Entrepreneurial Microbiology: Bioethics, Biosafety

EXPLORING THE BUSINESS AND COMPLIANCE ASPECTS OF PROPRIETARY MICROBIAL INNOVATIONS

Risk of Biosecurity & Dual-Use Research

Biosecurity refers to measures that prevent the misuse of biological agents, including microbes, pathogens, and biotechnologies, that could pose threats to human, animal, or environmental health.

In microbiology, secret processes involving genetic modifications, microbial engineering, or synthetic biology may have unintended biosecurity risks if misused or leaked.

Dual-Use Research of Concern (DURC)

Dual-Use Research refers to scientific research that can be **used for both beneficial and harmful purposes**

DURC

3. Risks in Secret Microbial Processes

Risk Factor	Potential Concern	Example
Genetically Engineered Microbes	Accidental or intentional release	Synthetic bacteria with antibiotic resistance escaping into nature
Microbial Toxins & Biowarfare Agents	Unauthorized access to harmful microbial strains	Anthrax-producing *Bacillus anthracis* modifications
Unregulated Synthetic Biology	Unknown ecological or health consequences	CRISPR-edited microbes interacting with ecosystems
Lack of Transparency in Secret Processes	Hinders biosecurity oversight and risk assessment	Hidden modifications in probiotics or biopesticides

Biosafety

Biosafety refers to the **responsible use of biological materials** and curbing the risk of leaks to protect human health and the ecosystem.

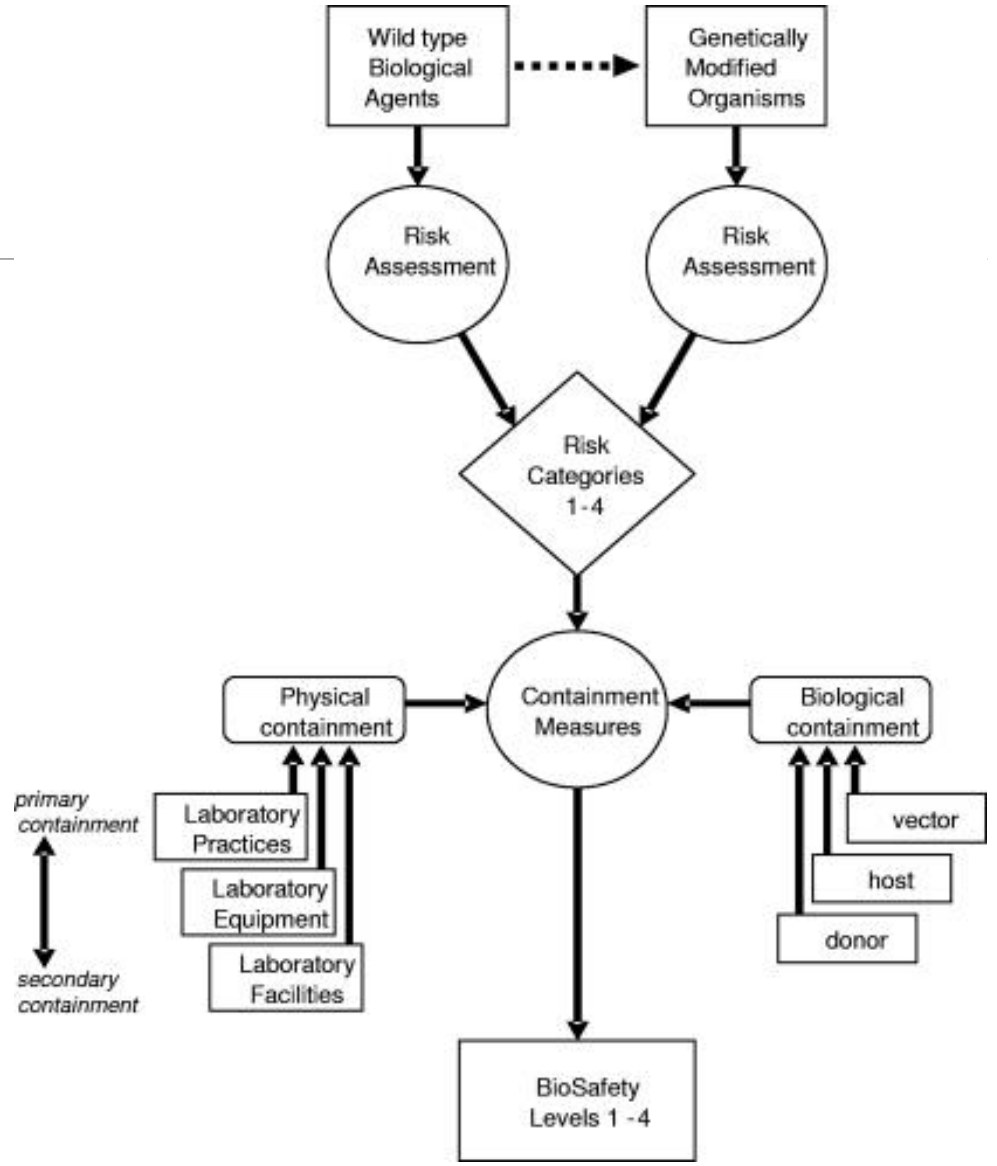
❖4 Principles:

1) Risk Assessment

2) Biological Containment

3) Physical Containment

4) Hazard minimization



https://pmc.ncbi.nlm.nih.gov/articles/PMC2493080/figure/f1/

Risk assessment

1) Risk assessment is the first and central step, and includes hazard recognition and identification, understanding of exposure potentials, frequency of occurrence, evaluation of work tasks and equipment, and assigning protective measures to the specific tasks involved.

