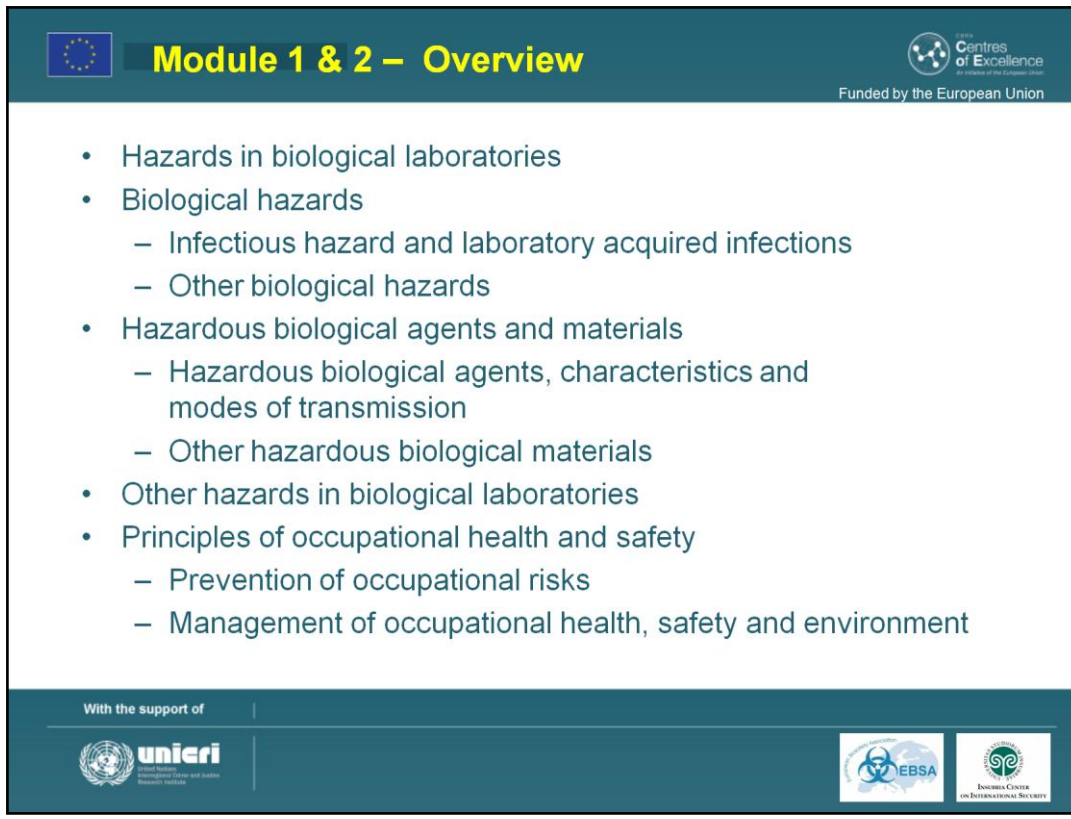
Module 1: C.2.1.2.1 Biological and other hazards in the work area*
Micro-organisms and occupational infections (LAI - Laboratory Acquired Infection)
Genetically modified organisms
Toxins
Allergens
Bloodborne pathogens
Materials potentially infected, e.g., blood, body fluids, soil samples …
Modes of transmission: means and routes
Emerging and re-emerging diseases
Parasites
Cell lines (e.g., primary, permanent, immortalized, GM)
Aerosols
Other hazards, e.g., chemical, gases, radiological, fire, mechanical, electrical, etc.
Objectives: The participant should be able to understand the risks associated with work with biological agents and consideration of other hazards; she/he could describe some occupational infections that have led to the development of current biosafety practices and should be able to decide when expert help is needed to address a specific issue.

Module 2: C.2.1.2.2 Occupational health and biosafety*
Prevention of occupational risks (POR)
Medical surveillance
Incident / accident response
Allergens and hypersensitivity
Immuno-compromised workers
Pregnant workers
Partnership between occupational health provider, Health Safety and Environment and Biosafety
Objectives: The participant should be able to understand the working relationship with the occupational health provider and of the prevention and surveillance measures to



General references

CWA 15793:2011 Laboratory biorisk management (ftp://ftp.cenorm.be/CEN/Sectors/TCandWorkshops/Workshops/CWA15793_September 2011.pdf)

WHO – "Laboratory biosafety manual", 3rd edition, 2004 (http://www.who.int/csr/resources/publications/biosafety/Biosafety7.pdf)

WHO – "Biorisk management - Laboratory biosecurity guidance" 2006 (http://http://www.who.int/csr/resources/publications/biosafety/WHO_CDS_EPR_2006 _6.pdf)

In giving the training to a group, the slide could be used asking to identify the various hazards (can be animated, logos being added on request)

NOTES

1. Chemical hazards can be due to various characteristics of chemical substances: corrosion, toxicity, carcinogenicity, flammability, explosiveness… Harm can be direct, and due to skin exposure, inhalation, ingestion, etc, or indirect.

2. Depending on the radioactive substance and the situation, radiation hazards can be due to exposure to distance sources, skin contact, inhalation or ingestion.

Reality of biological hazards

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- A number of micro-organisms are transmissible and pathogenic
  - They can be transmitted and cause infection and disease
  - Pathogens = micro-organisms that are likely to cause disease
- Laboratory-acquired infections (LAIs) have occurred in the past and continue to occur

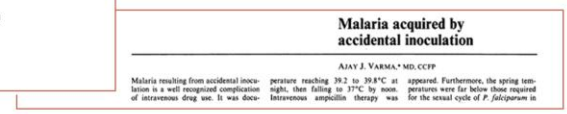
Article

Applied Biosafety, 12(1) p. 17 © ABSA 2007

Editorial on Laboratory-Acquired Incidents in Taipei, Taiwan and Singapore Following the Outbreak of SARS Coronavirus

Ai Ee Ling

Singapore General Hospital, Singapore



Malaria acquired by accidental inoculation

AJAY J. VARMA,* MD, CCFP

Malaria resulting from accidental inoculation is a well recognized complication of intravenous drug use. It was documented in a patient who developed a temperature reaching 39.2 to 39.8°C at night, then falling to 37°C by noon. Intravenous ampicillin therapy was appeared. Furthermore, the spring temperatures were far below those required for the sexual cycle of *P. falciparum* in

- Other cases of infection, including outbreaks, have originated from laboratory activities

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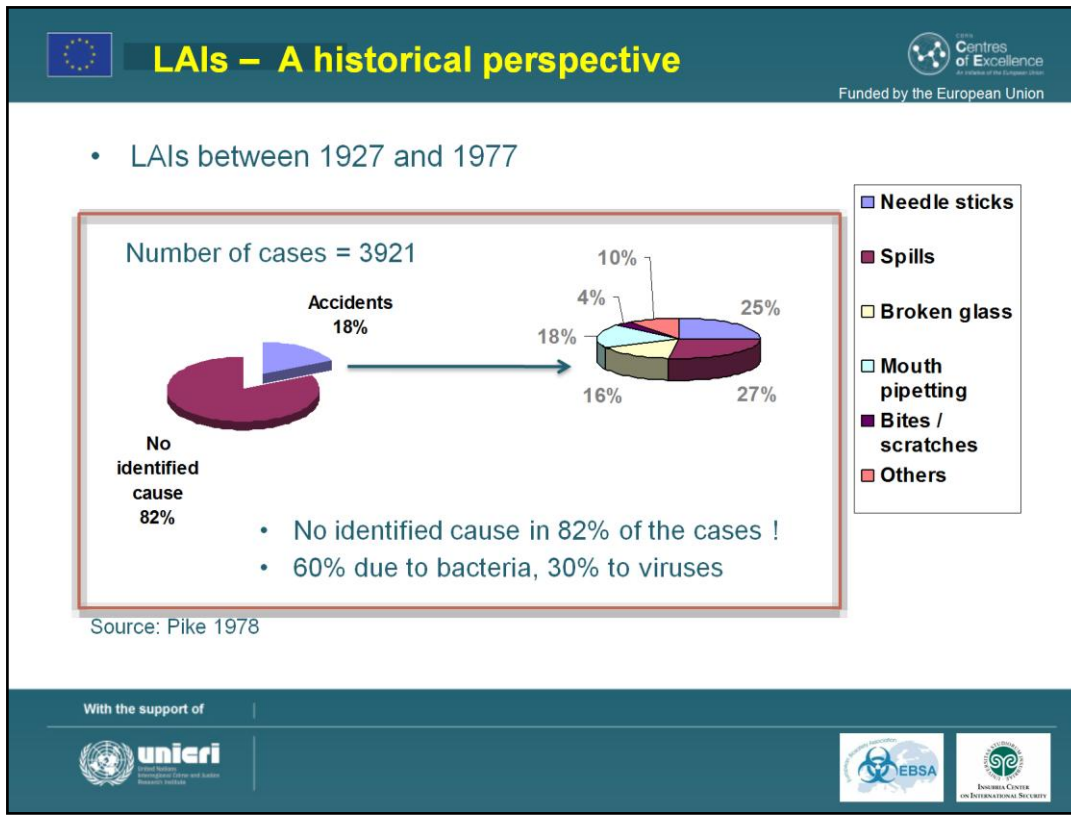

NOTES:

1. This period before the seventies can be considered as mostly before the development of modern biosafety.

2. Of interest: the large proportion of non-identified cause of LAIs (more than 80%). Now we assume that a large part of those unexplained cases were probably due to aerosols.

