

BIOSAFETY GUIDELINES

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ADDITIONAL MATERIALS

EHS PROGRAM DOCUMENT REFERENCED IN THE BIOSAFETY GUIDELINES

(Copies available on the [EHS web site](#))

UNL Bloodborne Pathogen/Exposure Control Plan

EHS SOPS REFERENCED IN THE BIOSAFETY GUIDELINES

(Available on the [EHS web site](#))

EHS SOP – Incident Reporting – National Institutes of Health (NIH) Guidance

EHS SOP – Select Agents

EHS SOP – Recombinant DNA – IBC and Other Review Requirements

EHS SOP – Preparing a Laboratory Biosafety Manual

EHS SOP – Biosafety Training

EHS SOP – NUgrant IBC Protocol Form Instructions

1 Introduction

Hazards associated with pathogens and recombinant nucleic acids may be encountered in many UNL research, clinical/diagnostic, and/or teaching activities. The University must comply with certain regulatory requirements, generally recognized consensus standards, and/or funding agency guidelines to remain in good standing and retain funding eligibility, particularly as it relates to eligibility for funding from the National Institutes of Health (NIH).

The UNL Biosafety Guidelines describe the methods, means, procedures, and policies that govern the conduct of work by UNL employees and/or within UNL facilities that presents possible biohazard risks to employees, visitors, the general public or the environment. These Guidelines also delineate roles and responsibilities for Principal Investigators (PI), Laboratory Workers, the University Biosafety Officer (BSO), the Institutional Biosafety Committee (IBC), and certain Administrative Officials.

1.1 Scope

The UNL Biosafety Guidelines apply to clinical/diagnostic, research, and teaching activities involving any of the following:

- **Recombinant Nucleic Acids**
- **Human, animal, and plant pathogens** *including toxins of biological origin*
- **Bloodborne pathogens**, as defined by the United States Occupational Safety and Health Administration (OSHA)
- **Select agents**, including designated biologically-derived toxins, as defined by the United States Departments of Agriculture or Health and Human Services
- **Transgenic animals and plants** (*other than field trials of transgenic plants authorized by United States Department of Agriculture, Animal and Plant Health Inspection Service (APHIS)*)
- **Field Collection or Sampling of Wild Animals**, when there is risk of exposure to zoonotic diseases

1.1.1 Activities not subject to IBC review

Clinical/diagnostic, research, and teaching activities that:

- Are properly conducted at biosafety containment level 1 (BSL-1); and
- do not involve human, animal, or plant pathogens; and/or
- involve only the in vitro use of nucleic acids (i.e., PCR, siRNA, sequencing) and does not involve the cloning and propagation of recombinant DNA in cells; and
- the nucleic acids are not able to produce infectious forms of a biological select agent or encode for the functional form of a select agent toxin. (See EHS SOP “Select Agents” for details.)

1.2 Definitions

The following terms are used throughout this document and their meaning is defined here.

Principal investigator (PI) – any person with primary authority over the work conducted, whether the work is research-, clinical/diagnostic- or teaching-related.

Work activities – any activity involving conducting experiments on or with, testing, sampling, or analyzing any biological material or sample from a human, animal or plant that falls into one of the categories outlined in [Section 2](#).

Recombinant Nucleic Acids (rNA) – molecules constructed by joining nucleic acid segments, regardless of their origin, into biochemically unique constructed molecules that can (i) replicate in a living cell or (ii) generate molecules that can replicate in a living cell.

1.3 Regulatory Authority

The UNL Biosafety Guidelines are based on several regulatory requirements, as well as nationally recognized consensus standards and guidelines. The following list is illustrative; not exhaustive. Other regulations, standards, or funding agency requirements may apply to specific work activities. PIs must identify and familiarize themselves with all applicable requirements pertaining to their particular work activities.

- NIH Guidelines for Research Involving Recombinant DNA Molecules¹ (Herein referred to as “NIH Guidelines”), U.S. Department of Health and Human

¹ Simple possession of recombinant DNA-containing microbes and recombinant DNA molecules is not covered by the NIH Guidelines, **only if** the organisms or molecules are not further manipulated or inserted into other organisms, as these types of activities connotes “research”.

Services, National Institutes of Health. 59 FR 34496 (Final Rule) and subsequent amendments. http://oba.od.nih.gov/rdna/nih_guidelines_oba.html

- *Biosafety in Microbiological and Biomedical Laboratories*, (latest edition). (Herein referred to as “BMBL or CDC Guidelines”), U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention. <http://www.cdc.gov/od/ohs/biosfty/bmbl5/bmbl5toc.htm>
- Possession, Use, and Transfer of Select Agents and Toxins, 42 CFR 73, U.S. Department of Health and Human Services, Public Health Service; 7 CFR 331 and 9 CFR 121, U. S. Department of Agriculture, Animal and Plant Health and Inspection Service. <http://www.selectagents.gov/index.html>
- 49 CFR 171-178, Hazardous Materials Transportation regulations, incorporating by reference the International Air Transport Association (IATA), Dangerous Goods Regulations (DGR), *Latest edition*
- 29 CFR 1910.1030, Occupational Exposure to Bloodborne Pathogens, U.S. Department of Labor, Occupational Safety and Health Administration
- 42 CFR Subpart F, Importations (Particularly 71.54, Etiological Agents, Hosts, and Vectors)
- 9 CFR Parts 92, 94, 95, 96, 122, and 130, Importation of Etiologic Agents of Livestock, Poultry, and Other Animal Diseases
- 7 CFR Part 330, Importation and Domestic Transfer of Plant Pests
- 7 CFR Part 340, Introduction of Plants Genetically Engineered to Produce Industrial Compounds
- 15 CFR Parts 730 to 799, Export of Etiologic Agents of Humans, Animals, Plants, and Related Materials

Biological materials such as reagents, cell lines, plasmids, and vectors are often subject to the terms of a Material Transfer Agreement (MTA), which governs the transfer of tangible research materials between two organizations, when the recipient intends to use it for his or her own research purposes. The MTA defines the rights of the provider and the recipient with respect to the materials and any derivatives. The UNL Offices of Sponsored Programs and Technology Development have primary authority related to MTAs; therefore, the specific procedures and policies related to MTAs are beyond the scope of these Guidelines. Nevertheless, PIs must understand MTA implications that may impact their work.

1.4 Violations

Non-conformance with *NIH Guidelines* and nationally recognized standards may endanger human, animal, or plant health. Violations of *NIH Guidelines* regardless of the specific funding source can jeopardize funding from the NIH and other granting agencies for all of UNL. Non-conformance may result in civil and/or criminal penalties.

Violations of the NIH Guidelines and adverse incidents, as summarized in the EHS SOP, ***Incident Reporting – National Institutes of Health (NIH) Guidance***, must be reported to the NIH. PIs are responsible to notify the BSO (or Director of EHS in the absence of the BSO). The BSO, IBC Chair, and Office of Research Responsibility (ORR) will cooperate to investigate the incident and file necessary verbal and written reports with the NIH. The ORR is responsible to communicate with the Senior Administrative Official. The Senior Administrative Official is responsible to determine and administer appropriate disciplinary actions, if any, and in accordance with existing UNL human resource and responsible conduct of research policies and procedures.

2 Specific Requirements for IBC Protocols

More than one of the following subsections may apply to a given protocol; in which case, the most stringent reporting and initiation requirements apply.

2.1 Recombinant Nucleic Acid Molecules

PIs are required to submit a completed IBC protocol registry form when conducting research experiments with recombinant nucleic acids, regardless of whether the experiment is given exempt status under the *NIH Guidelines*. The review, approval and initiation requirements for work that falls under the *NIH Guidelines* are listed below.

