

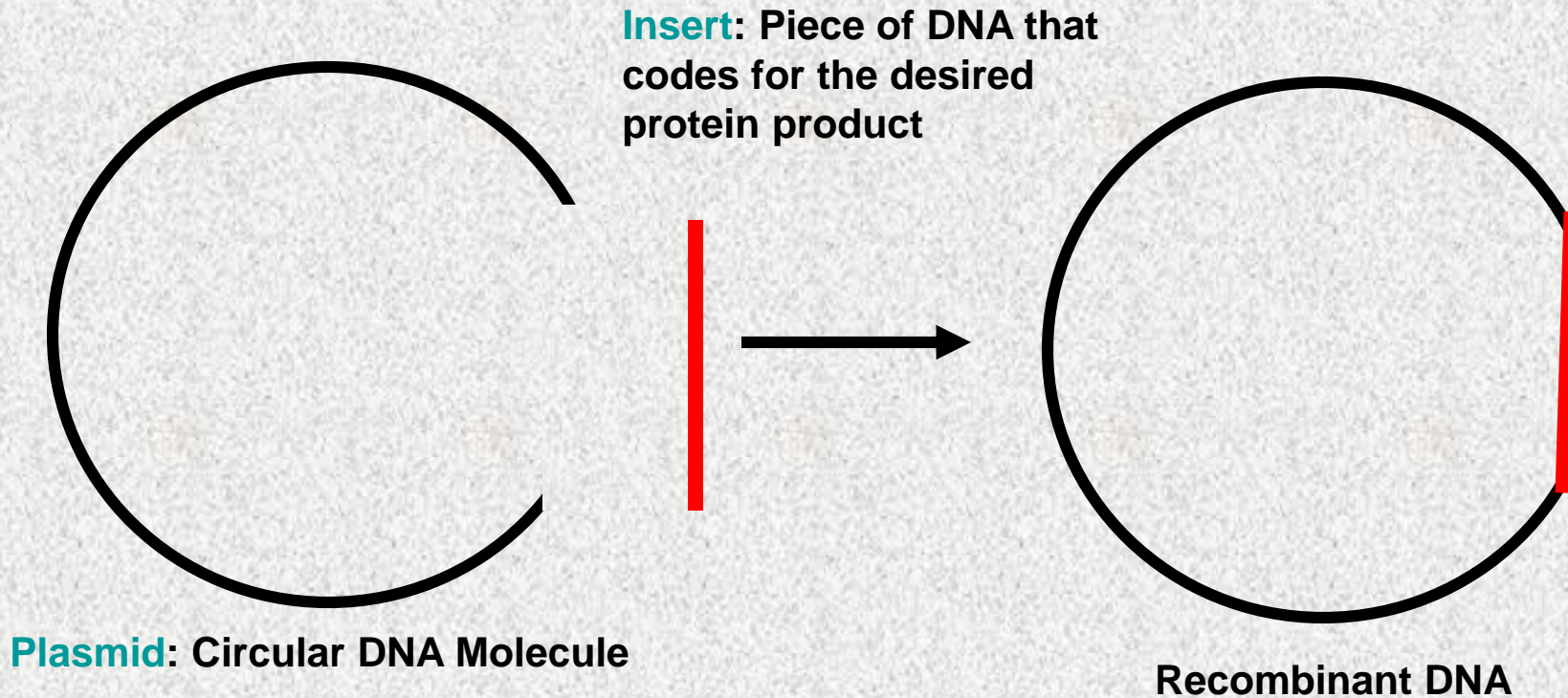
# Introduction to Adenoviral Vectors and the Institutional Biosafety Committee (IBC)

This presentation is intended to serve as an aid for researchers that are new to viral vectors for use with mammalian systems and would like assistance writing IBC applications.

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# NIH's Definition of Recombinant DNA (rDNA)

- Molecules that are constructed outside living cells by joining natural or synthetic DNA segments to DNA molecules that can replicate in a living cell.
- Molecules that result from the replication of those described above.



# **An institution's IBC is charged with ensuring compliance with NIH guidelines for research involving rDNA.**

Any institution receiving funds from NIH to perform research involving recombinant DNA must have an IBC.

The IBC must review the recombinant DNA research conducted at the institution.

