ROUTES OF EXPOSURE FOR BIOHAZARDS

INVOLVED IN LABORATORY ACQUIRED INFECTIONS

LAB ACQUIRED INFECTIONS 1930 -2015

- 1930 – 2015
  - 7,325 LAIS (SYMPTOMATIC AND ASYMPTOMATIC)
  - 210 FATAL LAI'S
    - BYERS KB AND HARDING, AL. LABORATORY-ASSOCIATED INFECTIONS. 2017. IN: WOOLEY, DP, AND BYERS, KB, EDITORS, BIOLOGICAL SAFETY: PRINCIPLES AND PRACTICES, 5TH ED., WASHINGTON, DC: ASM PRESS. P. 59 – 94.
    - PIKE RM. 1979. LABORATORY-ASSOCIATED INFECTIONS: INCIDENCE, FATALITIES, CAUSES, AND PREVENTION. ANNU REV MICROBIOL: 33: 41 -66.
    - SULKIN SE, PIKE RM. SURVEY OF LABORATORY-ACQUIRED INFECTIONS. AM J PUB HLTH. 1951; 41: 769-81.

WHAT IS KNOWN ABOUT EXPOSURE ROUTES?

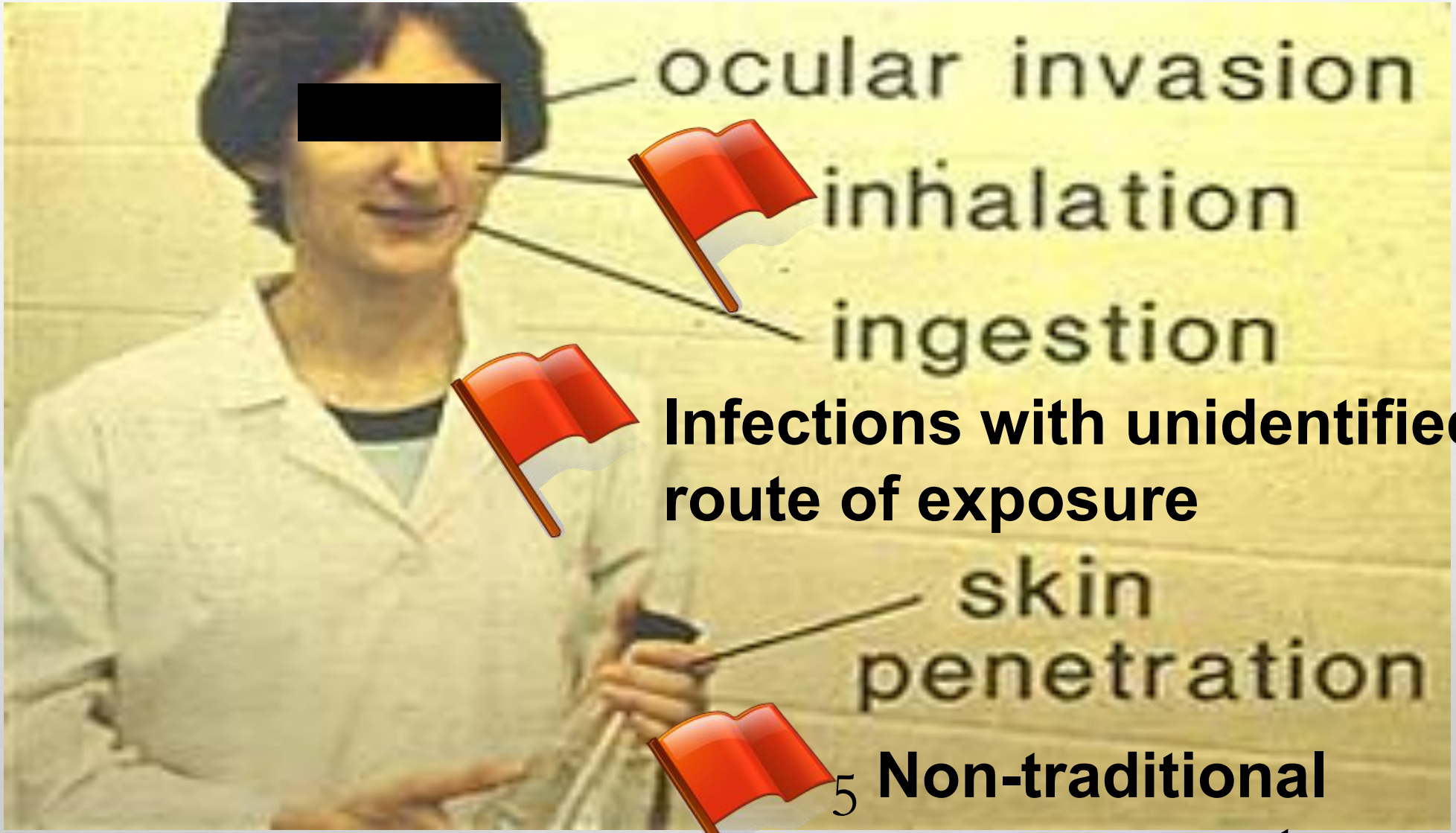
- Percutaneous
- Facial Mucous Membranes
- Ingestion
- Inhalation
- *Contact