2.1.1 *NIH Guidelines, Section III-F (Exempt Experiments)*

Those protocols involving experiments described in Section III-F of the *NIH Guidelines* (Exempt Experiments) and which are appropriately conducted at biosafety level 1 (BSL-1) containment are reviewed only by the BSO and Chair of the IBC. The purpose of this review is to confirm the exempt status and proper containment level. Experiments described in a protocol of this nature may be initiated simultaneously with submittal of the completed protocol registry form.

Some exempt classes of work are experiments with or experiments where:

- III-F-1:** Recombinant nucleic acids are outside of living organisms or viruses
- III-F-2:** DNA segments from a single nonchromosomal or viral DNA source

- III-F-3:** DNA from a prokaryotic host (indigenous plasmids or viruses included) is propagated in that host (or a closely related strain of the same species)
- III-F-4:** DNA from a eukaryotic host (chloroplasts, mitochondria, or plasmids included; viruses excluded) is propagated in that host (or a closely related strain of the same species)
- III-F-5:** The DNA source organism and the host organism normally exchange DNA (organisms that are considered to normally exchange DNA are listed in Appendix A of the *Guidelines*)
- III-F-6:** The DNA does “not present a significant risk to health or the environment...”, as listed in Appendix C of the *Guidelines*:
- The recombinant nucleic acids are used exclusively in tissue culture and has < 1/2 eukaryotic viral genome. *There are other exceptions to this rule (Appendix C-I-A). Check with the BSO.*
 - Experiments using an *E. coli* K-12 host-vector system in which the host does not contain conjugation proficient plasmids. (**Note: strain BL21 is not a K-12 strain.**) There are some restrictions on the vectors used (**Appendix C-II, C-II-A**). BSL-1 containment is suggested.
 - Experiments with *Saccharomyces* host-vector systems. There are some restrictions (**Appendix C-III, C-III-A**). BSL-1 containment is suggested.
 - Experiments involving *Kluyveromyces lactis* host-vector systems. There are some restrictions (**Appendix C-IV, C-IV-A**). BSL-1 containment is suggested.
 - Experiments with *Bacillus subtilis* or *B. licheniformis* host-vector systems and in which reversion to spore formation is < 10⁻⁷. There are some other restrictions (**Appendix C-V, C-V-A**). BSL-1 containment is suggested.
 - Experiments with rDNA derived entirely from extrachromosomal elements of gram positive organisms listed in **Appendix C-VI** and propagated in those same organisms. There are some restrictions (**Appendix C-VI-A**).
 - The domestic purchase or transfer of transgenic rodents (e.g., not constructed at UNL) for experiments that require BSL-1 containment are exempt from the *NIH recombinant DNA Guidelines*. (**Appendix C-VII**)
 - The breeding of two different transgenic rodents or the breeding of a transgenic rodent and a non-transgenic rodent with the intent of creating a new strain of transgenic rodent that can be housed at BSL-1 containment will be exempt from the NIH Guidelines if:
 - (1) Both parental rodents can be housed under BSL-1 containment; and
 - (2) neither parental transgenic rodent contains the following genetic modifications: (i) incorporation of more than one-half of the genome of an exogenous eukaryotic virus from a single

- family of viruses; or (ii) incorporation of a transgene that is under the control of a gammaretroviral long terminal repeat (LTR); and
- (3) the transgenic rodent that results from this breeding is not expected to contain more than one-half of an exogenous viral genome from a single family of viruses. (**Appendix C-VIII**)

2.1.2 NIH Guidelines, Section III-E

Those protocols involving experiments described in Section III-E of the *NIH Guidelines* are reviewed by the full IBC. Experiments described in a protocol of this nature and which are appropriately conducted at BSL-1 may be initiated simultaneously with submittal of the completed protocol registry form. If the experiments are to be conducted at BSL-2 or higher, initiation cannot occur without IBC approval. This section also includes experiments that don't fall into any other section of the NIH Guidelines, e.g. *experiments involving the introduction of Risk Group 1 (RG1)² DNA into RG1 organisms such as E. coli BL21, non-viral RG1 or Risk Group 2 (RG2) rDNA used in tissue culture systems, or creation of certain transgenic rodents that can be housed at BSL-1 (See Section 2.1.1 above).*

2.1.3 NIH Guidelines, Section III-D

Those protocols involving experiments described in Section III-D of the *NIH Guidelines* are reviewed by the full IBC. Experiments described in a protocol of this nature cannot be initiated without IBC approval.

2.1.4 NIH Sections III- A, B, and C

Those protocols involving experiments described in Section III- A, B, or C of the *NIH Guidelines* are reviewed by the full IBC. Experiments described in a protocol of this nature cannot be initiated without approval by the IBC and NIH (Director, RAC, or OBA, as applicable).

2.2 Human, Animal, and Plant Pathogens

Clinical, diagnostic, research, or teaching activities involving organisms that are generally considered non-pathogenic to a healthy host are not subject to the UNL Biosafety Guidelines or review by the IBC or BSO.

Clinical, diagnostic, research, or teaching activities normally and appropriately conducted at BSL-2 or higher containment; and any work requiring USDA, CDC or other federal permits, will be subject to review and approval by the IBC. Work may be initiated only after submission of a completed IBC protocol registry form and approval by the IBC.

² See Appendix B of the NIH Guidelines for a list of organisms divided into Risk Groups

2.2.1 Biological Toxins

Work with toxins of biological origin is also subject to review and approval by the IBC when the toxin used is expressed in or produced by biological organisms and isolated for use in the lab.

2.3 Bloodborne Pathogens

Work activities with bloodborne pathogens (BBP), as defined below, requires compliance with the OSHA Bloodborne Pathogens Standard as described in UNL's ***Bloodborne Pathogen/ Exposure Control Plan (BBP/ECP)***. This includes, but is not limited to, initial and annual refresher Bloodborne Pathogen training and recommended vaccinations.

2.3.1 Potentially Infectious Body Fluids

Clinical, diagnostic, research, or teaching activities involving potentially infectious body fluids are subject to review and approval by the IBC. Work may be initiated only after submission of a completed IBC protocol registry form and approval by the IBC. Potentially infectious body fluids include:

- Human blood, blood components, and products made from human blood;
- The following human body fluids: semen, vaginal secretions, cerebrospinal fluid, synovial fluid, pleural fluid, peritoneal fluid, amniotic fluid, saliva in dental procedures, any body fluid that is visibly contaminated with blood, and all body fluids in situations where it is difficult or impossible to differentiate between body fluids;
- Any unfixed tissue or organ (other than intact skin) from a human (living or dead);
- HIV-containing cells or tissue cultures, organ cultures, and HIV- or HBV-containing culture medium or other solutions;
- Blood, organs, or other tissues from experimental animals infected with pathogens present in blood that can cause disease in humans.

2.3.2 HIV, HBV and other Bloodborne Pathogens Research Labs

Research and teaching laboratory activities involving the culture, production, concentration, experimentation, and manipulation of Human Immunodeficiency Virus (HIV), Hepatitis B Virus (HBV), or other bloodborne pathogens may be initiated only after submission of a completed IBC protocol registry form and approval from the IBC.

2.3.3 Use of Primary or Established Human or Human-derived Cell Lines and Tissues

Work activities with established human or animal cells that are potentially infectious or contaminated with bloodborne pathogens, primary human cell explants from tissues and subsequent in vitro passages of human tissue explant cultures, and laboratory work with primary human tissues or body fluids are covered by the UNL **BBP/ECP** and may be initiated only after submission of a completed IBC protocol registry form and approval from the IBC.

Work activities with established human cell lines which are characterized to be free of contamination from HBV, HIV, and other recognized bloodborne pathogens are not subject to BBP requirements, or review and approval by the IBC. Documentation of the tests verifying the cells to be pathogen free is required and a copy should be sent to the UNL BSO.