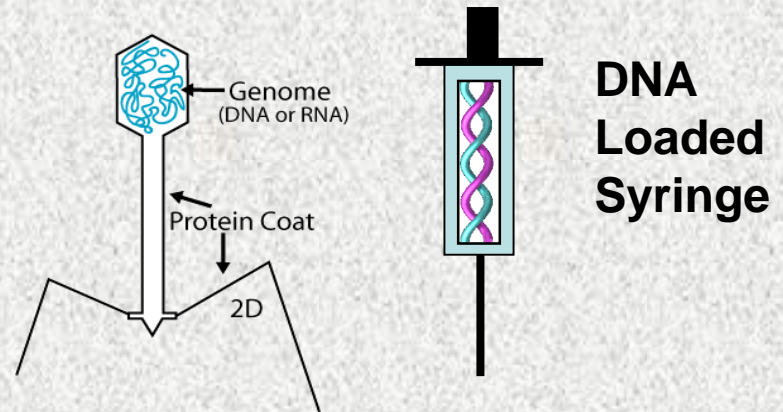
NIH guidelines refer to CDC guidelines for Biosafety in Microbiological and Biomedical Laboratories (BMBL)

Failure to comply with these guidelines can result in loss of NIH funding by the institution and additional fines.

# Infectious Viruses: A Genetic “Syringe”

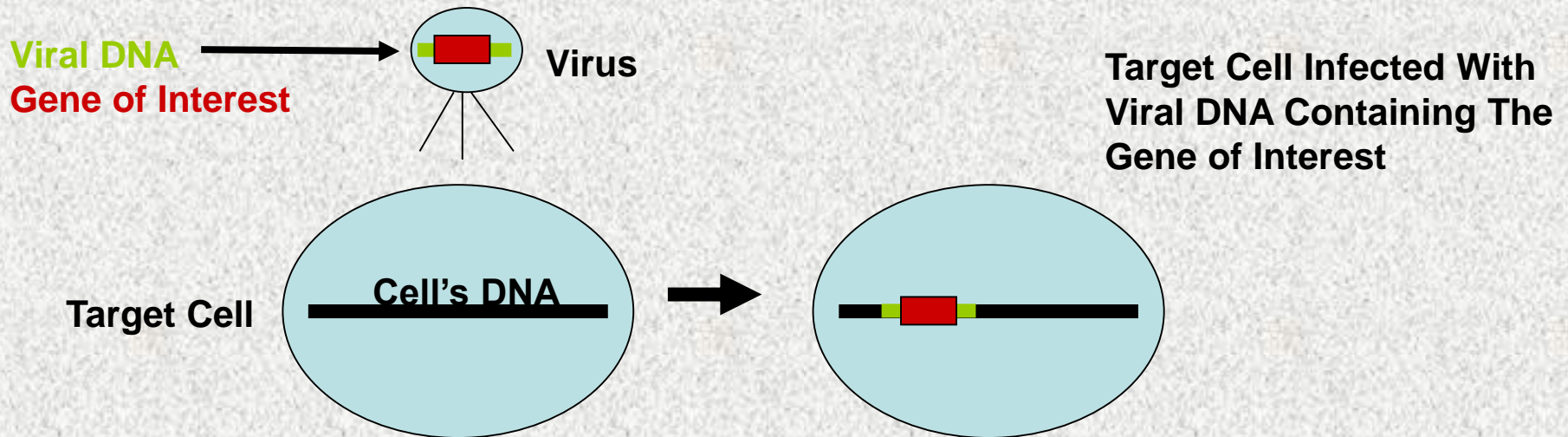
Viruses are composed of genetic material encapsulated in a protein coat.

Viruses inject their genetic material into target cells.



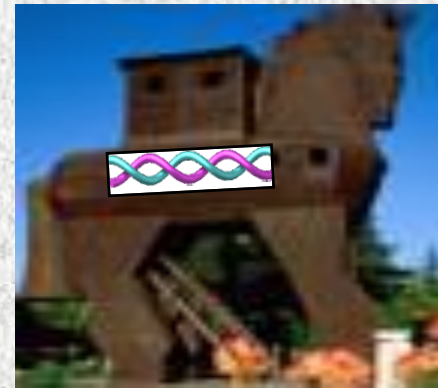
Viruses infect target cells with their genetic material.

The viral DNA can be altered to contain a gene of interest (rDNA) to infect that gene into the target cell.