*Contact involves self-inoculation through one of the known exposure routes

GOLDEN AGE OF BIOSAFETY (1949 – 1979)

THERE CAN BE **UNNATURAL ROUTES OF EXPOSURE** IN THE LABORATORY SETTING THAT ARE GENERALLY NOT SEEN IN NATURE.

(SULKIN 1960)



Infections with unidentified route of exposure

Non-traditional exposure route

NON-TRADITIONAL EXPOSURE ROUTES

GI Pathogens: Salmonella, Listeria, Shigella, Campylobacter, E. coli, etc.

Thomas, R.J., "Particle Size and Pathogenicity in the Respiratory Tract." Virulence 4:8, 847-858; November 15, 2013.

NON-TRADITIONAL EXPOSURE ROUTES

GI Pathogens: Salmonella, Listeria, Shigella, Campylobacter, E. coli, etc.

Aerosol → **Nasal muco-ciliary escalator** → **Throat** → **Gut**

Aerosol → **Tracheo-bronchial mucociliary escalator** → **Throat** → **Gut**

ROUTE OF EXPOSURE TREES

INGESTION

- VIA EATING, DRINKING OR CONTACT
- VIA NASAL
  LACRIMAL DUCT
- VIA MUCOCILLIARY ESCALATOR

INGESTION LIKELY UNRECOGNIZED

- NOT COGNIZANT OF HAND TO FACE CONTACT
- POOR WORK PRACTICES IN SHALLOW WATER (JIM WELCH)
- LACK OF RECOGNITION OF POSSIBLE ROLE OF AEROSOLS FROM CONTAMINATION TO HOST ENTRY
- CAN'T "FEEL" THE EXPOSURE
- COMPETING RISKS OUTSIDE OF LAB
  - **CDC: 48 MILLION FOODBORNE ILLNESSES ANNUALLY**
  - **MANY SELF MEDICATE AND DON'T REPORT**
  - **OVER 250 FOODBORNE PATHOGENS**

NON-TRADITIONAL EXPOSURE ROUTES

West Nile Virus, Yellow Fever Virus, Rabies Virus, Influenza Virus, Neisseria meningitidis, Streptococcus pneumoniae

Aerosol → **Nasal Cavity** → **Cranial Nerves** → **Brain**

NASAL CAVITY TO BRAIN VIA CRANIAL NERVES

INFLUENZA A VIRUS, HERPES VIRUSES, POLIOVIRUS, PARAMYXOVIRUSES, VESICULAR STOMATITIS VIRUS, RABIES VIRUS, PARAINFLUENZA VIRUS, ADENOVIRUSES, JAPANESE ENCEPHALITIS VIRUS, WEST NILE VIRUS, CHIKUNGUNYA VIRUS, LACROSSE VIRUS, BUNYAVIRUSES, STREPTOCOCCUS PNEUMONIAE, NEISSERIA MENINGITIDIS, BURKHOLDERIA PSEUDOMALLEI, LISTERIA MONOCYTOGENES, LYMPHOCYTIC CHORIOMENINGITIS VIRUS, NAEGLERIA FOWLERI, EEE, VEE, WEE