See Appendix D of the UNL BBP/ECP for further details related to human cell lines covered by the BBP/ECP.

2.4 Select Biological Agents and Toxins

Some biological agents and toxins, referred to as Select Agents by the U.S. Department of Health and Human Services (HHS) or Agriculture (USDA), are capable of causing substantial harm to human health and safety.

Possession* of select agents requires issuance of a certificate of registration by the appropriate federal agency (USDA/APHIS or HHS/CDC).

Note: The only exception to this requirement relates to received diagnostic specimens suspected to contain select agent organisms or toxins. When a select agent is positively identified notification must be sent to CDC/APHIS by the indentifying lab and the samples must be destroyed or transferred to a registered facility. See EHS SOP, **Select Agents and Toxins – Clinical and/or Diagnostic Laboratory Activities.*

Work with select agents can be initiated only after submission of a completed IBC protocol registry form, approval from the IBC, and completion of the registration process with the appropriate federal agency. See EHS SOP, **Select Agents**.

2.5 Transgenic Animals and Plants

The *NIH Guidelines* do not permit experiments involving deliberate release of transgenic organisms into the environment unless, as provided in *Section I-A-1 of the Guidelines*, another federal agency has jurisdiction over the experiment and approves the proposed release.

2.5.1 **Animals**

All live vertebrate animal research at UNL is subject to review by the Institutional Animal Care and Use Committee (IACUC) regardless of IBC review requirements. Following is a summary of general requirements pertaining to transgenic animals. Refer to the EHS SOP, **Recombinant DNA – IBC and Other Review Requirements** for a full discussion and to determine if your project must be approved by the IBC prior to initiation. For the purposes of these guidelines, activities involving transgenic animals are divided into two categories:

A. **Rodents**

The purchase or transfer of transgenic rodents is exempt from the *NIH Guidelines*, but experiments involving creation or administration of rDNA to rodents may not be exempt (See sections III-E-3 and III-D-4 of the *NIH Guidelines*). Those activities exempt from the *NIH Guidelines* require submission of an IBC protocol registry form with review by the BSO and Chair of the IBC. Rodent activities that are not exempt from the *NIH Guidelines* must be reviewed and approved by the full IBC prior to initiation.

B. **Other Vertebrates and Invertebrates**

With few exceptions, all activities involving transgenic animals other than rodents must be reviewed and approved by the full IBC prior to initiating work.

2.5.2 **Plants**

PIs planning transgenic plant field trials pursuant to a valid and current APHIS permit must submit their application to the UNL Biotechnology Quality Management System (BQMS) committee. The BQMS committee is responsible for review of these applications. IBC is notified of the actions of the BQMS committee on a regular basis.

Review and approval of other transgenic plant experiments is conducted in accordance with the *NIH Guidelines* as described in [Subsection 2.1](#) above.

2.6 **Field Collection or Sampling of Wild Animals**

The following activities involving the field collection or sampling of wild animals requires submission of an IBC protocol registry form and approval by the IBC prior to initiation of work activities due to the risk of zoonotic diseases.

- Trapping and handling of wild animals for surveillance of agents infectious to humans and/or animals designated at BSL-2 or higher.
- Trapping and handling of wild animals that may transmit significant or life threatening zoonotic diseases (e.g. rabies, Hantavirus Pulmonary Syndrome)

as determined by risk assessment of the target species and proposed procedures.

- Laboratory processing of diagnostic samples collected from these studies.

3 Protocol Development, Approval, and Maintenance

An IBC Biosafety protocol will be required for each PI working with materials described in [Section 2](#); it should cover all research activities requiring registration with the IBC. If you are working with multiple model systems or microorganisms but the basic techniques and procedures are the same, the IBC encourages you to enter all of the information in one protocol form with a generalized title. The individual projects can be described separately in the “Research Description” section of the protocol form. A separate protocol will be required for PI’s directing/managing teaching labs and/or core/diagnostic facilities that exist outside of the PI’s research activities; and for experiments or work activities that are not closely related in objectives, techniques, or procedures.

The IBC approval process begins with the PI completing all required documentation and supporting material necessary for thorough review by the IBC and Biosafety Officer (BSO). Documentation and supporting materials consist of the following items:

- A completed NUgrant IBC protocol form, and;
- A written biosafety manual (See EHS SOP, *Preparing a Laboratory Biosafety Manual*).
- Protocols approved by the IBC are valid indefinitely contingent on the PI following the requirements for protocol maintenance described in [Subsection 3.4](#).

3.1 Protocol Development and Submission

Protocols are registered electronically using the NUgrant research administration system found at <https://nugrant.unl.edu/>. Log-in credentials default to the PI’s *Blackboard* username and password. Refer to the EHS SOP, *NUgrant IBC Protocol Form Instructions* for additional information. The information requested in the protocol registry form is necessary and required to support consideration of the following:

- Dual use considerations (as further described in [Appendix A](#))
- Risk assessment, leading to proper selection of appropriate containment level, safety equipment, and laboratory practices and procedures
- Training and expertise of the PI and laboratory workers

The EHS SOP, *Preparing a Laboratory Biosafety Manual* provides guidance on the content required for a written biosafety manual. The manual is not submitted for IBC review; however, it is evaluated by the BSO as part of the review process, as described below. EHS provides a number of standard Safe Operating Procedures (SOPs) related to accidents/injuries, spills, emergency preparedness/response that the PI may opt to include in their manual. If the PI opts to develop individual procedures in lieu of these standard procedures provided on the [EHS web page](http://ehs.unl.edu/sop/) (<http://ehs.unl.edu/sop/>), then those lab-specific procedures must be submitted with the protocol for review and approval by the IBC. The EHS SOP, *Biosafety Training* provides guidance as to the training that the PI is required to deliver to each lab worker prior to beginning work activities.

3.2 Initial Protocol Review

The protocol review process is depicted in [Appendix B](#) to these Guidelines. As applicable, a protocol is released to the IBC for review only after it has been accepted as substantially complete by the BSO, and the department head/chair has indicated his/her support of the protocol by electronic signature. A unique project number is assigned to each protocol when a New Protocol Form is started. All future correspondence related to an approved protocol must reference this protocol number.

For those protocols requiring approval by the full committee, the BSO will conduct a pre-approval audit to verify adequacy of the facilities and biosafety manual. Findings will be communicated to the IBC at the time of protocol consideration and/or prior to issuance of the final approval notification.

3.3 IBC Review

The IBC meets monthly, when there is pending committee business. Committee meeting schedules are published on the EHS web page. Meetings are open to the public. If the PI requests a closed meeting, or redaction of information from the publically available protocol or meeting minutes, the BSO will arrange for review of the request by NU legal counsel prior to consideration by the committee. NU legal counsel will determine the appropriate level of public restriction or redaction.

Protocols requiring review by the full committee **must be complete no less than two (2) weeks prior to the next scheduled meeting** (including revisions requested by the BSO during the pre-review process). In some cases, a longer period may be necessary to allow for scheduling and completion of a pre-approval audit by the BSO. PIs are encouraged to communicate with the BSO early in their planning stages.

After the BSO determines the protocol to be substantially complete, it is released for viewing by the Department Head/Chair (DH/C). The DH/C will review and sign off on

the protocol unless they deem revisions are necessary, if so, it will be sent back to the PI for revisions. Once the DH/C signs off on the protocol it is released for viewing by the IBC committee and placed on the agenda for discussion at the next meeting. The BSO will supplement the information in the protocol with a report on the facilities, laboratory biosafety manual, personnel training and other relevant information.