Summary of considerations in the risk assessment for GMOs

Category	Factor(s) to be considered
Recipient microorganisms	Virulence, transmissibility, host range, susceptibility to antivirals or antibiotics, availability of prophylaxis, control and treatment
Vectors	Replicative capacity, integration into host genome
Insert or donor sequences	Toxicity, biological properties, replicative capacity, properties (known/unknown), gene-gene and gene-environment interactions
Activities	Scale, animal experiments, transport
Host factors	Immunodeficiencies
Population factors	(Vaccine-derived) immunity

Biological Containment

Selection of measures to ensure biosafety is to minimize biological hazards associated with the work by employing host microorganisms with a reduced host range, strains with natural or genetically modified characteristics that diminish their invading capacity or virulence, self-inactivating vectors, etc

Principles and methods of establishing biological containment

Principle	Method	Example(s)
Attenuation	Natural or genetically modified deletion of virulence genes	Modified vaccinia virus Ankara, herpesvirus vectors, *E. coli* K-12, *Salmonella aro* mutants, *Vibrio ctx* mutants, *Lactococcus lactis thyA* mutant
Host range restriction	Natural host-restricted viruses	Canarypox virus, fowlpox virus, baculovirus
Host range alteration	Ecotropic packaging cell lines, pseudotyping	Retroviral vectors
Use of replication-defective vectors	Deletion and provision of essential gene products in *trans*	Herpesvirus vectors, alphavirus vectors, retroviral vectors, adenovirus vectors, adeno-associated virus vectors, respiratory syncytial virus, lentivirus vectors, *Salmonella aro* mutants, *E. coli* K-12
Prevention of gene transfer	Expression of suicide functions	*E. coli relF*

Risk Group classification of micro-organisms

Table 1. WHO and NIH risk group classification in relation to biosafety levels, practices and equipment

Risk Group	Biosafety Level	Laboratory Type	Laboratory Practices	Safety Equipment
1	Basic-Biosafety Level 1	Basic teaching, research	Good microbiological techniques (GMT)	None; open bench work
2	Basic-Biosafety Level	Primary Health Services, diagnostic services, research	GMT plus protective clothing, biohazard sign	Open bench plus biological safety cabinet (BSC) for potential aerosols
3	Containment-Biosafety Level 3	Special diagnostic services, research	Level 2 plus special clothing, controlled access, directional airflow	BSC and/or other primary devices for all activities
4	Maximum containment-Biosafety Level 4	Dangerous pathogen units	Level 3 plus air lock entry, exit showers, special waste disposal	Class III BSC or positive pressure suits with Class II BSCs, double ended autoclaved (through the wall), filtered air

Risk Categories for Physical containment

Regulatory Oversight & Ethical Responsibility

	WHO International Health Regulations (2005)	UN Security Council Resolution 1540 (2004)	Biological Weapons Convention (1972)
Applicability:	All 192 UN Member States	All 192 UN Member States	163 States Parties
Purpose:	"to prevent, protect, protect against, control and provide a public health response to the international spread of disease…"	To prohibit **non-State actors** from developing, acquiring, manufacturing, possessing, transporting, transferring or using nuclear, chemical or biological weapons and their delivery systems.	To prohibit the development, production, acquisition, transfer, stockpiling and use of biological and toxin weapons
Requirements:	8 core capacities "to detect, assess, notify, and report events" [Laboratory core capacity includes biosafety / biosecurity]	Domestic controls to prevent the proliferation of nuclear, chemical and biological weapons, their means of delivery, and related materials	Any necessary measures to prohibit and prevent the development, production, stockpiling, acquisition, retention, transfer or use of biological weapons
Entry into force:	15 June 2007	28 April 2004	26 March 1975
Mandated reporting / where / when:	Status of implementation / WHO/*"As soon as possible but no later than five years from entry into force …"*	Status of implementation / 1540 Committee / *"without delay"*	None* "CBM voluntary reporting/ BWC ISU/ annually by 04/15

https://bmcpublichealth.biomedcentral.com/articles/10.1186/1471-2458-10-S1-S12

Carategena Protocol

The Cartagena Protocol on Biosafety (CPB) is an international agreement under the Convention on Biological Diversity (CBD).

It aims to ensure the safe handling, transfer, and use of living modified organisms (LMOs) resulting from modern biotechnology to protect biodiversity and human health.

Adopted: January 2000 | Came into force: September 2003

Parties Involved: 173 countries :Some major biotech-producing countries (USA, Canada, Argentina) have not ratified the protocol.

Implementation varies across countries due to different regulatory capacities.

Conflict between trade interests and biosafety measures.

Key Objectives

Protect Biological Diversity from risks associated with genetically modified organisms (GMOs/LMOs).

Establish Biosafety Regulations for transboundary movement of LMOs.

Ensure Informed Decision-Making through risk assessment before importing GMOs.

Promote Public Awareness & Participation in biosafety-related decisions.

Cartagena Protocol & Biosafety Regulations in Microbiology

Regulates the use of Living Modified Organisms/ genetically modified microbes in agriculture, industry, and medicine.

Ensures containment measures for bioengineered probiotics, microbial pesticides, and bioremediation strains.

Requires labeling of GMOs for transparency in trade and consumer choice.

3. Core Principles of the Cartagena Protocol

Principle	Description
Precautionary Approach	Even if scientific evidence is uncertain, countries can **restrict or ban** GMOs if there is potential harm.
Advance Informed Agreement (AIA)	Exporting nations must obtain consent from importing nations before transferring LMOs.
Risk Assessment & Management	LMOs must undergo scientific risk evaluation before approval for use.
Biosafety Clearing-House (BCH)	A global platform for **sharing information** on LMOs and biosafety regulations.