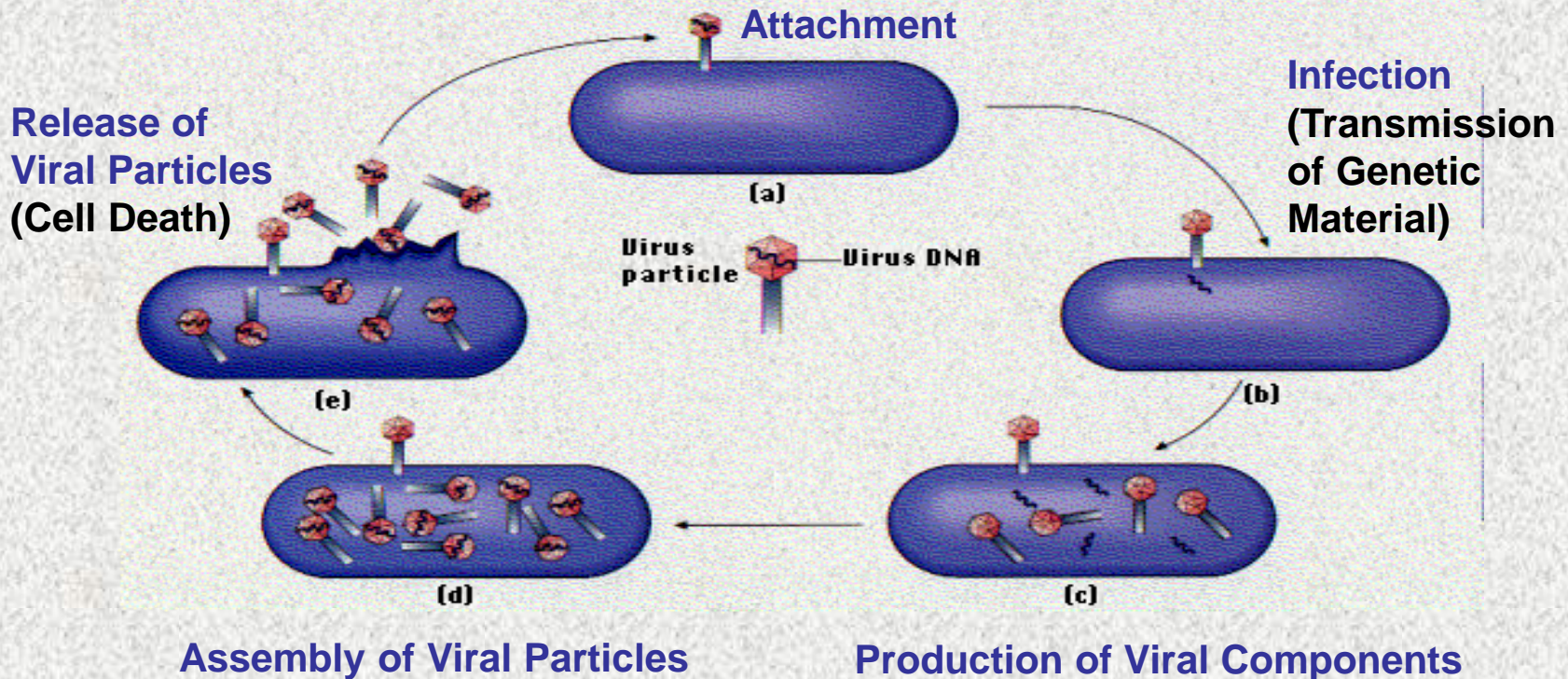




# Safety Concerns Related to Infectious Viruses: A Genetic “Trojan Horse”

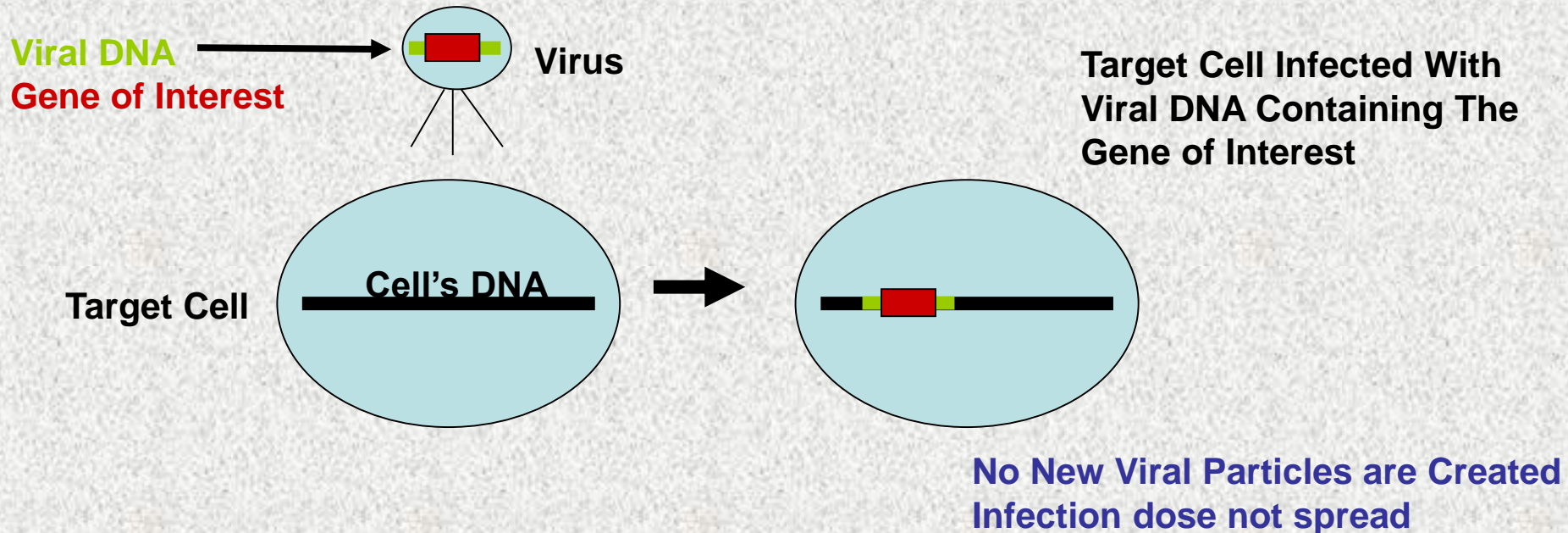


**Viruses Cannot reproduce by themselves, so they infect cells with their genetic material to hijack the cellular machinery to produce more viruses. This