Following discussion and review, possible actions by the IBC are:

- (1) a vote to approve as submitted;
- (2) a vote to approve the protocol contingent upon specific conditions set forth by the committee;
- (3) a vote to table the protocol for discussion at the next meeting pending revision or submission of additional information by the PI to address specific concerns of the committee;
- (4) denial.

Following committee action, the BSO will notify the PI of the Committee's decision, by e-mail letter. A formal approval letter will be issued only after the PI has satisfied all contingencies imposed by the IBC. Timing of initiation of work activities described in the protocol was previously discussed in [Section 2](#) of these Guidelines.

3.3.1 *Tabled Protocols*

When a protocol is tabled until the next IBC meeting, a letter outlining the issues to be resolved is sent to the lead PI listed on the protocol. The PI will also be invited to attend the next IBC meeting at which his/her protocol will be re-reviewed by the committee.

3.4 Protocol Maintenance

3.4.1 *Protocol Amendments*

Requests for changes to a protocol after initial approval will be done by submission of an Amendment Form. Amendments can be submitted at any time after a protocol is approved and do not take the place of the Annual Update Form. Major changes/modifications to the work described in the protocol (e.g., changes in host vector systems, new transgenes, factors affecting the final risk assessment, adding transgenic animals, etc.) will require submittal of a Protocol Amendment Form to the IBC for review and approval prior to initiation of the change. Review of major change protocol amendments will be the same as for New Protocol Forms.

Minor changes to a protocol are reviewed by the BSO and can be approved without full committee review only if they involve one of the following:

- Changes to Personnel
- Changes to Facilities (Facility inspection by the BSO is required.)
- Changes to funding
- Changes to Decontamination/Disinfection/Disposal procedures

All amendments approved under these conditions will be reported to the IBC at the next meeting following approval.

3.4.2 Annual Update Form

Every year on the anniversary of protocol approval the PI will be notified by email to login to the NUgrant system and submit an Annual Update Form. Reminders will be sent 30 days and two weeks before the anniversary date, on the anniversary date and every week after that until the form is submitted.

This form asks if the project is still active, documents minor (e.g. facilities, personnel, etc.) changes, and helps the PI determine if major changes have been made and a formal amendment is required.

Submission of an Annual Update Form is a condition of continued protocol approval and failure to submit annual update forms or amendments in a timely manner may result in the IBC taking action to suspend or withdraw approval of the protocol until the requested information/documents are received.

3.5 Institutional Oversight

3.5.1 Laboratory Audits

The BSO conducts annual inspections of all IBC approved BSL-2 facilities to ensure continued observance of safety procedures, adequacy of facilities and equipment, and adherence to the approved protocol. IBC approved BSL-3 facilities are inspected biannually and BSL-1 facilities every other year. BSL-1 facilities in which research that has been classified as “Exempt” from the NIH Guidelines is conducted will be inspected with a frequency determined by the BSO.

3.5.2 Training

Training in the principles and practices of general biosafety is essential to maintaining a safe work environment and it is the responsibility of each PI to ensure that his/her lab personnel are properly trained.

Training in the following areas is required of all PIs and laboratory personnel working on IBC approved research protocols. This training must be completed

prior to working on experiments/protocols that require IBC approval. Additionally, laboratory workers must review the laboratory-specific biosafety manual at least annually as a means of refresher training.:

- General biosafety (as applicable to approved protocol)
 - BSL-1 – web-based - Biosafety Basics (UNL EHS)
 - BSL-2 – web-based - [Biosafety in the BSL-2 Laboratory](#) (UNL EHS)
 - BSL-3 – provided by BSL-3 facilities director
- Awareness of the *NIH Guidelines for Research Involving Recombinant DNA Molecules* (See [Section 2.1](#) and [2.5](#))
 - web-based - NIH Guidelines for Research Involving Recombinant DNA Molecules (NIH Guidelines (UNL EHS))
- “Dual-Use” concerns ([Appendix A](#))
 - Video - <http://www.youtube.com/watch?v=0yS1ur24j40> (NIH/OD)
- Export Control issues <http://research.unl.edu/orr/exportcontrol.shtml>

PIs and their staff working with bloodborne pathogens or OPIM including human cell lines are additionally required to take bloodborne pathogens training annually.

Completion of training is a condition of continued IBC protocol approval and failure to comply may result in suspension or termination of an IBC protocol. See [Section 4.3.3](#) for details about violation of the UNL Biosafety Guidelines.

3.5.3 Medical Surveillance

The IBC medical professional member is responsible for recommending medical surveillance requirements specific to a protocol for consideration by the IBC. In some cases, immunization of workers will be required as a condition of project approval. The medical surveillance regime generally includes the following components, as appropriate:

- (1) Medical history and counseling including previous exposure(s) and the need for preventative immunization or pre-exposure prophylaxis including the related risks of vaccination**
- (2) Level of immunity for an employee and whether the employee may be immunocompromised**
- (3) Other tests as the medical professional may deem necessary (e.g., serum banking, post-exposure management, etc.)**

The Biosafety Officer will assist the PI in arranging for immunizations and medical counseling for all indicated employees when deemed necessary by the IBC.

4 Roles and Responsibilities

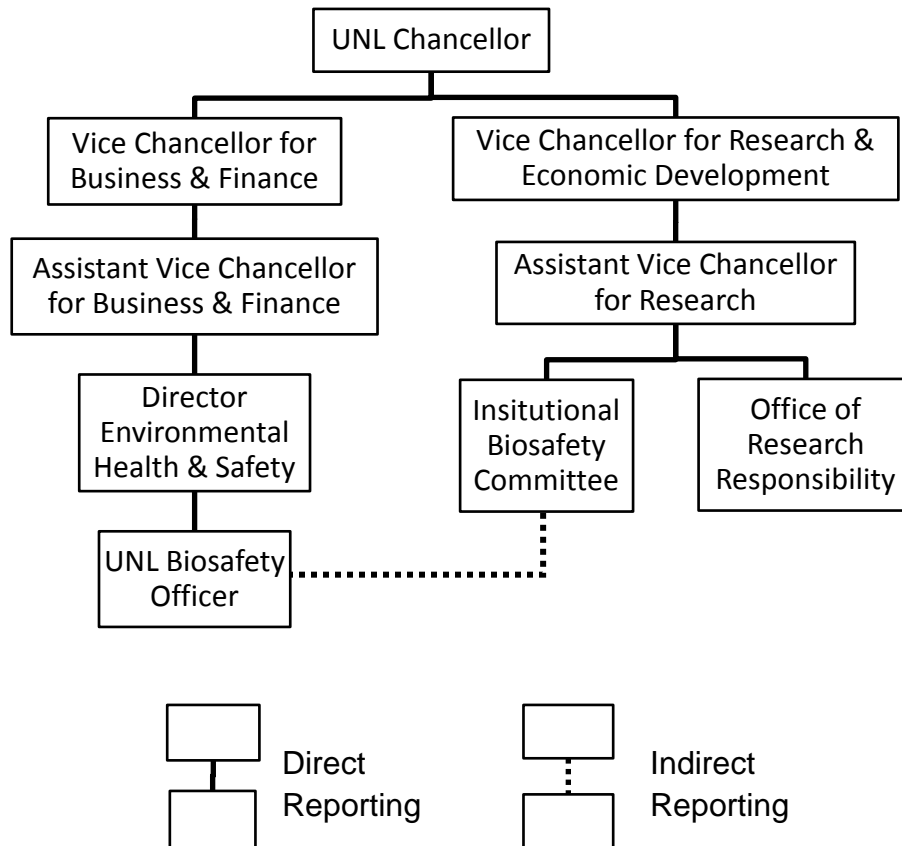


Figure 4-1 Organizational Chart for the UNL Biosafety Program

4.1 Senior Administrative Oversight

The UNL Chancellor is the Senior Administrative Officer overseeing biosafety activities at the University of Nebraska-Lincoln. The UNL Chancellor has delegated this authority to the Vice Chancellor for Research & Economic Development (VCRED). The VCRED has further delegated oversight of biosafety to the Associate Vice Chancellor for Research (AVCR). (Figure 4-1)

4.1.1 *The Associate Vice Chancellor for Research (AVCR)*

is responsible for:

- Acting as the Administrative Advisor to the IBC.

