section may not be associated with the correct hypotheses by the reader. In the discussion of the results section, one would again restate the tested hypothesis and then generalize about the data related to that hypothesis. It is in this section that one clearly indicates if the hypothesis was supported by the findings. It is quite proper to list the hypotheses one at a time and look at the gathered data. One must be careful of the way in which the data are interpreted.

(Taken from John Andrew's work)

In this experiment, the hypothesis was partly supported. As the graphs read, the static coefficient seemed to increase with mass, yet surface area did not cause an increase in either coefficient. It appears that mass had an effect because of the forces involved in friction, all which depend on mass, shown by the equations:

$$\mu_s = \frac{mg\sin\theta_s}{N} = \frac{mg\sin\theta_s}{mg\cos\theta_s} = \tan\theta_s$$

and

$$\mu_k = \frac{mg\sin\theta_k}{N} = \frac{mg\sin\theta_k}{mg\cos\theta_k} = \tan\theta_k$$

The results produced may have been more conclusive with better and more precise equipment, yet they did show some results.

h. CONCLUSIONS - By this point in the paper, the conclusions should have become clear to both the writer and the reader. However, not all people take the time to read the report and look at the data. Many researchers read only the hypotheses and the conclusions-at least initially. In general, the conclusions would review the hypotheses and the general trend of the collected data related to the hypotheses. The conclusion section should contain sources of possible error, as well as any future action that is planned.

Never, ever use the word "prove" in a science project or report.

i. WORKS CITED - In all such studies, you will refer to some specific articles and make indirect references to other books or papers. You should identify all such resource materials. Basically, in this section, you would list the references alphabetically, by author. Use the Marian Style Guide for correct bibliography form. You should be using the MLA style of reference citation. IMPORTANT: By using the system noted in section b. INTRODUCTION and section h. WORKS CITED, there is no need for a footnotes or endnotes page, all you need is a Works Cited page!! **For this project, you should always have a minimum of six (6) resources.**

j. APPENDICES--Appendices are optional parts of a science research paper. They may contain necessary information that is not an integral part of the experiment(s) performed. They may also include photographs, and other information that you do not wish to include in the main paper. Appendices should be labeled by capital letters. If there is only one appendix, no letter label is necessary.

k. COVER PAGE

(1) Title is centered and placed about one quarter below the top. It should be all in capitals unless lowercase letters are necessary (as in pH).

(2) Your name, centered, with initials capitalized only, is placed half way down from the top.

(3) The following information should be in the lower right corner:

(a) Teacher's name

(b) Class name and hour

(c) Date

l. Additional Notes

(1) Do **not** use folders, report covers, etc.

(2) Use only one or two staples in the left corner to attach pages.

(3) **Proofread** your paper at least twice, and have two other people proofread it as well.

F. <u>Abstract</u>

1. The purpose of the abstract is to present the key points of your project and report, giving a quick, basic understanding of important information and findings. It should be a maximum of 250 words long, and never more than three paragraphs (usually only one).

2. An abstract should include the purpose of the experiment and the procedures used, as well as a summary of the data and conclusions. It may also include any possible research applications.

3. The abstract should be the last part of the report to be completed, although it appears just after the cover page.

4. The abstract should <u>begin</u> with the following information (no indentations):

    a. **TITLE (ALL CAPITALS)**

    b. **Your name, last name first**

    c. **Your full address**

    d. **Marian High School, Mishawaka, IN** (skip one line only)

5. The body of the abstract should be <u>single-spaced with no indentations</u>. The entire abstract (including the above information) **must fit in a space 5-1/2 inches high by 6 inches wide.**

6. Use elite type and make sure the ribbon or cartridge is good and will print dark letters.

7. See Mr. Andrzejewski for samples. See the website in Appendix B for form.

G. <u>Statistics</u>

1. Your data will be much more accurate and valid if run through a statistical analysis. This will determine if your collected data varies from expected results, and whether the difference falls within the realm of chance, or is significant to your study. These analyses should be included in your data section. All projects should minimally show an analysis of Central Tendencies of the data (mean, median, mode, standard deviation). Advanced course projects should minimally include a Student T Test.

2. Analysis of Central Tendencies and Student T test instructions are available from your teacher. Different types of statistical analyses are also available from your teacher. We also have many of these analyses on computer programs.