process can result in cell death, tissue damage or even the death of the infected organism.**

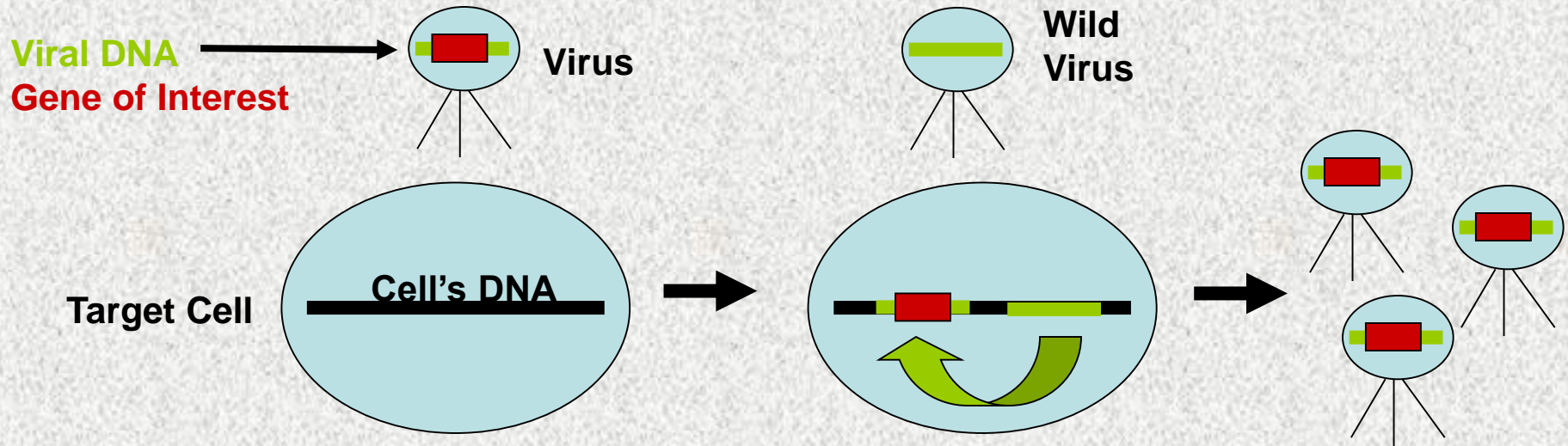


# Replication Deficient Viral Vectors: Genetically Engineered So The Viral Infection Cannot Spread

- The viral DNA does not contain the viral genes needed to make more viruses.