SOURCE: Pike RM. Past and present hazards of working with biological agents. Arch. Pathol. Lab. Med. 1978: 102: 333-336.

Some recent LAIs (2002-2010)

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- Acute Adenovirus respiratory infection (USA, 2009)
- Bubonic plague (USA, 2009)
- Vaccinia virus infections (USA, 2008)
- Brucellosis (USA, 2006)
- Tuberculosis (USA, 2004)
- Pneumonic tularemia (USA, 2004)
- Ocular Vaccinia infection (USA, 2004)
- SARS infections (China 2004, Singapore & Taiwan, 2003)
- Legionellosis (Sweden, 2003)
- Vaccinia infection (Brazil, 2002)
- Cutaneous anthrax (USA, 2002)

Laboratory-acquired Vaccinia virus infection – Virginia, 2008
(CDC, MMWR 58: 797-800, July 2009)

Cutaneous anthrax

Also "CDC: 11 lab workers infected from 2004 to 2010" (USA Today,15.01.2013)

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Based on some internet search. Certainly not complete.

LAIs – A recent case study

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Article

Applied Biosafety, 12(1) p. 17 © ABSA 2007

Editorial on Laboratory-Acquired Incidents in Taipei, Taiwan and Singapore Following the Outbreak of SARS Coronavirus

Ai Ee Ling

Singapore General Hospital, Singapore

Severe Acute Respiratory Syndrome (SARS) LAIs in Asia, 2003-2004

- Cases of SARS Coronavirus laboratory-acquired infections in 4 distinct institutions in Singapore, Taiwan and China
- Cases mostly ascribed to deficient work practices
- Taiwanese case spread infection to the community (secondary outbreak)
- Incidents prompted strong reactions from the authorities
  - Stop of the activities and control of BSL3 labs (China)
  - Development of more stringent regulations and control

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LAIs – The real picture?

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- Laboratory incidents and accidents still not reported and recorded in many institutions
- Only some major or significant incidents and LAIs published
- Many biosafety professionals know about non-published cases

- There are a number of published cases of LAIs
- These are probably only the visible part of the iceberg – *How many laboratory incidents and LAIs are never reported, recorded and published?*

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Risks from biological agents & materials

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- Risks from biological agents and materials
  - Infection
    - By infectious or pathogenic biological agents
    - The main biological hazard
  - Allergies
    - From allergens produced by various living organisms (some micro-organisms, animals and plants…)
  - Intoxication
    - By toxins produced by biological agents, fungi or plants
    - Can be part of the infectious process

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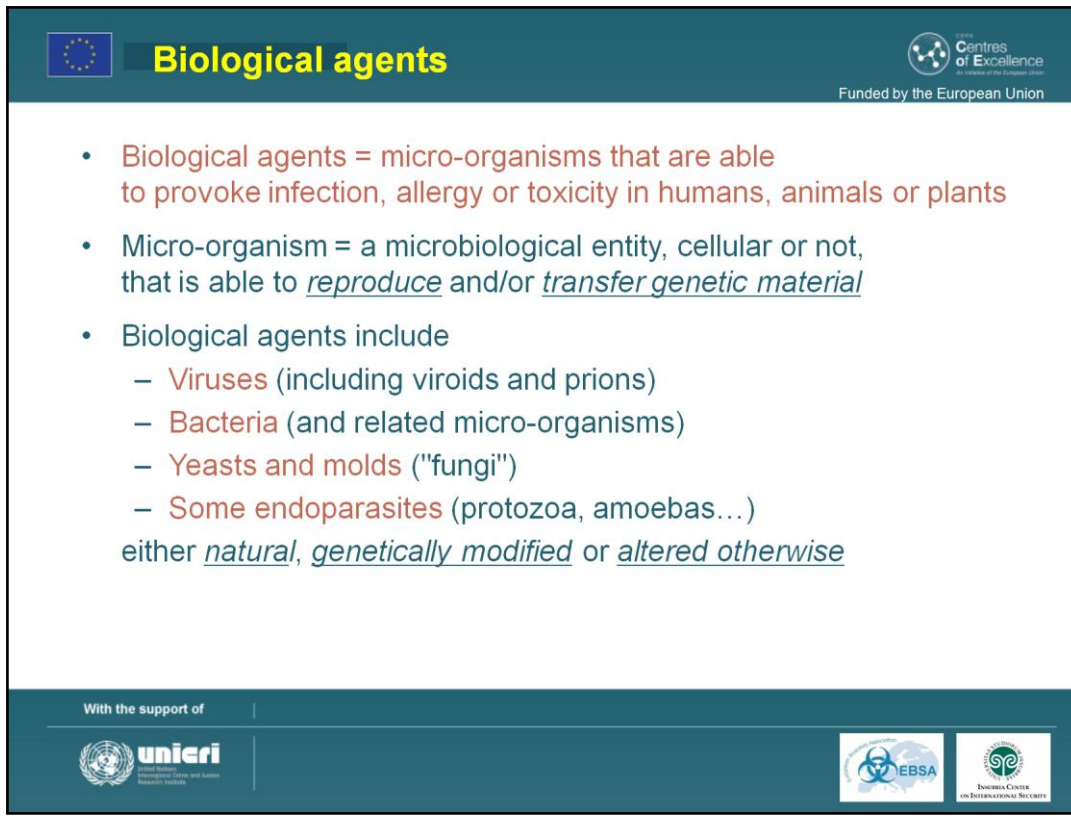
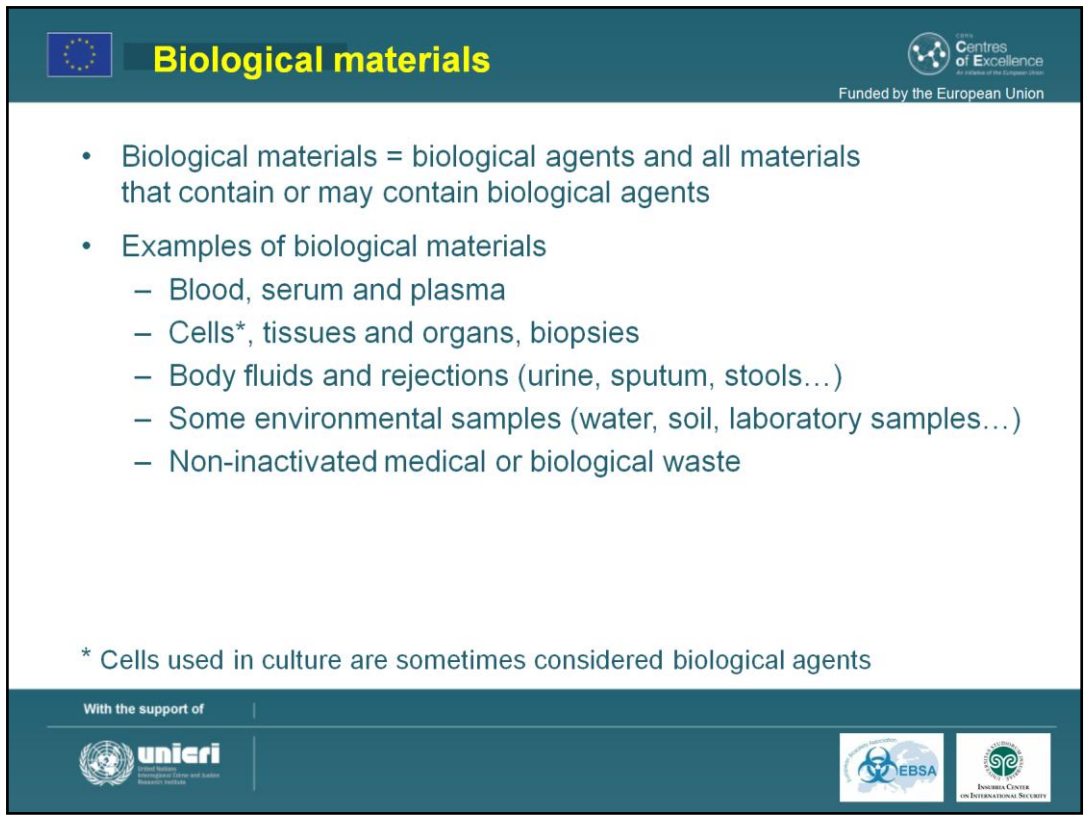


"Altered otherwise" – Examples:

- Attenuated strains used for vaccine production or even live vaccine strains

- Strains that are modified by other techniques than those considered as genetic modifications.