H. Poster Presentation

1. The Poster Presentation is a common method of reporting progress in an ongoing experiment. It is a miniature version of your final presentation, designed to show what **progress** has been made in the first stages of your investigation.

2. This presentation is made on a typical posterboard. It should fit onto the front side only, with no overlap. If you find that you have too much for one poster, then you must edit your information.

3. The Poster Presentation should include the following:

a. **The Title** of your project in question form. (This should be large enough to stand out, but should not take up a large amount of room on your board. Keep it plain and simple.)

b. **Problem** - a minimum of **four (4) sentences** that gives background knowledge of your experiment, ending with a question that can be answered by your hypothesis.

c. **Hypothesis(es)** - an assumption that begins with the word **"that"**.

d. **Materials used thus far** - a list of materials used and their measurements. Use **metric measurements** at all times.

e. **Procedure used thus far** - a step-by-step set of instructions written clearly enough so that anyone can repeat your experiment.

f. **Preliminary Data** - this is where you place tables and graphs. All tables and graphs should include a one line explanation below them, summing up what they represent. This is where you show calculations, pictures, and diagrams of your experimental setup. A minimum of three photographs is required.

g. **Results** - explain the meaning of your tables, graphs, and calculations in a **minimum of four (4) sentences**.

h. **Discussion** - restate your hypothesis, tell whether it was **supported or not supported** and why, and list any sources of error. Remember, never use any form of the word "prove".

i. **Current conclusions**, **future course of action, and errors**
- what would you change about this experiment?
- Did this experiment raise new questions?
- What were these questions?
- What direction will you take for the remainder of your project?

j. **Bibliography** (which may be on the back of the poster)

Suggested format for Poster Presentation

	TITLE	
Problem	Data (Tables/Graphs & Pictures)	Discussion
Hypothesis		Conclusion and Future Action
Materials	Results	
Procedure		Bibliography

I. <u>Presentations</u>

1. You may be required to give a 10-15 minute presentation on your project. You will need to use your backdrop for this. You may bring in other props, videos, etc. to aid your presentation.

2. Suggested format

    a. State your title and explain it.

    b. List an aspect which nearly everyone has heard or read about, i.e. benefits of exercise, etc.

    c. Discuss the work of previous researchers

    d. State the reason for your investigation.

    e. Describe your experiment.

    f. State your hypotheses.

    g. Review your procedures.

    h. State the results and conclusions.

    i. State the uncertainties and sources of error.

    j. Ask for questions...

3. A PowerPoint Presentation will also be required. Information about this will be given to you by your instructor. Rules pertaining to PowerPoint Presentations are determined by the Junior Science and Humanities Symposium sponsored by the U.S. military.

II. Grading

The science research project comprises a major portion of your grade. Worksheets, outlines, proposals, presentations, and the research paper are all included for your semester total.

Grading Outline Total Worth--**250** possible

1. **Design**--Subtotal **30** pts.

   a. **Neatness: 5**

   b. **Typing: 5**

   c. **Organization: 5**

   d. **Clear Labels: 5**

   e. **Visuals: 5**
   --includes photos, drawings, diagrams, mattes, etc.

   f. **Construction: 5**

2. **Experimentation Verification** --Subtotal **30** pts.
   --Photographs from duration of project showing progress as well as distinct experimental and control groups. Additionally, projects involving surveys or questionnaires must show **<u>all</u>** surveys or questionnaires.

3. **Data/Report**--Subtotal **100** pts.

    a. **Title: 5**

    b. **Hypothesis: 5**

    c. **Problem: 5**

    d. **Procedure: 10**

    e. **Materials: 5**

    f. **Data: 15 --** must be presented in a quantitative manner.

    g. **Central Tendencies/Statistics: 10**

    h. **Abstract: 10**

    i. **Results: 10**

    j. **Discussion: 10**

    k. **Conclusions: 10**

    l. **Bibliography: 5**

4. **Quality**--Subtotal **90** pts.

    a. **Scientific thought/complexity: 50**
    (Clear and concise problem; limited variables; adequate data; future research possibilities; use of literature; time involvement; how much was actually done by student; reliance on consultant; sources of equipment; site of experiment; repeat project sufficiently different; appropriate to ability level)

    b. **Creativity: 30**
    (Question asked; approach to solution; analysis of data; interpretation of data; equipment used; new equipment design; similarity to published experiments)

    c. **Sources of Error and Future Action: 10**

III. Grant Opportunities

For motivated students, learning is not done for the sole purpose of getting good grades. The opportunity to better understand how processes function within the universe and to apply knowledge learned in the classroom to the real world should be the ultimate goal of education. Below is a list of science opportunities in which some of you may be interested. Because of certain limitations no one can be actively involved in all of them. We will try to advise you and help you prepare the necessary forms or proposals. See your Science Research Director for current information.