# Rescue of Replication Deficient Viruses by superinfection with Wild Viruses

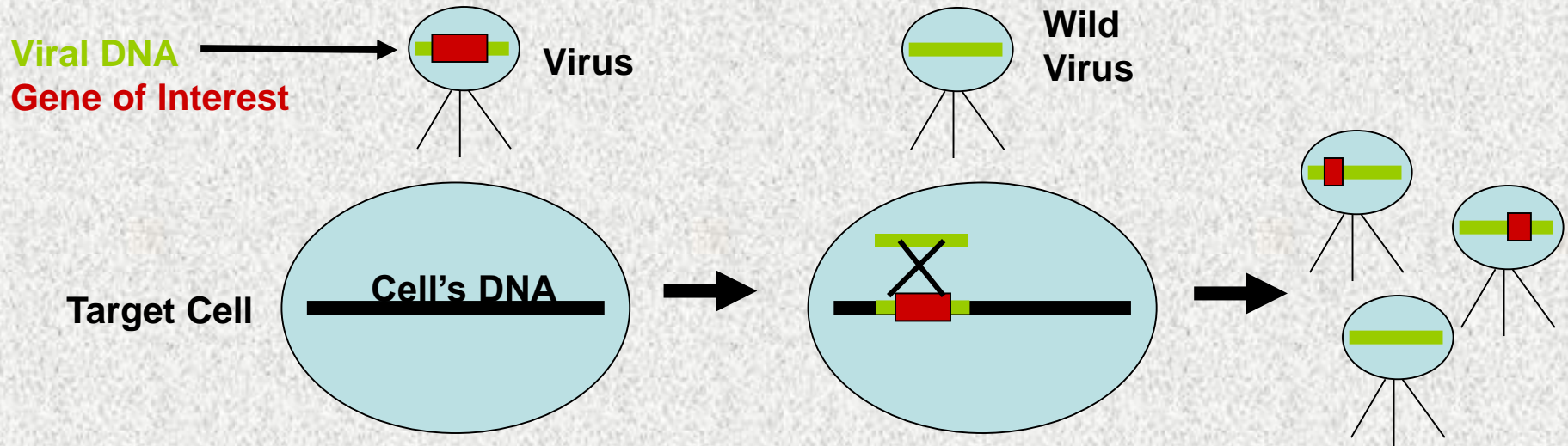


## Complementation:

The genome from the wild virus provides the missing proteins needed for the viral vector to replicate. The superinfected cell functions similarly to a packaging line.



# Rescue of Replication Deficient Viruses by superinfection with Wild Viruses



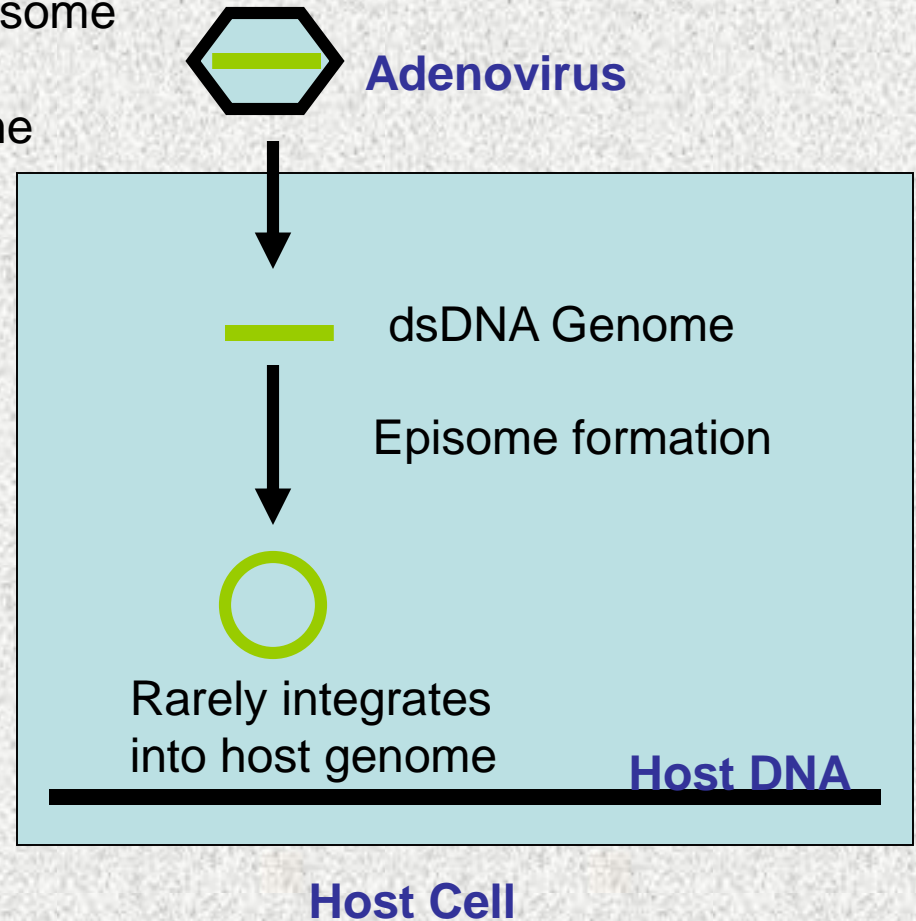
## Recombination:

The genome from the wild virus randomly recombines with the viral vector, providing sufficient genetic material for the viral vector to replicate. The resulting rescued virus may possess pieces of the original insert gene. The viral genome is impossible to predict due to random recombination. The virus may exhibit altered virulence.



# Adenovirus

- dsDNA genome
- Non-Lipid Enveloped
- Upon infection, the viral DNA forms an episome
- Episome rarely integrates into host genome
- Fixed host range affecting Rodents, humans and other animals
- Known receptors: Cocksacki & Adenovirus Receptor (CAR) HLA / MHC I



# Risks Associated with Adenoviruses

- Adenovirus is transmitted by inhalation, contact with mucus membranes (eyes, nose and mouth), fecal-oral transmission and waterborne transmission.
- There is an Increased risk from infection due to aerosol production ([see slide 18](#)).
- Adenovirus infections most commonly cause illness of the respiratory system with symptoms ranging from the common cold to pneumonia, croup, and bronchitis. Depending on the infecting serotype, adenovirus infection may also cause other illnesses such as gastroenteritis, conjunctivitis and rash.
- Patients with compromised immune systems are especially susceptible to severe complications of adenovirus infection.
- Transplacental infection can occur during pregnancy and can lead to teratogenic effects.

# The Adenoviral Genome



**ITR** – Inverted Terminal Repeat (origin of viral replication)

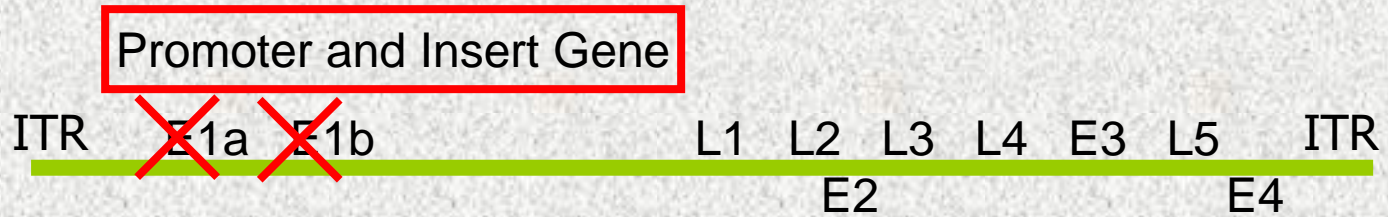
**E** – Early Response Genes

- Initiation and activation of viral replication
- Suppression of host cell gene expression and protein synthesis
- Activation of late response genes (L)

**L** – Late response (viral structural components)



# Design of **Replication Incompetent** Adenoviral Vectors

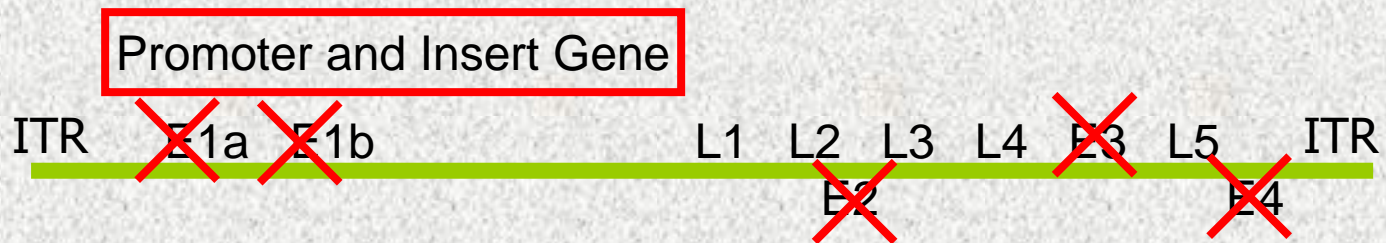


**E1a** – Initiates replication, activates adenoviral transcription, stimulates infected host cell to enter S phase

**E1b** – Viral RNA transport while blocking host mRNA transport, blocks apoptosis

All E1 deficient adenoviral vectors are replication deficient in cells that neither express E1 or E1 like proteins.