Note: Some European regulations tend to consider cells used in cultures as micro-organisms or biological agents.

Infection

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- The main risk from biological agents
- Infection = invasion of an organism by a biological agent
  - Infection can cause a wide variety of symptoms and diseases, according to the agent and the organism's reactions
  - Infection can be asymptomatic (without symptoms and disease)
  - Asymptomatic infections can generally still be transmitted
- Disease = any impairment of the normal physiologic functions affecting all or part of an organism
  - Disease is not necessarily caused by an infection
  - Infectious disease = any disease caused by the entrance, growth and multiplication of micro-organisms
  - Infectious diseases are transmissible

Intoxication

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- Intoxication = poisoning by a harmful chemical substance, including toxins produced by some biological agents
- Due to the inhalation, ingestion or contact to toxin substances, including those that are produced by biological agents
- Intoxication can be
  - Linked to an infection (toxins emitted by the infecting micro-organism during the infection process)
  - Due to exposure to a toxic substance
- Endotoxins (in bacteria) = heat-stable biological toxins that are not secreted but excreted when cells are disrupted
- Exotoxins (in bacteria and fungi) = potent toxins that are formed by the cells and secreted in their growth environment

Allergy – reaction of the immune system to foreign substances (allergens). Weather an allergic reaction is induced depends largely on the structure of the protein, the immune system of the person and the environment (exposure, pollution, stress, etc.). With repeated or routine exposure to an allergen and stimulation of the immune system, a local and/or systemic allergy can be built up.

Main groups of hazardous biological agents /1

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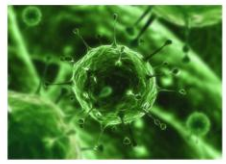
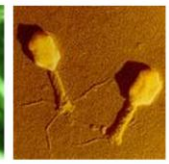
- Viruses
  - Incomplete living forms
  - Genome composed of RNA or DNA
  - Common sizes: 20-200 nm
  - Use of the machinery of a more complete cell to achieve metabolism and replication
  - Infectious by nature (but not necessarily to humans, and not necessarily pathogenic)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Main groups of hazardous biological agents /2

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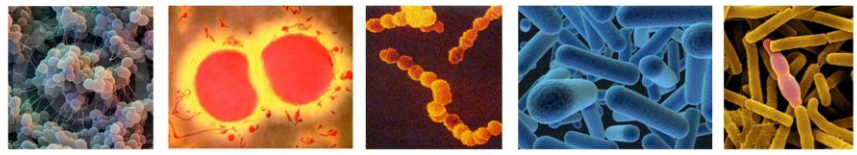

- Bacteria
  - Absence of nucleus
  - Genome made of DNA, including mobile plasmids
  - Usual sizes: 0,5-5 µm
  - A minority of strains are human or animal pathogens
  - Some toxin-producing strains (exotoxins or endotoxins)
  - Existence of opportunistic strains (not pathogenic in healthy individuals, but possibly in weak or immunodeficient organisms) – Some responsible for nosocomial infections

Main groups of hazardous biological agents /3

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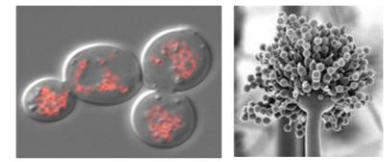
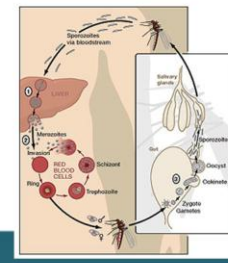
- Fungi (yeasts & molds)
  - Complete cellular structure
  - Genome made of DNA
  - Usual sizes: 5-15 µm
  - Relatively low number of pathogenic or opportunist strains



- Endoparasites
  - Different types of biological organisms (Amoebas, Protozoa…)
  - Complete cellular structure
  - Genome made of DNA
  - Usual sizes: 1-150 µm
  - Complex life cycles
  - Low number of pathogenic strains



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Main common characteristics of biological agents

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- Capable of rapid replication or multiplication in favourable conditions
  - A minor contamination may have major effects
- Capable of spontaneous modifications of some characteristics due to mutations, re-assortments and environmental pressure
  - Adaptation, development of resistances, of new strains…
  - Potential for modifications dramatically increased through molecular biology (GMOs)
- Ability to cause disease
- Not visible and no immediate detection and identification
- Huge diversity
  - In forms, biological mechanisms, environmental preferences…

➔ All characteristics of importance in biological risk management

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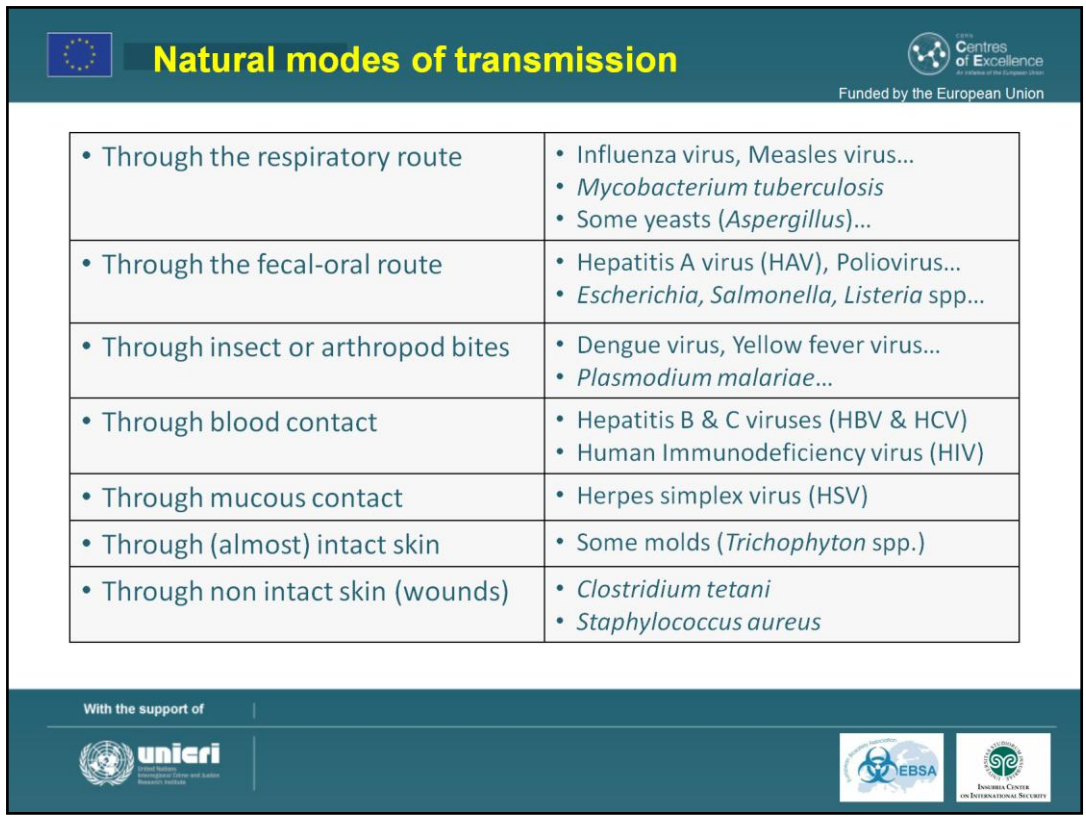

NOTES:

1. The most common natural transmission modes are the respiratory route (mainly but not exclusively used by respiratory pathogens) and the fecal-oral route (mainly but not exclusively used by enteric pathogens)
2. These are the natural modes of transmission, that are likely to be effective also in laboratories. However, laboratory activities may produce situations where infection can occur through different routes (e.g., accidental injection of an agent that is normally not transmissible by insect or arthropod bite).