- Allocating resources required to carry out the provisions of UNL Biosafety Guidelines. (*Resources are allocated through the Office of Research Responsibility and the Department of Environmental Health and Safety.*)
- Appointing the IBC committee members and designating a committee chair person. Ensuring that those selected are appropriately qualified and trained regarding laboratory safety and implementation of the *NIH Guidelines*.
- Determining and administering disciplinary action for willful violation of *NIH Guidelines*, BMBL, UNL Biosafety Guidelines or other authoritative safety document.
- Keeping the VCRED apprised of any and all issues with regard to the operation of the UNL Biosafety Program.

4.1.2 The Office of Research Responsibility (ORR)

represents the AVCR and is responsible for:

- Serving as an *ex officio* member of the IBC, primarily representing the AVCR. In addition, participation of the ORR on the IBC facilitates sharing of information with other campus committees, such as the IACUC, Institutional Review Board (IRB), and Radiation Safety Committee (RSC).
- Filing the IBC membership roster with NIH/OBA, including (i) a roster of IBC members clearly indicating the chair, contact person, BSO, plant expert, and animal expert; (ii) biographical sketches of all IBC members, including community members. This roster must be filed when changes occur in membership and at least annually, as applicable.
- In cooperation with the IBC Chair and BSO, reporting incidents to NIH/OBA as specified in the *NIH Guidelines*.
- In cooperation with the Biosafety Officer, forwarding public comments on IBC actions to NIH/OBA, as applicable.

4.2 Department Head/Chair or Dean/Director

Department Heads/Chairs and/or Deans/Directors are responsible for:

- Indicating support of a PI's protocol prior to consideration by the IBC.
- Ensuring that adequate facilities are available and maintained to properly support the proposed protocol.
- Ensuring that biosafety requirements and safety policies and procedures are enforced at the departmental level.

4.3 Institutional Biosafety Committee

4.3.1 Membership

As mandated by the *NIH Guidelines*, at a minimum the IBC is composed of no fewer than five (5) members selected for their collective expertise in recombinant DNA.

- Two (2) members of the IBC are not affiliated with UNL (do not have faculty appointments).
- At least one (1) member has expertise in plant, plant pathogen, or pest containment procedures.
- At least one (1) member has expertise in animal containment procedures.
- One (1) member represents laboratory technical staff.
- One (1) member is the Biosafety Officer.
- At least one (1) member of the IBC is a medical professional with expertise in immunity and infectious disease. This position may be an ad hoc consultant.
- At the present time, UNL is not engaged in human gene therapy studies or clinical trials; therefore, such an expert is not included on the committee.

The AVCR appoints the committee chair and members for a term of three (3) years. The term of the Biosafety Officer is consistent with the term of employment. The term of the medical professional is at the discretion of the Vice Chancellor for Research, and may exceed three years. The members listed above are vested with voting rights. However, they must abstain from voting if they are engaged or have a vested interest in a project proposal that is before the committee for consideration.

A quorum consists of at least 50% of the total membership of the committee and a vote of approval requires at least a simple majority of the members in attendance. The Chair or designee must be present. The Biosafety Officer or designee must be present for approval of BSL-3 protocols.

4.3.2 Responsibilities

The IBC is responsible for:

- Investigating potential violations of the *NIH Guidelines* in coordination with the BSO and ORR.
- Reviewing protocols and amendments, including independent assessment of the containment levels required by the *NIH Guidelines* for the proposed research; and consideration of information provided in the protocol or by the

BSO regarding facilities, procedures, practices, and training and expertise of personnel involved in the protocol.

- Setting final containment levels for certain experiments as described in the *NIH Guidelines*, specifically Section III-D-2-a (Experiments in which DNA from RG 2-3 or *Restricted Agents* are Cloned into Nonpathogenic Prokaryotic or Lower Eukaryotic Host-Vector Systems); Section III-D-4-b (Experiments Involving Whole Animals); and III-D-5 (Experiments Involving Whole Plants).
- Adopting standard emergency procedures covering accidental spills and personnel contamination resulting from activities subject to the *NIH Guidelines* and the UNL Biosafety Guidelines. This includes reviewing and approving alternate procedures proposed by individual PIs, as applicable.
- The IBC Chair is responsible for ensuring that IBC members are appropriately trained regarding laboratory safety and implementation of the *NIH Guidelines*.

4.3.3 Authority

A. Existing protocols

The committee has authority to withdraw or suspend protocol approval in response to violations of the NIH Guidelines or UNL biosafety policies and procedures. Suspension of approval may be instituted when a serious violation is identified pending thorough investigation by the IBC. The investigation will include an opportunity for the PI to provide information and explanation. Resolution of the cause(s) for suspension of approval will result in reinstatement of approval and continuation of the work, unless further IBC review of the work is indicated by the investigation or information provided by the PI. At the discretion of the IBC, approval may be permanently withdrawn for serious violations that cannot or have not been resolved in a timely manner by the PI or which are of an egregious nature. The AVCR will be notified of all suspensions and withdrawals.

B. Unapproved work activities

If it is discovered that a PI is conducting work activities for which he/she is not approved, the IBC or BSO on behalf of the committee will notify the PI and require submittal of a biosafety protocol for review by the IBC. If the work is subject to the *NIH Guidelines*, the PI will be informed that protocol submission is required within thirty (30) days of receipt of the notice of violation. The IBC will notify the AVCR of all such occurrences.

4.3.4 Meetings

IBC meetings are scheduled once per month during the academic year from September through May and as needed during the summer months. Meetings are conducted in a manner that facilitates discussion, public attendance, and PI participation. Committee business is always conducted in a live meeting and never conducted by email or other electronic means. The schedule and meeting location is available on the EHS website at <http://ehs.unl.edu/committees/#ibc> and is posted on the University calendar accessed at <http://events.unl.edu>. PIs are notified of the meeting date at which their protocol will be discussed and are invited to attend at their discretion.

Minutes of the IBC Meetings will contain sufficient detail to serve as a record of the major points of discussion and the committee's rationale for specific decisions and contain the following information:

- Date and time of meeting
- Approval status of prior meeting minutes
- Individuals in attendance
- Whether and why meeting was open or closed
- All major motions, including rationale
- Major points of order and discussion
- Whether motions were approved
- Time of meeting adjournment

Minutes of the committee are maintained by the BSO and distributed at the next meeting for review and approval by the IBC. Minutes are available to the public upon request in accordance with **NEB. REV. STAT. §§ 84-712 to 84-712.09 (1999, CUM. SUPP. 2006, Supp. 2007)**, but are not posted electronically on a publically accessible webpage. Minutes of the committee meetings or subject protocols may be redacted after consultation with NU legal counsel. Redaction of personal information (such as home phone numbers, addresses, etc.) does not require review by NU legal counsel. Redaction is usually reserved for information that is necessary to protect trade secret information; confidential commercial information; information that, if disclosed, could directly compromise institutional or national security; and similar information.

In accordance with the NIH Guidelines, all public comments made on IBC actions and the IBC's response will be forwarded to NIH/OBA. The Biosafety Officer, in cooperation with the Office of Research Responsibility, is responsible for this reporting.