- DANDO, S.J. ET AL, "PATHOGENS PENETRATING THE CENTRAL NERVOUS SYSTEM: INFECTION PATHWAYS AND CELLULAR AND MOLECULAR MECHANISMS OF INVASION." 2014. CLINICAL MICROBIOLOGICAL REVIEWS, VOL. 27 NO. 4, 691-726, OCTOBER 2014
- BELOOR, J. ET AL, "SMALL INTERFERING RNA-MEDIATED CONTROL OF VIRUS REPLICATION IN CNS IS THERAPEUTIC AND ENABLES NATURAL IMMUNITY TO WEST NILE VIRUS," 2018. CELL HOST & MICROBE, 23, 549-556, APRIL 11, 2018.
- VAN RIEL, ET AL, "THE OLFACTORY NERVE: A SHORTCUT FOR INFLUENZA AND OTHER VIRAL DISEASES INTO THE CENTRAL NERVOUS SYSTEM, JOURNAL OF PATHOLOGY; 235, 277-287, 2015.

NON-TRADITIONAL EXPOSURE ROUTES

West Nile Virus, Yellow Fever Virus, Rabies Virus, Neisseria meningitidis, Sabia Virus, EEE, WEE, VEE

Thomas, R.J., "Particle Size and Pathogenicity in the Respiratory Tract." Virulence 4:8, 847-858; November 15, 2013.

Winkler, W.G. 1973. Airborne rabies transmission in a laboratory worker. JAMA 226 (10):1219-1221.

Centers for Disease Control. 1977. Rabies in a laboratory worker, New York. MMWR 26(22): 183-184

ROUTE OF EXPOSURE TREES

INHALATION

- FACIAL MUCOUS MEMBRANES
- CRANIAL NERVES FROM NOSE TO BRAIN
- Mucociliary Escalators - Gut

INHALATION

- Lung (Epithelial cells, other)
- Blood (alveoli, lymphatic system)
- Contact (from contaminated surfaces)

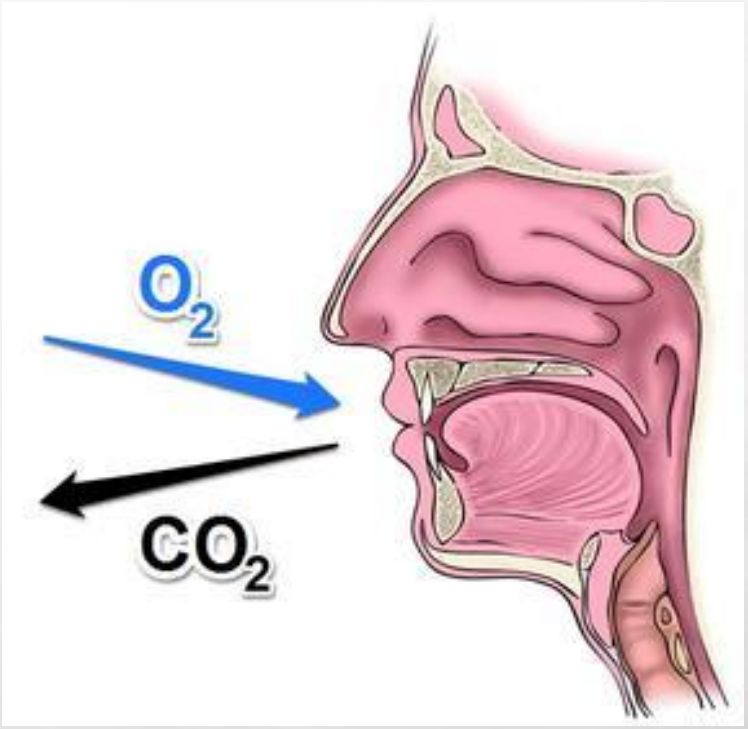
RECOGNIZED VS. UNRECOGNIZED EXPOSURES: PEOPLE REPORT WHAT THEY CAN "FEEL"

Feel splashes/splatter to face or skin

Feel needle sticks, lacerations, punctures, cuts, etc.

WHAT YOU CAN'T FEEL IS (PROBABLY) NOT REPORTED?