1. **INDIANA ACADEMY OF SCIENCE** -research funds, presentations at conventions, exchange of ideas with scientists. Research grants of up to $300 are given. A final research report must be submitted in May. Proposal deadline is late October.

3. **INTEL SCIENCE TALENT SEARCH** -scholarships, trips, discussions with professional scientists. Student must be in top 5% of graduating class. No vertebrate animal experimentation can be entered. An extensive application must be completed by the November deadline.

4. **INDIANA SCIENCE TALENT SEARCH** -scholarships, trips, discussion with scientists, tours of research facilities You can enter your research paper from this Research Program. Vertebrate animal work **CAN BE** entered. A brief application must be completed. Deadline is Mid-June with presentations in October of the following year.

5. **NORTHERN INDIANA REGIONAL SCIENCE AND ENGINEERING FAIR** AT NOTRE DAME -awards, recognition, opportunity to exchange ideas with other science students and professional scientists. Usually held between late February through mid-March.

6. **JUNIOR ACADEMY OF SCIENCE**--Awards, trips, discussion with scientists. Deadline for applying is late September for early November presentations.

7. **THREE RIVERS SCIENCE SYMPOSIUM**--Scholarships and guided investigations in advanced science techniques at St. Francis College in Fort Wayne. Held on a Friday and Saturday in October and March.

8. **INDIANA JUNIOR SCIENCE AND HUMANITIES SYMPOSIUM**--Awards, trips, discussion with scientists. Deadline for applying is about Dec. 1st for March presentations.

Acknowledgments

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A. Blakeman, John--Perkins High School, Sandusky, Ohio

B. IUSB

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D. Marian High School English Department

E. Purdue University School of Agriculture

F. Society for Science & the Public (International Science and Engineering Fair)

G. Showboard, Inc.

H. Sollenberger, Harold--East Noble High School, East Noble, Indiana

I. University of Notre Dame

Technical Assistance

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B. Duplication: Janet Tricker

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D. Computer Assistance: LeRoy Castle

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F. Web page Assistance: Byra Warner

APPENDIX A

WORKSHEETS

RESEARCH PROPOSAL FORM

(This form should become the first entry in your Project Data Book.)

Name_______________________________________

Category of Research (from p.27-30)____________________________

1. General title of research proposal:

2. Explain the purpose of your intended research, **describing experimental setup and control**.

3. Suggested timeline with dates. (This may be modified in the future.)

4. Why do you want to research this topic?

5. List six (6) keywords or terms likely to be associated with your proposed area of investigation. (These will help you in your Literature Search.)

_____________________ _______________________ ___________________

_____________________ _______________________ ___________________

Instructor's Approval

____

Parents' Approval

____

HOW TO DO A LITERATURE SEARCH

When beginning a research project in Science, or any subject, it is important to investigate and collect some background information on your chosen topic. An important way of doing this is to perform a Literature Search.

A Literature Search is the first step (after choosing your topic) in doing a research paper or annotated bibliography. In this exercise, you will do a short Literature Search on your chosen subject. **Follow the steps carefully.**

1. Locate a **minimum** of six (6) references that relate to your chosen topic. They can be exact matches, or only indirectly related to your subject. For example, a study on how light affects plant growth could use references dealing with that exact subject, or with light, plant growth, plants in general, etc.

--Use the six (6) keywords from your topic proposal to search through the reference systems at libraries, or the Internet. (Try Google Scholar)
--Your references may include:

a) Magazine or journal sources, or
b) Internet sources.

-- References that are solely from the Internet are usually frowned upon in competitions. Most reliable Internet resources will actually have the bibliographic info of the original source included.

--Encyclopedia entries, including computer and Internet encyclopedia sites, may be used as extra background info, but **do not** count towards the six source minimum. **Never use Wikipedia as a source!**

2. When you have located your sources, duplicate the article, or print the Internet information.
3. Read the sources, highlighting with a highlighter pen the following information:
   - a) Title of article or information
   - b) Author
   - c) Hypotheses used
   - d) Focus of article or experiments
   - e) Control and experimental groups
   - f) Procedure
   - g) Results
   - h) Category of research
4. Don't forget to include complete bibliographic data for the source.