Airborne respiratory pathogens

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- Respiratory pathogens are usually transmitted through the air, using airborne droplets ("*aerosols*") as vehicles for transmission

  - Influenza virus
  - Adenoviruses (causing rhinitis…)
  - Coronaviruses (as SARS Coronavirus)
  - *Mycobacterium tuberculosis*
  - *Streptococcus pneumoniae*
  - *Bordetella pertussis*…

- Some other pathogens that enter or can enter the body through the respiratory system also use the air transmission route
  - Measles virus, Mumps virus
  - *Neisseria meningitidis*…

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Importance of aerosols

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- Aerosols = solid particles or liquid droplets suspended in the air

- Aerosols are likely to be generated during many lab activities
  - Pipetting, pouring, mixing. of liquids
  - Centrifugation, use of pressurized devices
  - Accidental spills…

- Infectious aerosols are likely to cause
  - Infection by respiratory pathogens or other pathogens that use the respiratory route
  - Contamination of the work environment, generating a risk of infection with different types of pathogens

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Enteric pathogens

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- Enteric pathogens
  - Usually excreted in faeces and transmitted by ingestion
  - Most generally transmitted in an indirect way, through contaminated objects (water, soil, food, hands…)
  - Usually quite resistant to environmental conditions
- Examples
  - Hepatitis A virus, Polio virus
  - *Escherichia, Salmonella, Shigella, Vibrio cholerae*
  - Parasites such as Amoebas, *Giardia, Cryptosporidium* spp.
- Enteric pathogens represent an occupational hazard to
  - Lab workers handling the pathogens, stool samples or soiled samples from contaminated environments (waste waters…)
  - Workers working in contaminated environments (sewage…)

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Bloodborne pathogens

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- Bloodborne pathogens = Infectious biological agents that can be present in blood and blood-derived products
- Main human bloodborne pathogens
  - Hepatitis B virus (HBV)
  - Hepatitis C virus (HCV)
  - Human Immunodeficiency virus (HIV)

- Bloodborne pathogens represent a major occupational hazard to
  - Lab workers handling human blood products, especially if they use needles or other sharps
  - Nurses and other healthcare personnel
  - First aid team members…

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Relative frequency of the most common bloodborne pathogens in most populations: HBV > HCV > HIV.

Genetically modified organisms (GMOs)

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- Genetically modified organism (GMO) = an organism in which the genetic material has been altered in a way that does not occur naturally by mating and/or natural recombination*
- All types of (micro)organisms can be genetically modified
  - Viruses
  - Bacteria
  - Fungi
  - Animals
  - Plants

  as well as animal and plant cells

* European legal definition

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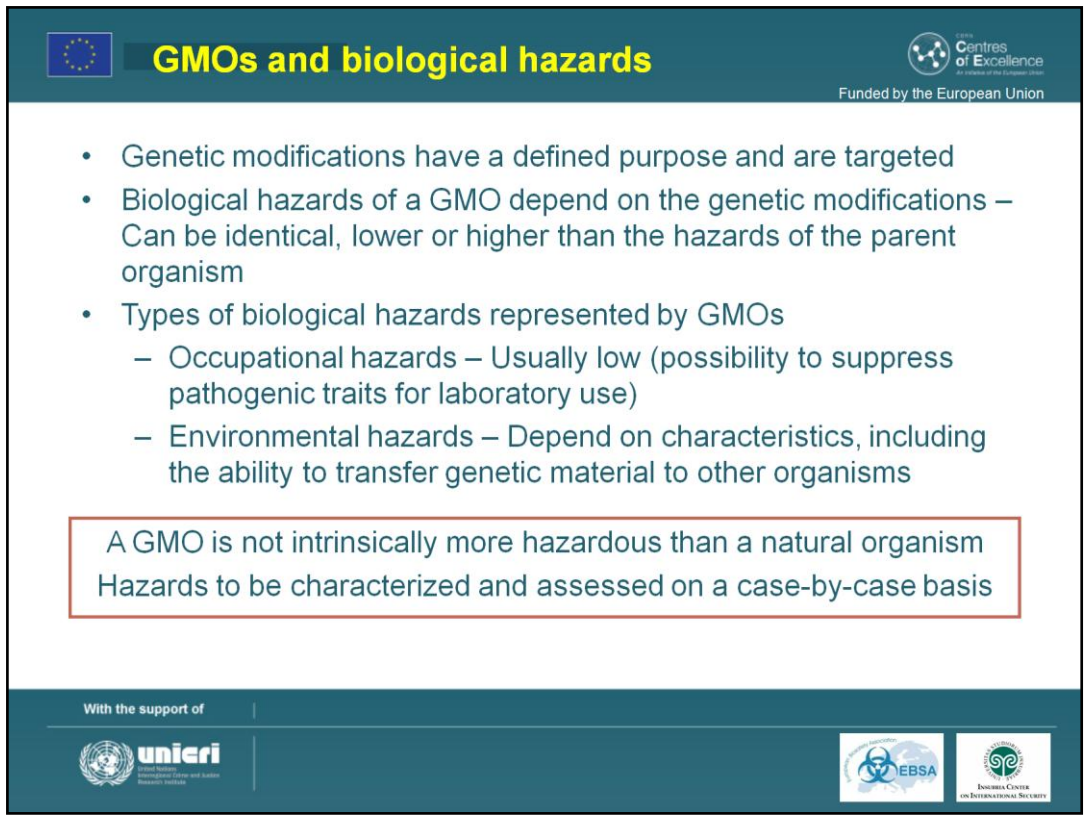

Note: In most cases, only a very few, specific genes are modified on an entire genome.

Hazardous biological materials

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- Materials that contain or may contain biological agents
- The hazard lies in the biological agents that *may be* present
  - Bloodborne pathogens (in serum, cells, body fluids…)
  - Enteric or fecal pathogens (water samples…)
  - Various types of pathogens (diagnostic specimens…)

- Application of the principle of precaution:

  Basic protective measures as if the pathogens are present

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Basic protective measures are sometimes referred to as "good microbiological techniques" (GMT) (in general) or the so-called "universal precautions" (e.g., in the US).

Cells and cell lines used in cultures

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- Various types are used in cell culture
- Characterization according to:
  - Their source (human, non-human primate, mammalian, avian, insect, plant…)
  - The tissue of origin (fibroblast, endothelium…)
  - The type of culture
    - Primary cells = cells isolated from patients, organisms or explants
    - Classical (= non-immortalised) cell lines
    - Immortalised or continuous cell lines = cell lines that have been transformed in order to proliferate indefinitely
  - Their properties and functional characteristics
  - Possible screening, testing and certification

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Hazards from cells and cell lines