Ingestion



Inhalation

May also not feel exposure through micro-abrasions

GOLDEN AGE OF BIOSAFETY (1949 – 1979)

THE **LABORATORY CAN BE MORE DANGEROUS THAN NATURE** DUE TO THE ABILITY TO **AMPLIFY** AND CONCENTRATE PATHOGENS TO LEVELS NOT SEEN IN NATURE. ALSO, THE GROWTH AND PROPAGATION OF INFECTIOUS AGENTS IN LABORATORY SETTINGS ARE **CONDUCTED REPEATEDLY** WITHIN THE LABORATORY AS PART OF THE RESEARCH EFFORT, ENHANCING THE POTENTIAL EXPOSURE.

(LANGMUIR 1960)

ROUTE OF EXPOSURE TREES

Facial Mucous Membranes

- FACIAL MUCOUS MEMBRANES
- Blood, Lymph
- CRANIAL NERVES - FROM NOSE TO BRAIN
- GUT (from eye, nose or mouth)

HAND TO FACE CONTACT (HFC) ARTICLE

- 72% of researchers touched face at least once
- Average of 2.6 HFCs/hr
- HFC found "common" among BSL-2 lab workers
- Possibly an overlooked route of exposure for unknown LAIs

- High likelihood of finger, hand and wrist contamination
- Only 3 of 93 researchers wore eye or face protection in the BSL-2 lab

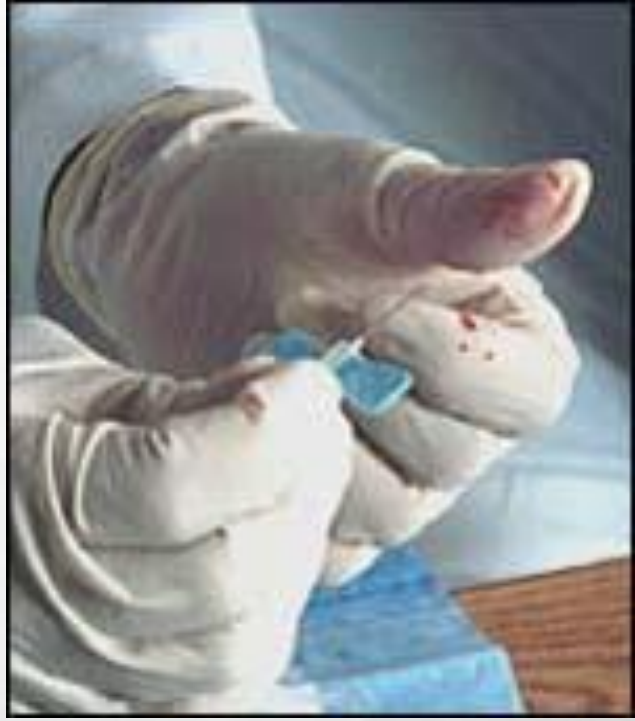
Johnston, J.D., et al, "The Influence of Risk Perception on Biosafety Level-2 Laboratory Workers' Hand-To-Face Contact Behaviors," Journal of Occupational and Environmental Hygiene, Vol. 11, pp 625-632, September 2014

ROUTE OF EXPOSURE TREES

Percutaneous

- SKIN (Local infections)
- BLOOD STREAM
- FACIAL MUCOUS MEMBRANES

PERCUTANEOUS EXPOSURES



Needle sticks, lacerations, punctures, bites

Unhealed wounds

Breaks in skin, cuticles, posion ivy, eczema, dermatitis

Acne, other micro-abrasions

GLOVE - LEAK RATE - FACTS

Glove Leak Rates	Exam Gloves	Surgical Gloves
Before Use (FDA)	2.5%	1.5%
After Use	*21 – 35%	**15.2%

****Double gloving: leak rates for inner gloves when double gloved - 1.17% (98.83% Effective!)**

*Boyle, B & Boyle, T, "Loss of Glove Integrity During Laboratory Animal Care Providers Daily Tasks," Lenape Regional High School, Medford NJ, Science Fair Poster Presentation, 2017

**Makama, J.G. et al, "Glove Perforation Rate in Surgery: A Randomized, Controlled Study to Evaluate the Efficacy of Double Gloving," Surgical Infections, Vol. 17 No. 4, pp 436-442, March 16, 2016