## Additional Early Response (E) Genes May Be Deleted for Added Safety



**E1a** – Initiates replication, activates adenoviral transcription, stimulates infected host cell to enter S phase

**E1b** – Viral RNA transport while blocking host mRNA transport, blocks apoptosis

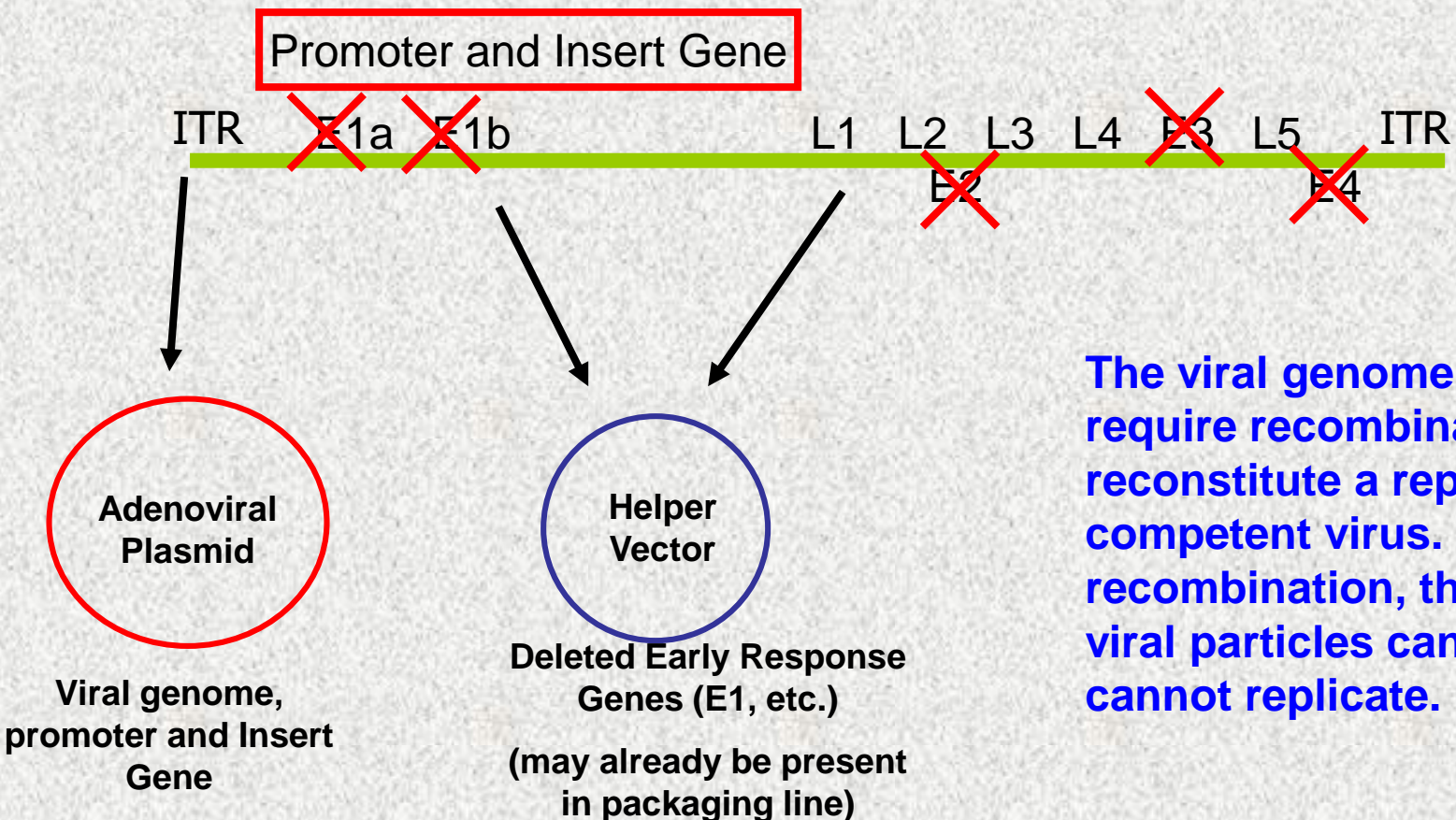
**E2** – Involved in replicating viral genome