5. Hand in all highlighted copies by specified due date.

USE OF REFERENCE MATERIALS
THE BACKGROUND LITERATURE SUMMARY

Library research is a very important component of scientific investigation. The investigator should be familiar with experiments done previously, related to his/her field. This background knowledge could lend new insight to the scientist's current course of investigation. A journal search and background literature summary is an important and valuable method to accomplish this background research.

Scientific journals are magazines written for the scientific community. They contain basic facts, data, and conclusions without any unnecessary commentary. In this assignment, you will be doing a background literature summary of journal articles. Do not use magazine sources written for the general public, because the content is watered down and contains little helpful data. Using the resources at IUSB, Notre Dame, and Saint Mary's, or the Internet, complete the following:

1. List at least six (6) specific keywords used in your journal search. (These can be the same ones you used for your proposal and your Literature Search.)
2. Find a **minimum total of six (6)** reference articles from the various possible sources. (Sources include the various CD-ROM programs or reference catalog systems at the Universities, the computer reference system in our library, and the Internet. Google Scholar is a great resource.)
3. Photocopy or print the articles, making sure to correctly identify each journal or Internet source.
4. Read the articles and highlight important information with a highlighter pen. (Do **not** simply underline.)
5. Write an annotation (short summary) of each article, beginning with a proper bibliographical entry for the source (see page 15.) This annotation should include all major points, and should be one (1) to two (2) paragraphs long. (A paragraph contains five (5) sentences.) Do **not** attempt to copy the summary provided by either the long form of a CD-ROM search or the article itself.
6. Attach the annotation to the Photocopied or printed article and turn in all six (6) by the specified due date.

THE PROJECT DATA BOOK

The Project Data Book is a journal of your progress through your Science Research Project. It is an accurate record of your data collection, including timelines, notes and photographs. The Project Data Book may be a notebook or binder, but must be bound in some way. Perhaps the best method would be a 3-ring binder with loose-leaf paper. That way, more paper can be added as needed. You can either attach photographs to paper (glue, tape, or staple), or add pages from a photograph album to hold the pictures.

Requirements for the Project Data Book

1. The first page should be the signed and approved copy of your topic proposal form.
2. Next, include a timeline page, which clearly defines your start date and completion date. This timeline should give an approximation of when you will perform each segment of your research project.
3. You should include an observation entry about your research project for a **minimum** **of once every other day.**
   --Make sure your entries are complete descriptions with commentary. ("No change" is **not** an acceptable entry.)
   --Date each entry.
4. Include at least one photograph of your project in progress once every two weeks. To avoid extra costs in developing film, you may include a signed note from a parent or supervisor that confirms you have taken a picture.
5. Project Data Books will be checked every two weeks for a grade of 20 points. You should have a minimum of seven (7) entries (one every other day) valued at two (2) points each, and one (1) photograph (or signature) valued at six (6) points.
   --You may include extra observations or photographs, background research, possible sources of error, completed surveys or questionnaires, or anything else that may be assigned by your individual teacher.
6. The entire Project Data Book will be turned in with your final project.

THE BACKGROUND RESEARCH PAPER

The purpose of a background research paper is to present background information related to your research project. This information could include explanatory narratives of techniques and equipment, general information that enhances your topic, and/or other related research experiments that have been performed in the past.

REQUIREMENTS:

1. This paper should be three (3) to five (5) pages, typed.
2. You should double-space, and use standard margins and indentations.
3. Use 12 point type, and choose from the following fonts: Helvetica, Times New Roman, Courier New.
4. Always write in third person.
5. Do not include any description of your own current experiment. That is not the purpose of this paper.
6. Cite **ALL** references. You should have a Citation page of at least six (6) reference sources, excluding encyclopedias. It would be assumed that your paper should include at least eight (8) to ten (10) references to these sources.
7. Cover pages are optional.
8. This paper will eventually become the Introduction of your final paper. Keep this in mind when you write it. Save this paper to a disk for future use.
9. Proofread your paper. Twice. Have two (2) other people proofread it as well. You will be glad you did.
10. See the section of the Research Guide on Writing the Research Paper for more information.
11. Hand in two (2) copies of this paper on the specified due date.