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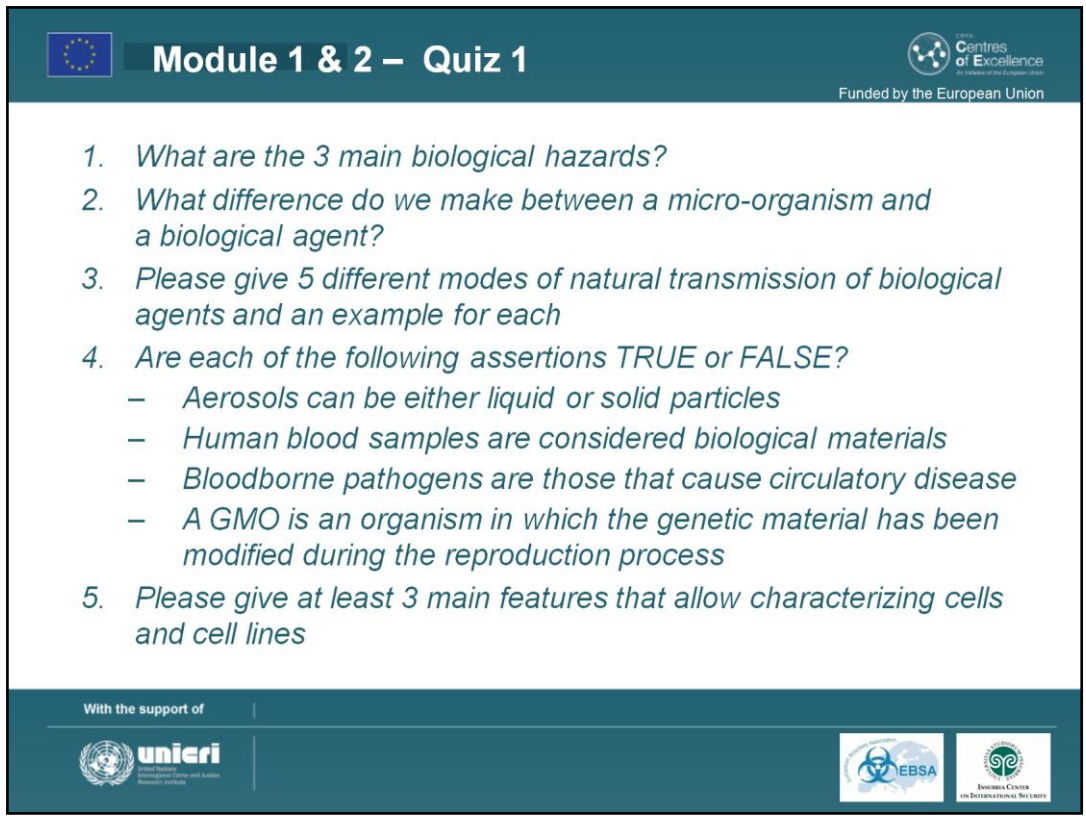
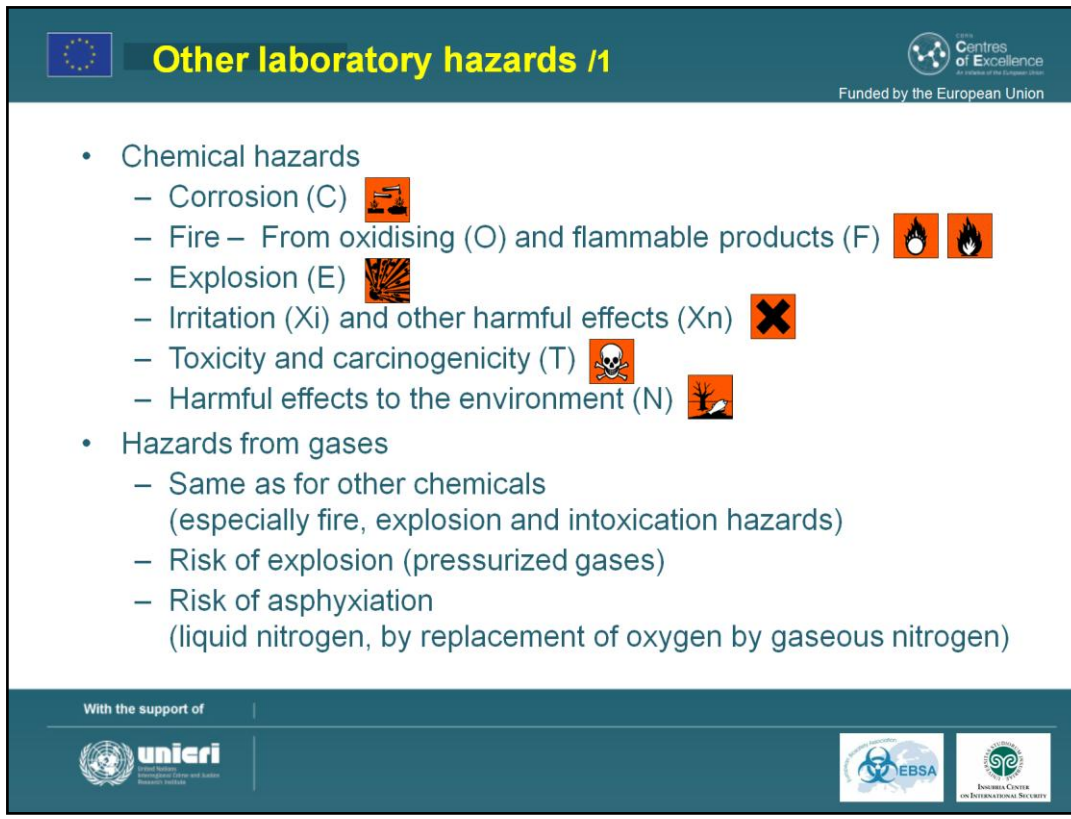
- Cells and cell lines are not infectious by themselves
- Main hazards
  - Contamination by pathogenic agents (virus, mycoplasms…)
    - Most likely in primary cells
    - May be inherent to some specific cell lines
    - May occur during handling (contamination by operator)
    - Sometimes difficult to detect
    - Expression of pathogen sometime depending on conditions
  - Oncogenicity (= ability to generate tumours) of some cells that were immortalized through mutations or viral infection
  - Expression of biologically active proteins or other cell products that may have harmful effects (as in some GM cells)



<u>Correct answers</u>:

1. Infection, allergies and intoxication. Slides 11 + 14-16
2. Biological agents are micro-organisms that are able to provoke infection, allergy or toxicity in humans, animals or plants. Slide 12
3. A. Respiratory route: Influenza virus, Measles virus, Mycobacterium tuberculosis, some yeasts... B. Fecal-oral route: Hepatitis A virus, Poliovirus, Escherichia coli, Listeria spp., Salmonella spp… C. Insect or arthropod bites: Dengue virus, Yellow fever virus, Plasmodia malaria… D. Blood contact: Hepatitis B & C viruses, HIV… E. Mucous contact: Herpes simplex virus… Slide 21
4. A: True / B: True / C: False / D: False. Slides 23 / 13 + 28 / 25 / 26
5. Their source, the tissue of origin, the type of culture, the properties and functional characteristics, the possible testing, screening and certification. Slide 29



Note: The illustrative logos are the recent European chemical hazard symbols (Directive 67/548/EEC). Classical DIN hazard symbols (black sign in a yellow triangle surrounded by a black border – see slide 3) are still commonly used. GHS standard symbols (black signs in a white square surrounded by a red border) are mainly used in the US. Other square pictograms are used for transport only.

Other laboratory hazards /2

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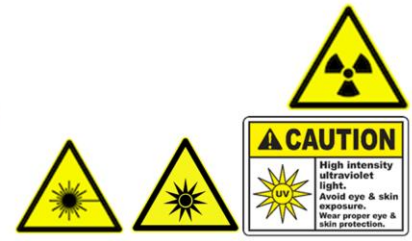
- Radiation hazards
  - Irradiation, external or internal (through inhalation or ingestion)
  - Mainly from radioactive materials
- Equipment-related hazards
  - Physical injuries and burns
  - Electrical hazards
  - Hazards from lasers, UV lights
- Fire and explosion hazards
  - From solvents, gases and other chemicals
  - From open flames, as with Bunsen burners
  - From deficient equipment, electrical outlets…



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Picture of a biosafety cabinet (BSC) destroyed by a fire due to the simultaneous use of solvents and an open flame. Description of several similar incidents (and pictures) available on internet.

Example of equipment-related hazard

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- Possible incidents with centrifuges
  - Break of rotor due to improperly loading or balance
  - Break of tube inside of a centrifuge (possible biological hazard), also possibly due to lack of balance of the loads
  - Explosion of the centrifuge

  - A rather rare but serious event
  - Complete destruction of the centrifuge and possible damages to people and the room
  - Due to the breakdown of the rotor at high speed
  - Rotor failure due to metal fatigue and physical stress

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Picture from an incident at Cornell University, NY, USA, in 1998 (more information on: http://www.chem.purdue.edu/chemsafety/newsandstories/centrifugedamages.htm). Several other centrifuge-related incidents described on internet.