4.4 Biosafety Officer

The UNL Biosafety Officer reports to the Director of Environmental Health and Safety and is responsible for:

- Assisting PIs to complete the IBC protocol registry form in a manner that allows for thorough and complete committee review.
- Evaluating adequacy of facilities, equipment, procedures and techniques and reporting findings to the committee for their consideration in support of initial protocol review, amendment, and on-going evaluation/institutional oversight.
- Notifying PIs of the meeting date, time and location at which their protocol will be considered by the committee, and notifying the PI of the results of the IBC review and basis for approval or denial of the proposed project. Following up with PIs concerning contingencies and other issues identified by the IBC following protocol review.
- Investigating and reporting to the IBC and ORR, significant problems related to accidents and illnesses, operations, non-compliance with NIH Guidelines or other authoritative source, or other adverse circumstances related to proposed or approved protocols.
- Providing technical services/advice and training to the IBC and PIs regarding NIH Guidelines, standard written safety, emergency, and security procedures and assisting them to train laboratory staff, as requested. Written standard procedures published by EHS that are substantially a restatement of recognized consensus standards or regulatory requirements do not require IBC approval; other policies and procedures require review and approval by the IBC.
- Serving as a voting member of the IBC and providing administrative support to the IBC, such as establishing and distributing agendas and minutes; maintaining records and files of protocols, registration documents, etc.; responding to FOIA requests; and other similar duties.
- Serving as the contact person on the annual OBA roster of IBC members.
- In cooperation with the Office of Research Responsibility, forwarding public comments on IBC actions to NIH/OBA, as applicable

4.5 Principal Investigator (PI)

PIs are responsible for adhering to all responsibilities and expectations articulated by the NIH, as detailed in [Appendix C](#); and the following:

- Adhering to and training all personnel in all applicable rules, regulations and standard practices, including but not limited to NIH and CDC (BMBL) guidelines.

- Adhering fully to UNL policies and procedures for work activities subject to the UNL Biosafety Guidelines.
- Adhering fully to other UNL policies related to responsible conduct of research (<http://research.unl.edu/orr/rcr.shtml>).
- Restricting activities to those which are approved by the IBC and abstaining from initiating or modifying research/experiments, as applicable under these Guidelines.
- Making available to all laboratory personnel a copy of the written approved protocol and biosafety manual; training and supervising laboratory workers in good microbial techniques and other practices and procedures related to safety, security, personal protective equipment (use, limitations, and maintenance), accidents, and emergency preparation/response. See the EHS SOP, ***Biosafety Training***, for further training guidance. NIH encourages PIs to retain training records.
- Routinely supervising the performance of laboratory workers to assure a safe workplace and correct work errors and conditions that are a risk to the worker or the environment.
- Immediately reporting violations of the *NIH Guidelines*, injuries and illnesses attributable to occurrences in the laboratory, personnel contamination, spills, and loss of containment to the Biosafety Officer or Chair of the IBC.
- Complying with applicable shipping regulations, permit requirements, and Material Transfer Agreements.
- Ensuring that facilities and equipment are maintained to support the required Biosafety containment level and enforcing laboratory access limitations to maintain adequate security.
- Informing laboratory staff of the reasons and provisions for any precautionary medical practices advised or requested (e.g., vaccinations or serum collection).

4.6 Laboratory Workers

Laboratory workers are responsible for:

- Completing relevant training as provided by EHS and the PI.
- Being familiar with hazards posed by all agents used in the laboratory regardless of whether he/she directly works with them.
- Knowing and adhering to all emergency procedures established by the PI.
- Reporting all occupational accidents, illnesses, and injuries to the PI and in accordance with UNL policy, as described in the EHS SOP, *On-the-Job Injuries and Accident Investigations*.

- Following all laboratory practices established by the PI.

Appendix A: Dual Use Research of Concern

Criteria and Considerations for Identifying Dual Use Research of Concern[†]

Definition: Research that, based on current understanding, can be reasonably anticipated to provide knowledge, products, or technologies that could be directly misapplied by others to pose a threat to public health, agriculture, plants, animals, the environment, or material.

Careful consideration should be given to knowledge, products, or technologies that:

- Enhance the harmful consequences¹ of a biological agent² or toxin³
- Disrupt immunity⁴ or the effectiveness of an immunization⁵ without clinical and/or agricultural justification
- Confer to a biological agent or toxin, resistance to clinically and/or agriculturally useful prophylactic or therapeutic interventions⁶ against that agent or toxin, or facilitate their ability to evade detection methodologies
- Increase the stability⁷, transmissibility⁸, or the ability to disseminate⁹ a biological agent or toxin
- Alter the host range¹⁰ or tropism¹¹ of a biological agent or toxin.
- Enhance the susceptibility of a host population¹²
- Generate a novel pathogenic agent¹³ or toxin, or reconstitute an eradicated¹⁴ or extinct¹⁵ biological agent

Footnotes

¹**Harmful Consequences:** The ability of a biological agent or toxin to critically alter normal biological functions, inflict damage on public health resources, material, and public safety. This would include augmenting properties such as virulence, infectivity, stability, transmissibility, or the ability of the biological agent or toxin to be disseminated.

²**Biological agent:** As is consistent with 18 U.S.C. § 178, any microorganism (including, but not limited to, bacteria, viruses, fungi, or protozoa), or infectious substance, or any naturally occurring, bioengineered or synthesized component of any such organism or infectious substance, capable of causing (A) death, disease, or other biological malfunction in a human, an animal, a plant, or other living organism; (B)

deterioration of food, water, equipment, supplies, or material of any kind; or (C) deleterious alteration of the environment.

³**Toxin:** As is consistent with 18 U.S.C. § 178, any toxic material or product of plants, animals, microorganisms (including, but not limited to, bacteria, viruses, fungi, or protozoa), or infectious substances, or a recombinant or synthesized molecule, whatever their origin and method of production, and includes (A) any poisonous substance or biological product that may be engineered as a result of biotechnology produced by a living organism; or (B) any poisonous isomer or biological product, homolog, or derivative of such a substance.

⁴**Immunity:** Encompasses all aspects of host immunity (e.g., active, adaptive, adoptive, passive, innate, and immune modulators).

⁵**Immunization:** Refers to the active or passive induction of immunity through inoculation (e.g., natural inoculation or vaccination) with an immunizing agent or with antibodies; this includes antitoxins and toxoids.

⁶**Clinically and/or agriculturally useful prophylactic or therapeutic interventions;** Includes first or second line prevention and treatment measures or alternative therapeutics used with special populations (e.g., pregnant women and pediatric patients), in the form of vaccines, antibiotics, antivirals, antiparasitics, antibodies, herbicides, fungicides, algaecides, insecticides, etc.

⁷**Stability:** The ability of a biological agent to remain viable when exposed to various environmental factors, including temperature, relative humidity, atmospheric pollution, and sunlight. Stability also includes persistence in a host.

⁸**Transmissibility:** The ease with which an agent spreads from host to host or from vector to host (e.g., via arthropod vectors).

⁹**Disseminate:** The process by which infectious diseases or toxins are dispersed. The same routes of entry pertinent to natural spread of diseases are also relevant when their etiologic agents are delivered intentionally (e.g., inhalation of biological agent disseminated as an aerosol, or ingestion of a biological agent disseminated through a water supply).

¹⁰**Host range:** The number of different species or populations that can become infected by a biological agent, causing disease in the host or allowing it to become a carrier.

¹¹**Tropism:** The specificity of a biological agent or toxin for a particular host tissue or cell.

¹²**Host population:** A collective of organisms that constitutes a specific group or occur in a specified habitat. In the context of the criteria, the use of this phrase implies that the misapplication of the knowledge, products, or technologies derived from the research has the potential to broadly impact a population of host organisms.