APPENDIX B

REQUIRED FORMS

REQUIRED FORMS FOR PRE-COLLEGE RESEARCH

The forms required by National Science Service for all Pre-College level Science Research can be found, filled in and downloaded at the following web address:

http://www.societyforscience.org/isef/document

(This link may not work. You may need to type the address in manually.)

APPENDIX C

Grade Guides

SCIENCE PROJECT POSTER GRADE GUIDE

Name ___________________________________

1. Title ________/5 points

2. Problem ________/5 points

3. Hypothesis ________/5 points

4. Materials ________/5 points

5. Procedure ________/5 points

6. Data
   3 Pictures _______/10 points
   Graph/Chart/Table ________/5 points

7. Results ________/5 points

8. Discussion ________/5 points

9. Conclusions/Future Action _______/10 points

10. Bibliography ________/5 points

11. Quality/Complexity ________/20 points

12. Neatness/Organization ________/10 points

13. Originality ________/5 points

Total Grade = _____________/100 points possible

Total Points Earned: _________
Total Points Possible: 250
Name ___________________________
Category of Research _______________________
Period ______________

Science Research Project

TITLE ____

1. **Design** – Subtotal **30** pts. **Total: _________________**

a. Neatness: ___________________ out of 5

b. Typing: ____________________ out of 5

c. Organization: _______________ out of 5

d. Clear Labels: ________________ out of 5

e. Visuals:_____________________ out of 5
-includes photos, drawings, diagrams, mattes, etc.

f. Construction:________________ out of 5

2. **Experimentation Verification** – Subtotal **30** pts. **Total: _________________**
Photographs from duration of project showing progress as well as distinct experimental and control groups. A minimum of six (6) photographs is required. Additionally, projects involving surveys of questionnaires must provide **all** surveys or questionnaires, as well as permission forms.

3. **Data/Report** – Subtotal **100** pts. **Total: ___________________**

a. Title: _________________________ out of 5

b. Problem: ______________________ out of 5

c. Hypothesis: ____________________ out of 5

d. Procedure: ____________________ out of 5

e. Materials: _____________________ out of 5

f. Data: _________________________ out of 20
-Data must be presented in a quantitative manner.

g. Statistics/Central Tendencies: ____________out of 10

h. Abstract: ______________________ out of 10

i. Results: _______________________ out of 10

j. Discussion: ____________________ out of 10

k. Conclusions: ___________________ out of 10

l. Bibliography: __________________ out of 5

4. **Quality** – Subtotal **90** pts. **Total: ___________________**

a. Scientific Thought/Complexity: _____________out of 50

b. Creativity: _____________________ out of 30

c. Sources of Error: ______________ out of 10

Science Research Paper Evaluation Form

Name ______________________________

I. Format and Content

A. Title Page

1. Title of Research ______/1
2. Name ______/1
3. Course Info ______/1

B. Numeration ______/1

C. Abstract

1. Heading ______/2
2. Format ______/2
3. Content ______/2

D. Introduction

1. Content ______/10
2. Use of References ______/10
3. Correct Reference Format ______/5

E. Problem ______/5

F. Hypothesis ______/5

G. Materials ______/5

H. Procedure ______/5

I. Data ______/5

J. Results ______/5

K. Statistics ______/5

L. Discussion ______/5

M. Conclusions ______/5

N. Works Cited

1. Format of entries ______/10
2. MLA style ______/5
3. Minimum number of References ______/5

TOTAL ______/100

II. Grammar, Punctuation, Spelling, etc.

Number of errors = ________ divided by 3 = _______

TOTAL (subtracted from 100) ______/100

FINAL GRADE =TOTAL I. and TOTAL II. averaged ______/100

Science Project Checklist

	Item	Due Date
1	Topic Proposal	
2	Background Literature Summary	
3	Literature Search	
4	Research Plan/Additional Forms/Checklist	
5	Problem	
6	Hypothesis	
7	Procedure	
8	Background Research Paper	
9	Research Grant Applications	Varies
10	Poster Presentation	
11	Project Data Book	Checked every two (2) weeks – due w/Final Project
12	Project	
13	Statistics/Tendencies	
14	Abstract	
15	Presentations	
16	Regional Science Fair Competition -- Those Chosen Projects	
17	Research Paper	
18	PowerPoint Presentation	