**E3** – Limits expression of HLA / MHC I and inflammation caused by  $\text{TNF}\alpha$  to limit antiviral immunity of the infected host

**E4** – Blocks host protein synthesis which can lead to death of host cell

# Design of Replication Incompetent Adenoviral Vectors

The viral vector is “gutted” as much as possible to create room for the insert gene and to divide the viral genome into cis- and trans- acting regions. The deleted regions are present in packaging cells or are provided by co-transfection completing the viral genome and allowing creation of viral particles.



The viral genome is divided to require recombination to reconstitute a replication competent virus. Barring such recombination, the resulting viral particles can infect but cannot replicate.



# Common Methods of Deactivating Viruses

## Lipid Enveloped Viruses

(Retro, Lenti, MMLV, HIV, Herpes Simplex, Flu, Hepatitis B and C)

Ethanol ← Cavicide  
Quaternary Ammonium Compounds  
Phenol  
10% Bleach  
Aldehydes (Paraformaldehyde, Gluteraldehyde)  
Autoclave

## Non-Lipid Enveloped

(Adenovirus, Adeno-Associated Virus)

10% Bleach  
Aldehydes (Paraformaldehyde,  
Gluteraldehyde)  
Autoclave

### Please note:

**Non-lipid Enveloped Viruses are Resistant to weaker disinfectants like ethanol and quaternary ammonium compounds.**

**10% bleach decomposes over time and has an approximate half life of 2 weeks. Recommend making fresh weekly.**

**Liquid disinfectants must be allowed the appropriate contact time to be effective.**

# Risk Assessment

Risk assessment is a vital part of the IBC review process as required by the NIH.

The purpose of a risk assessment is to determine the risk to researchers, the community and the environment.

## Steps to conduct a risk assessment:

Identify hazards

Assess possibility for exposure

Manage the risk

**Managing risk involves implementing controls to limit risk.**

**Example of controls include:**

**Personal Protective Equipment (PPE):** gloves, lab coat, eye and respiratory protection

**Engineering:** Biosafety Cabinet, centrifuge with sealed rotors or safety caps

**Work Place Practices:** Following the PI's approved biosafety protocol

**Administrative:** Training, supervision, lab inspections, vaccination, medical surveillance

# Containing Risks Associated with Aerosols

## **Aerosol Producing Procedure**

## **Method of Containment**

Splash/Spray	biosafety cabinet, fume hood, splash shield
Vortexing	sealed tubes, biosafety cabinet
Centrifugation	sealed tubes, sealed rotor, safety cups
Homogenization	biosafety cabinet, fume hood, splash shield
Flow cytometry	fixation or BSL2+ containment
Injection/administration Into animals	biosafety cabinet, animal restraint
Cage cleaning (infected animals)	biosafety cabinet, PPE (contact Biosafety Officer to review procedures and PPE)

PPE for BSL2 labs: gloves and lab coats are required,  
eye and respiratory protection (as needed)



# Factors of a Risk Assessment for Viral Vectors

Vector

Insert Gene

Procedures

Volumes

# Examples of Low Risk Work with Viral Vectors

**Vector** – Replication incompetent and self inactivating vector  
Limited tropism (incapable of infecting humans)

**Insert Gene** – Is Not: toxic, oncogenic, immune modulatory, or increases tropism or pathogenicity

**Procedures** – limited to cell culture in a biosafety cabinet, centrifugation with sealed tubes and safety caps or sealed rotors

**Volumes** – 1-10 mL (easy to contain and transport)

# Examples of High Risk Work with Viral Vectors

**Vector** – Replication competent vector, broad tropism, capable of infecting various animals including humans

**Insert Gene** – toxin or toxic at high levels, oncogene, immune modulation, increases viral tropism or pathogenicity

**Procedures** – aerosol production (homogenization, vortexing in open tubes, centrifugation without sealed tubes, safety caps or sealed rotors) injection/administration into animals

**Volumes** – Liters (requires bulkier containment and a cart to transport, higher likelihood of a spill)

# Additional Questions?

Please contact:

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