Hazards related to work with animals

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- Physical injuries
  - Bites and scratches
  - Injuries when handling cages or other items
  - Needle stick or scalpel injuries…
- Chemical hazards due to the use of anesthetics
- Biological hazards
  - Biological contamination and/or infection by infected animals
    - Due to bites, scratches or other injuries
    - Through contaminated needles
    - Through body fluids (as urine) and feces
  - In the long term, development of allergies

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Hazards related to molecular biology labs

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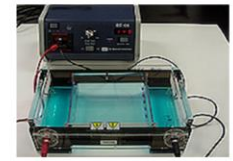

- Electrical hazards
  - Electrophoresis – Risk of lethal shock at a few mA when operating at 100 V
- Radiation hazards
  - Use of radioisotopes like ^{3}H, ^{32}P, ^{33}P, ^{35}S, ^{125}I…
  - Use of UV light – Eye damage possible
- Chemical hazards
  - Solvents (phenol and others) and staining agents
  - Polyacrylamide gels
  - Use of a number of mutagenic or carcinogenic substances (acrylamide, ethidium bromide…)
- Biological hazards, depending on the biological materials in use

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Principles of occupational health & safety

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- Moral and, most generally, legal obligation for the employer to protect the employees' health from all occupational hazards
- Overall principles
  - Legal responsibility of the employer
  - Obligation if information and training
  - Prevention of any work-related harm
  - Application of the precautionary principle
  - Preventive (rather than mitigating) measures
  - Rehabilitation and compensation in case of harm

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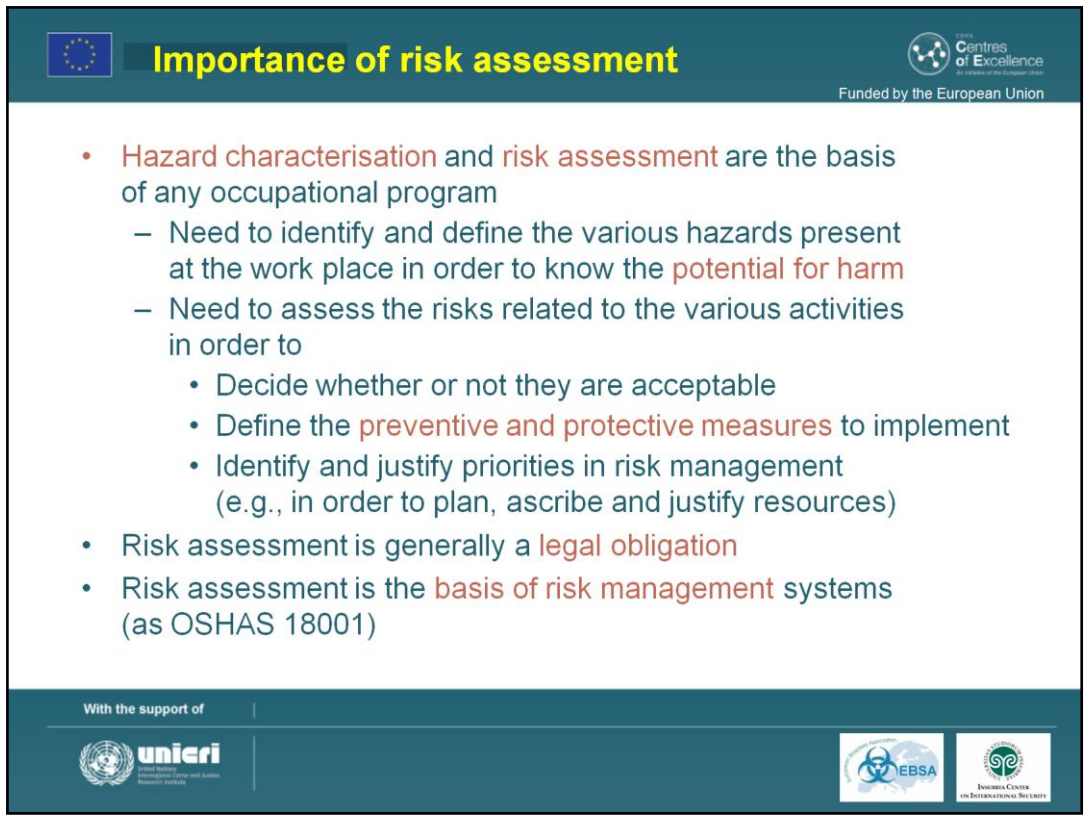
Application to biosafety and biosecurity: see Module 15 "Biosafety and biosecurity programme management"



More on hazard characterization and risk assessment in Module 5 (Modules 5&9 "Risk assessment and risk control through good microbiological and biosafety practices").

Emergency preparedness

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- Possible incidents and accidents to be identified in risk assessment
- Need to define a plan to respond these incidents and accidents
- Main elements of an emergency preparedness plan
  - Identification of the main scenarios of incidents and accidents
  - Emergency procedures
    - Roles and responsibilities
    - Actions to be taken – When, what, how, by whom?
  - Logistics means (availability of resources and equipment…)
  - Coordination and communication plans
  - Training, drills and exercises
  - Follow-up actions – Reporting, resuming operations…

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Medical surveillance

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- Regular (e.g., yearly) ad hoc health monitoring
  - Check-up
  - Serological testing (baseline and/or follow-up)
  - Specific examinations as needed (as X-rays)
- Personal information of employees on work-related health issues
  - Consultation on personal issues (as personal work adaptations, overall health or immune status, pregnancy, allergies…)
- Participation to prevention program
  - Advice on protective and preventive measures
  - Medical prevention – Vaccination
- Treatment (in case of harm or exposure)
  - First aid and medical emergency procedures
  - Post-exposure prophylaxis or treatment

With the support of

Vaccination

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- Vaccination to be proposed and offered free of charge
  - Hep B vaccine in case of work on human blood or other samples
  - Tuberculosis, Hep A, tetanus, meningococcal vaccines…
    on the basis of potential exposures (based on risk assessment)
- Possible legal obligations or restrictions
  - Vaccination mandatory, recommended or advisable?
  - Need to inform the employee
  - Vaccination to be provided free of cost
- Need for some vaccination follow-up
  (level of protection, non-responders, possible boosters…)
- Vaccination to be provided *in addition to other protective measures*
  (never "instead of")

With the support of

Pregnant women

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- High risk for the foetus and pregnancy in case of exposure to
  - Some chemicals (mainly mutagenic or carcinogenic substances)
  - Some biological agents (Rubella virus, Cytomegalovirus, Herpes viruses, Toxoplasma gondii, Listeria spp…)
  - Some radioactive substances and radiations

  mainly *at early development stages* (first months of pregnancy)
- Need to develop a policy to protect pregnant women
  - Early notification of pregnancy
  - Adaptation of work (e.g., restriction to "safe labs" or office work) or early maternity leave
  - Policy could also cover breastfeeding women
- Existence of legal constraints (equal work opportunity, medical confidentiality, protection of private life…) and related personal, social or financial issues

With the support of

Immuno-compromised workers

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- Immunocompromised workers are at high risk of infection, even possibly when exposed to non pathogenic biological agents (so-called "opportunistic agents")
- Immuno-compromission can be caused by
  - Diseases (diabetes…), including infectious diseases
  - Medical treatment (immunosuppression after organ transplant, radiotherapy, chemotherapy…)
- Policy for immunocompromised workers
  - Notification to occupational physician (or other practitioner)
  - Medical evaluation of immune status and health risks
  - Implementation of protective measures (adaptation of work, isolation from laboratories, or sick leave)