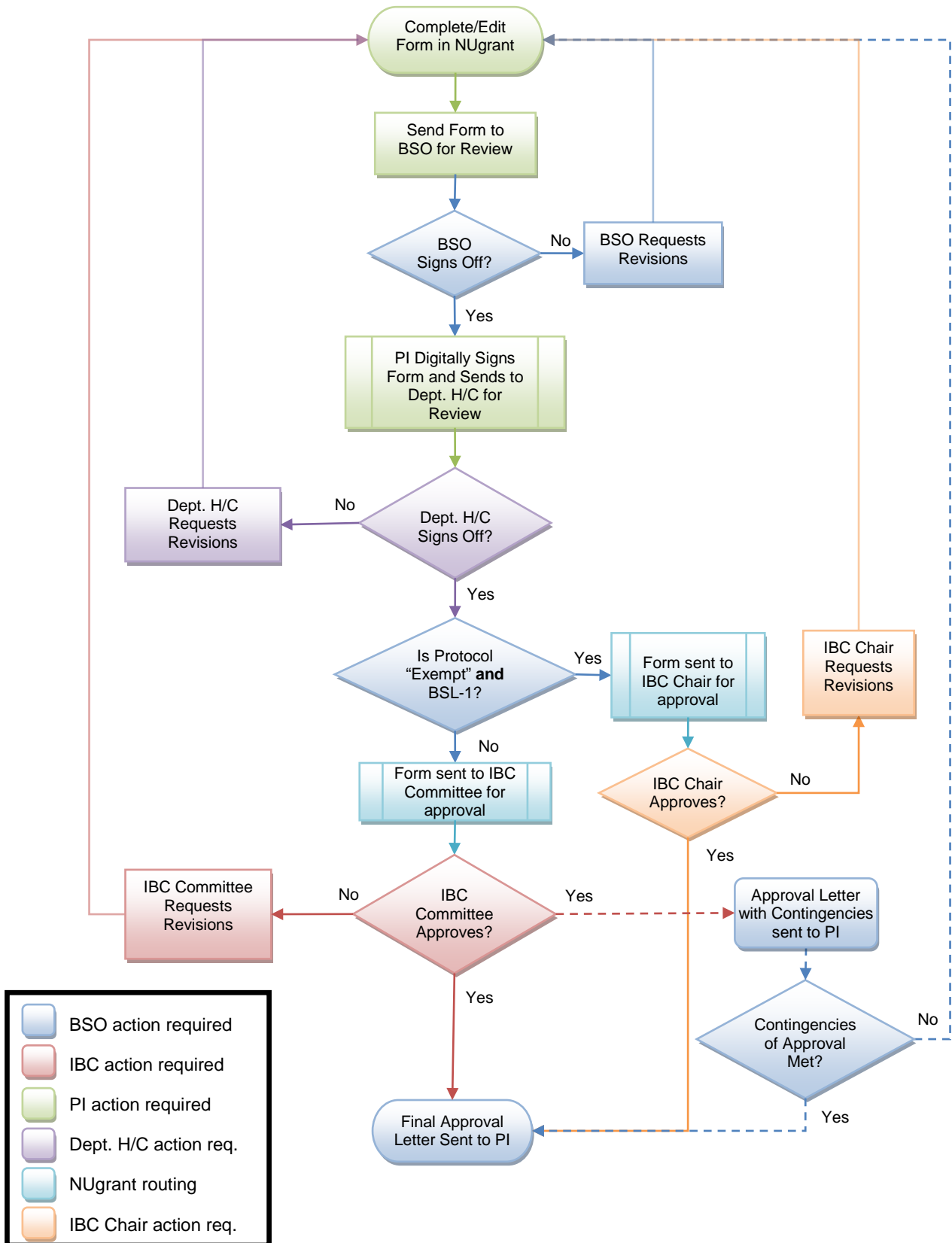
¹³**Novel Agent:** A novel agent is an agent that has not existed previously and is considered unique based on biological or other properties and traits (e.g., genotype and phenotype). Novel agents of concern are those for which there is no known or widely available prophylactic or therapeutic interventions, those that could evade detection, or those which there is no known immunity.

¹⁴**Eradicated agent:** A biological agent that has been exterminated through surveillance and containment resulting in the permanent reduction to zero in the worldwide incidence in the transmission of the agent and the infection/disease it causes; intervention measures are no longer needed. Eradicated agents are thought to no longer exist in circulation in plants, animals, and the environment. J Note: Reconstituted eradicated agents of concern are those for which there are no known or widely available prophylactic or therapeutic interventions, those that could evade diagnostics, or those for which there is no known immunity.

¹⁵**Extinct agent:** These agents are thought to no longer exist in nature or in the laboratory.

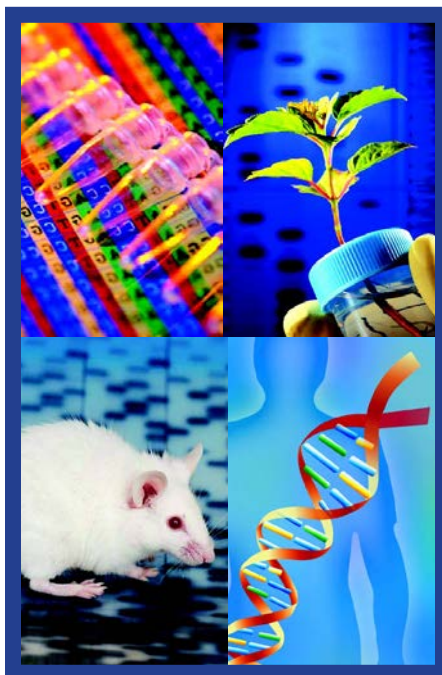
[†]Information from the National Science Advisory Board for Biosecurity (NSABB) Draft Guidance Documents, Section I. Criteria for Identifying Dual Use Research of Concern. Additional information can be found at <http://www.biosecurityboard.gov/index.asp>

IBC Protocol Approval Process



**National Institutes of Health
Office of Biotechnology Activities**

Investigator Responsibilities



under the
***NIH Guidelines
for Research Involving
Recombinant DNA
Molecules***



NIH Office of Biotechnology Activities

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What are the *NIH Guidelines for Research Involving Recombinant DNA Molecules*?

The *NIH Guidelines for Research Involving Recombinant DNA Molecules (NIH Guidelines)* detail procedures and practices for the containment and safe conduct of various forms of recombinant DNA research, including research involving genetically modified plants and animals, and human gene transfer.

Who must comply with the *NIH Guidelines*?

All institutions that receive NIH funding for recombinant DNA research must comply with the *NIH Guidelines*. Researchers at institutions that are subject to the *NIH Guidelines* must comply with the requirements even if their individual projects are not funded by NIH.

What is an Institutional Biosafety Committee?

Institutional Biosafety Committees (IBCs) provide local review and oversight of nearly all forms of research utilizing recombinant DNA. They ensure that recombinant DNA research conducted at or sponsored by the institution is in compliance with the *NIH Guidelines*. A requirement of the *NIH Guidelines* is that an IBC must review and approve all research subject to the *NIH Guidelines*.

What is the NIH Office of Biotechnology Activities?

The NIH Office of Biotechnology Activities (OBA) promotes science, safety, and ethics in biotechnology through the advancement of knowledge, enhancement of public understanding, and development of sound public policies. A core responsibility of OBA is to foster awareness of, and adherence to, the standards and practices set forth in the *NIH Guidelines*.

Safety and science go hand in hand

Principal Investigator Responsibilities

Principal Investigators (PIs) are responsible for full compliance with the *NIH Guidelines* during the conduct of recombinant DNA research. As part of this general responsibility, the PI should:

- ◆ Be adequately trained in good microbiological techniques.
- ◆ Provide laboratory research staff with protocols describing potential biohazards and necessary precautions.
- ◆ Instruct and train laboratory staff in: (i) the practices and techniques required to ensure safety, and (ii) the procedures for dealing with accidents.
- ◆ Inform the laboratory staff of the reasons and provisions for any precautionary medical practices advised or requested (e.g., vaccinations or serum collection).
- ◆ Supervise laboratory staff to ensure that the required safety practices and techniques are employed.
- ◆ Correct work errors and conditions that may result in the release of recombinant DNA materials.
- ◆ Ensure the integrity of physical containment (e.g., biological safety cabinets) and biological containment (e.g., purity and genotypic and phenotypic characteristics).
- ◆ Comply with permit and shipping requirements for recombinant DNA molecules.
- ◆ Adhere to IBC-approved emergency plans for handling accidental spills and personnel contamination.

Before initiating research subject to the *NIH Guidelines*, the PI must:

- ◆ Determine whether the research is subject to Section III-A, III-B, III-C, III-D, or III-E of the *NIH Guidelines*.
- ◆ Propose physical and biological containment levels in accordance with the *NIH Guidelines* when registering research with the IBC.
- ◆ Propose appropriate microbiological practices and laboratory techniques to be used for the research.
- ◆ Submit a research protocol to the IBC for review and approval.
- ◆ Seek OBA's determination of containment for experiments that require case-by-case review.
- ◆ Petition OBA, with notice to the IBC, for proposed exemptions from the *NIH Guidelines*.
- ◆ Obtain IBC approval before initiating research subject to the *NIH Guidelines*.
- ◆ Seek NIH approval, in addition to IBC approval, to conduct experiments specified in Sections III-A and III-B of the *NIH Guidelines*.

While conducting research subject to the *NIH Guidelines*, the PI must:

- ◆ Determine the need for IBC review before modifying recombinant DNA research already approved by the IBC.
- ◆ Submit any subsequent changes (e.g., changes in the source of DNA or host-vector system) to the IBC for review and approval or disapproval.
- ◆ Remain in communication with the IBC throughout the duration of the project.
- ◆ Report any significant problems pertaining to the operation and implementation of containment practices and procedures, violations of the *NIH Guidelines*, or any significant research-related accidents and illnesses to the IBC, OBA, and, as applicable, the Biological Safety Officer, Greenhouse or Animal Facility Director, and other appropriate authorities.

PIs conducting human gene transfer research must:

- ◆ Ensure that all aspects of Appendix M have been appropriately addressed prior to submission of a human gene transfer experiment to NIH OBA for review by the NIH Recombinant DNA Advisory Committee (RAC).
- ◆ Provide a letter signed by the PI(s) on institutional letterhead acknowledging that the documentation being submitted to NIH OBA complies with the requirements set forth in Appendix M.
- ◆ Not enroll research participants in a human gene transfer experiment until the RAC review process has been completed; IBC approval (from the clinical trial site) has been obtained; Institutional Review Board approval has been obtained; and all applicable regulatory authorization(s) have been obtained.
- ◆ Comply with reporting requirements for human gene transfer experiments (see Appendix M-I-C of the *NIH Guidelines*).

For More Information

To receive updates on current initiatives, policies, and news from OBA, subscribe to our listserv, "OBA_NEWS," by sending a message to: listserv@list.nih.gov with the message: [subscribe OBA_NEWS](#)

Visit the following websites for additional information:

NIH Office of Biotechnology Activities

<http://oba.od.nih.gov>

NIH Guidelines for Research Involving

Recombinant DNA Molecules

http://oba.od.nih.gov/rdna/nih_guidelines_oba.html

Appendix D: Applicability of the NIH Guidelines to RNA interference Experiments¹

What is RNA interference (RNAi)?

RNA interference (RNAi) is a method of suppressing gene expression in cells by introducing a double stranded RNA molecule that is complementary to a portion of your target gene. This double stranded RNA gets taken up by a complex designed to fight RNA based viruses. Using the introduced RNA as a targeting template, the complex binds to any RNA that is complementary to that template and degrades it, in this case the mRNA of your target gene. In this way, expression of a target gene is reduced or eliminated.

What are the most commonly used methods of RNAi?

Depending on the organism worked with, there are different methods of RNAi that can be used. Focusing on mammalian cell culture and mammalian animal models, the primary methods include: short interfering RNA (siRNA), short hairpin RNA (shRNA), microRNA (miRNA). In organisms, like *C. elegans* and *Drosophila*, long double stranded RNA dsRNA may be used also.

siRNA: When using siRNA the researcher will select a 20-22 nucleotide sequence that is unique to the target gene. A RNA oligonucleotide of this sequence and its complement are synthesized, mixed and allowed to anneal to form an RNA duplex. This duplex is then transfected into cells or introduced into animals. The duplex is then taken up by the RNAi machinery as outlined above. The resulting suppression of the target gene's mRNA is transient (3-7 days) as the amount of siRNA within the cells is reduced by degradation and cell division.

shRNA: To achieve a longer lasting gene suppression, the shRNA method was developed. In this method, a DNA cassette is made that contains a 19-29 nucleotide target sequence, a loop domain, and then a 19-22 nucleotides sequence complementary to the target sequence. When transcribed, the RNA twists into the short hairpin structure which brings the complementary target RNA sequences together to form an RNA duplex. This duplex is then processed and taken up by RNAi machinery as above. These shRNA DNA cassettes are placed into plasmid vectors and either directly administered to cells or animals or used to make viral vectors which then introduce the construct by infection. Depending on the method of introduction, the resulting shRNA gene suppression can be transient or persistent.

miRNA: miRNA are naturally occurring genes that code for an RNA that adopts a short hairpin structure. This hairpin is then processed by the RNAi machinery into a mature miRNA of 21 nucleotides which suppresses gene expression as described above. Many miRNAs are complementary to more than one gene's mRNA and thus can suppress the expression of several gene products at once. As with shRNA, the miRNA gene is placed into plasmid vectors and either directly administered to cells or animals or used to make viral vectors which then introduce the

construct by infection. Depending on the method of introduction, the resulting shRNA gene suppression can be transient or persistent.

dsRNA: Many organisms, most notably *C. elegans* and *Drosophila*, have the capacity to take up dsRNA segments of 200-400 nucleotides in length and then process them into 21 nucleotide pieces which are taken up by the RNAi complex as above. These dsRNA are generally expressed from a plasmid though there are kits for *in vitro* generation of dsRNA. Whole *C. elegans* and *Drosophila* cell culture can passively absorb dsRNA. Targeted microinjection of dsRNA is also used. Gene suppression is transient but long lived. Some RNAi mediated suppression in *C. elegans* persists into first generation offspring.

How is RNAi regulated under the NIH Guidelines for Research Involving Recombinant DNA Molecules?

In section I-B of the NIH Guidelines, recombinant DNA molecules are defined as either: “(i) molecules that are constructed outside living cells by joining natural or synthetic DNA segments to DNA molecules that can replicate in a living cell, or (ii) molecules that result from the replication of those described in (i) above.” It further goes on to say that, “If the synthetic DNA segment is not expressed *in vivo* as a biologically active polynucleotide or polypeptide product, it is exempt from the NIH Guidelines.”

siRNA duplexes are synthesized and not replicated within recipient cells. Thus, it is not considered recombinant DNA and is exempt from the NIH Guidelines. In contrast, plasmids containing shRNA, miRNA and dsRNA cassettes are replicated within *E. coli* during their creation and amplification protocols. Thus, they are rDNA and regulated by the NIH Guidelines. A risk assessment that evaluates the nature of the insert, the intended recipient, and the transmission method used would be needed to determine the exact regulations that apply to any given experiment.

¹ This document originally prepared by Vanderbilt Environmental Health & Safety office, Vanderbilt University, <http://www.safety.vanderbilt.edu/resources/biosafety.htm>