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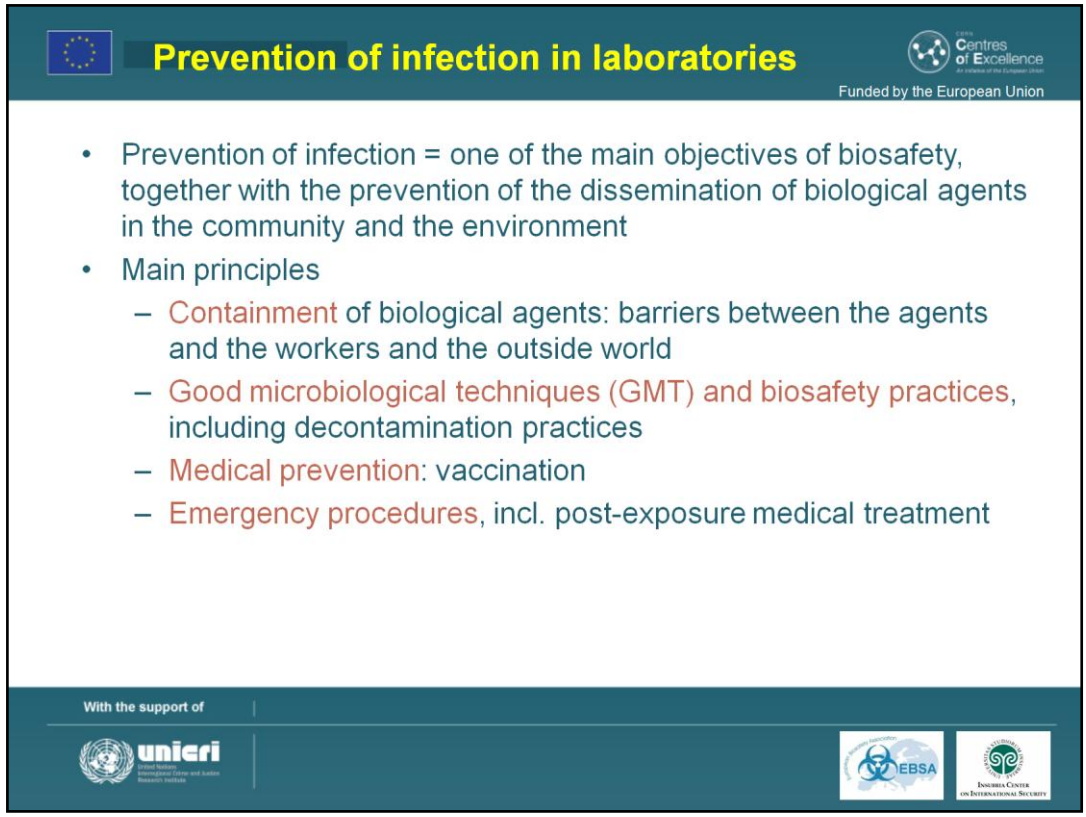

More on GMT in Module 9 (Modules 5&9 "Risk assessment and risk control through good microbiological and biosafety practices")

Prevention of allergies

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- Allergies are caused by chemical substances, including some produced by biological agents (as fungi), animal and plants
- Prevention main ensured through occupational health and chemical safety measures
  - Choice of chemicals and materials (e.g., gloves)
  - Chemical protection means (chemical hoods, masks…)
  - Medical surveillance
- Application of biosafety measures (biological containment, good microbiological and biosafety practices…) for activities involving biological agents that are likely to produce allergens

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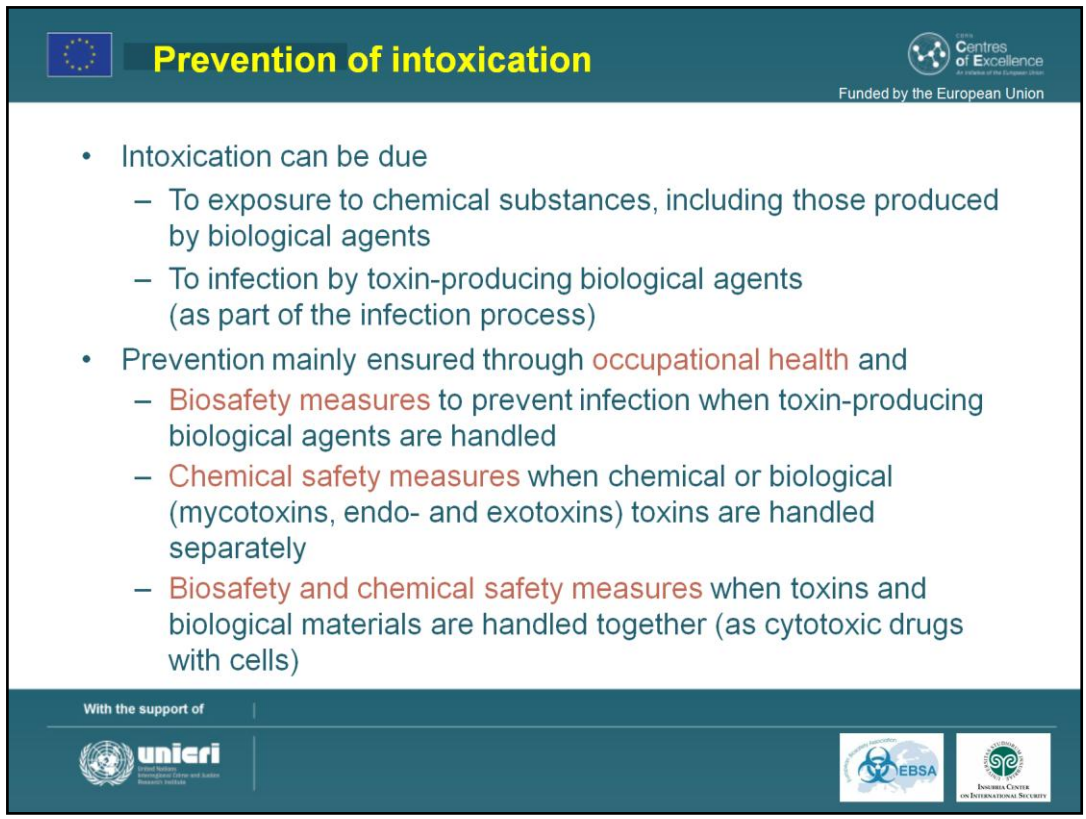
Allergies often a problem in animal facilities (extended exposure of animal caretakers, possibly after long-term exposure added to contacts with animals at home).

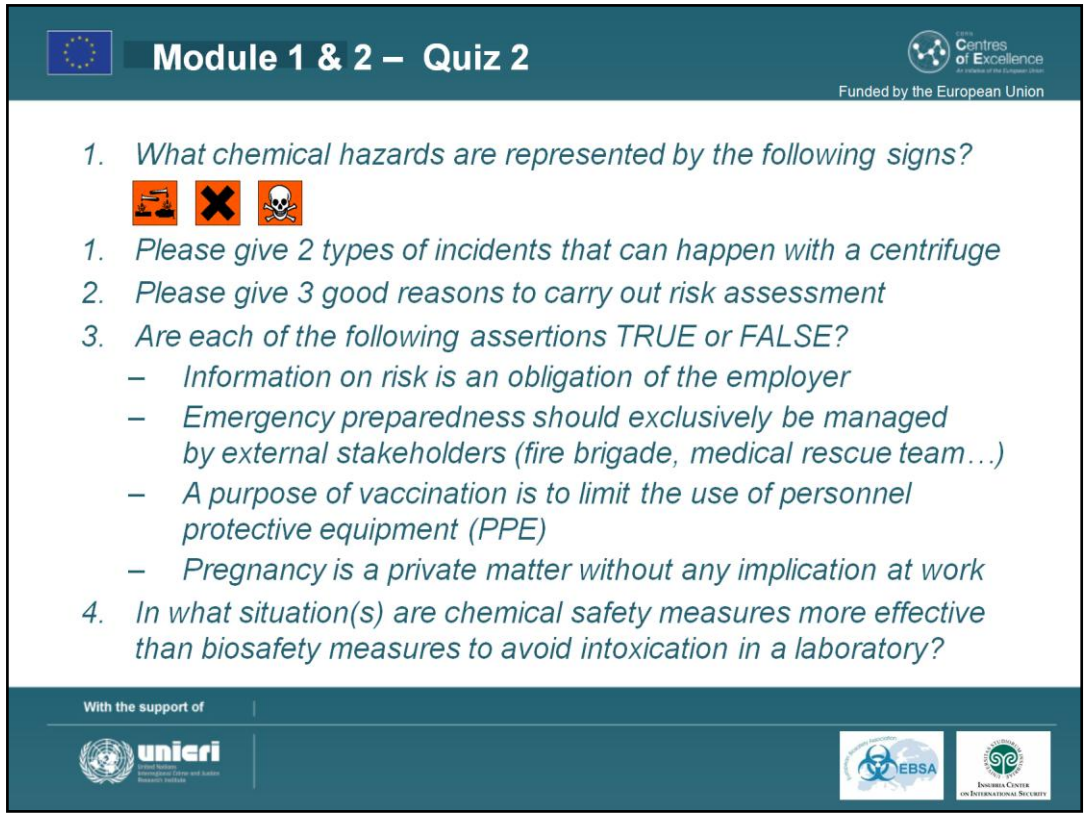
Allergy to latex gloves: contact dermatitis (picture) that may evolve in more severe systemic allergy. Contact dermatitis can affect up to 5% of health care workers in some settings. Can be one of the reasons to prefer nitrile gloves.



Biosafety covers the handling of biological agents including those that produce toxins. Biosafety measures (GMT and associated PPE) will prevent infection and therefore intoxication related to those agents.

Chemical safety covers the handling of biological toxins as well as any other toxin of hazardous chemical substance. Appropriate chemical safety will protect the operator when the toxins themselves are handled.

Biosecurity covers both biological agents and biological toxins.



Correct answers:

1. A: Corrosive / B: Irritant or other harmful effects / C: Toxic or carcinogenic. Slide 32
2. Explosion and complete destruction / Break of a rotor / Break of a tube. Slide 34
3. Identify potential harm / Decide if risk acceptable or not / Establish protective and preventive measures / Establish priorities / Comply with legal obligation. Slide 39
4. A: True / B: False / C: False / D: False. Slides 37 / 40 / 42 / 43
5. If the hazard is represented by either chemical toxins or biological toxins have been secreted by the biological agents. Slide 47

Managing risks in biological laboratories

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- Biological laboratory activities involve
  - Biological hazards
  - Chemical hazards
  - A number of physical hazards including radiation hazards
- Biological activities generate a number of risks for
  - The workers
  - The community (family, neighbours, general population)
  - The environment (animal, plants, ecosystems)
- Managing risks in laboratories requires a wide range of expertise (chemical safety, biosafety, occupational health, environment, waste management, engineering…)

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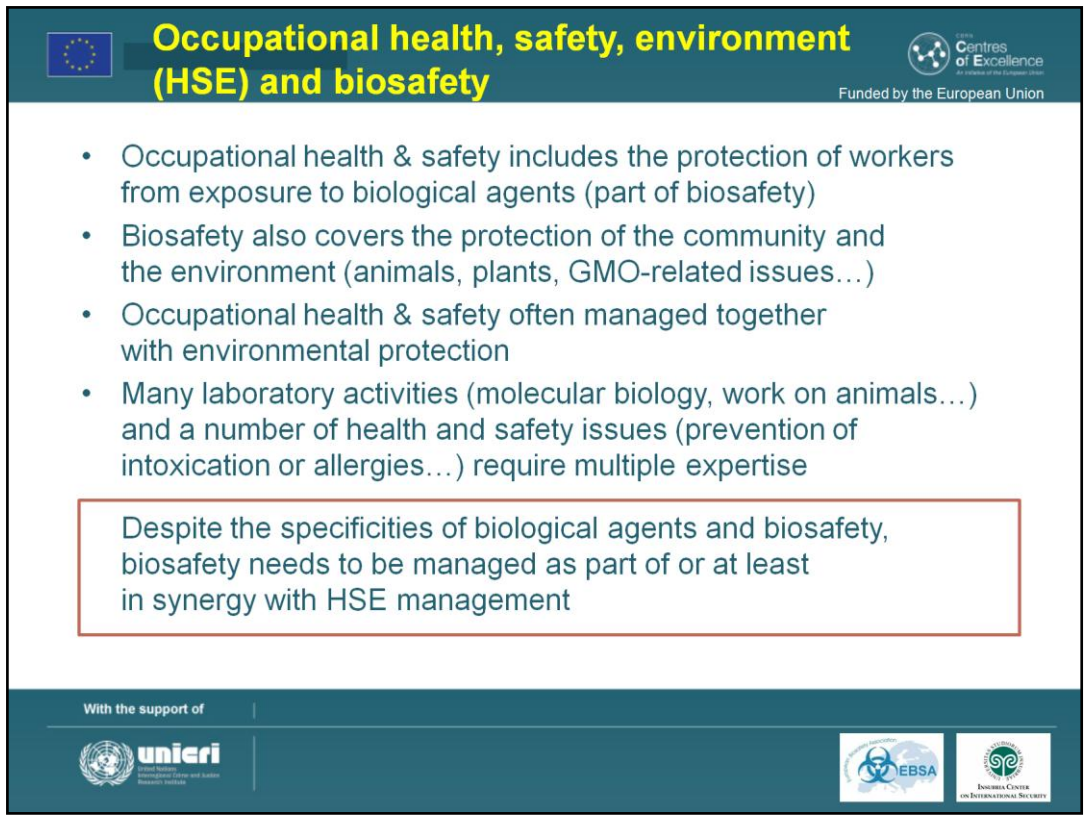

See also Module 15 "Biosafety and biosecurity programme management"

Partnership in HSE and biosafety management

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- Partnership required between all those with responsibility for health, safety, biosafety and environment, such as
  - The safety advisor
  - Industrial hygienists and other HSE specialists
  - The occupational health provider (physician or nurse)
  - The biosafety professional…
- Importance of having well-defined
  - Roles and responsibilities
  - Work processes (information, communication, decision…)
  - Management and review committees
- Importance of developing effective team work

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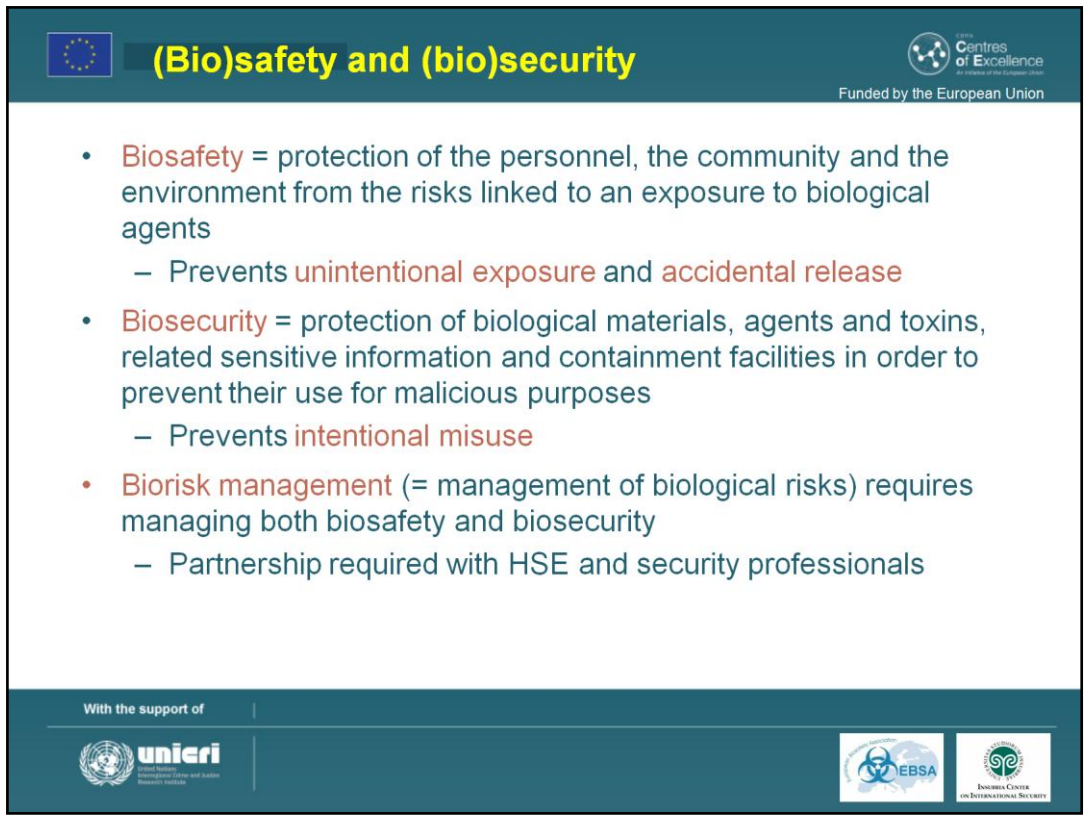

Biosafety covers the handling of <u>biological agents</u>

Biosecurity covers both <u>biological agents and biological toxins</u>, as well as other sensitive elements (information, facilities…)

(Bio)safety and quality management

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- Good microbiological techniques aim at both basic protection and quality
- Quality management programs and/or systems are being developed in many settings and institutions
  - Good Laboratory Practices (GLP)
  - Good Manufacturing Practices (GMP)
  - Laboratory Quality Assurance (QA) programs
  - ISO 17025 for the competence of testing laboratories
  - WHO External Quality Assessment Schemes (EQAS)…
- Existence of synergies between quality management and biosafety
  - Complementary objectives
  - Compatible and reciprocally re-enforcing approaches (but some diverging technical measures)

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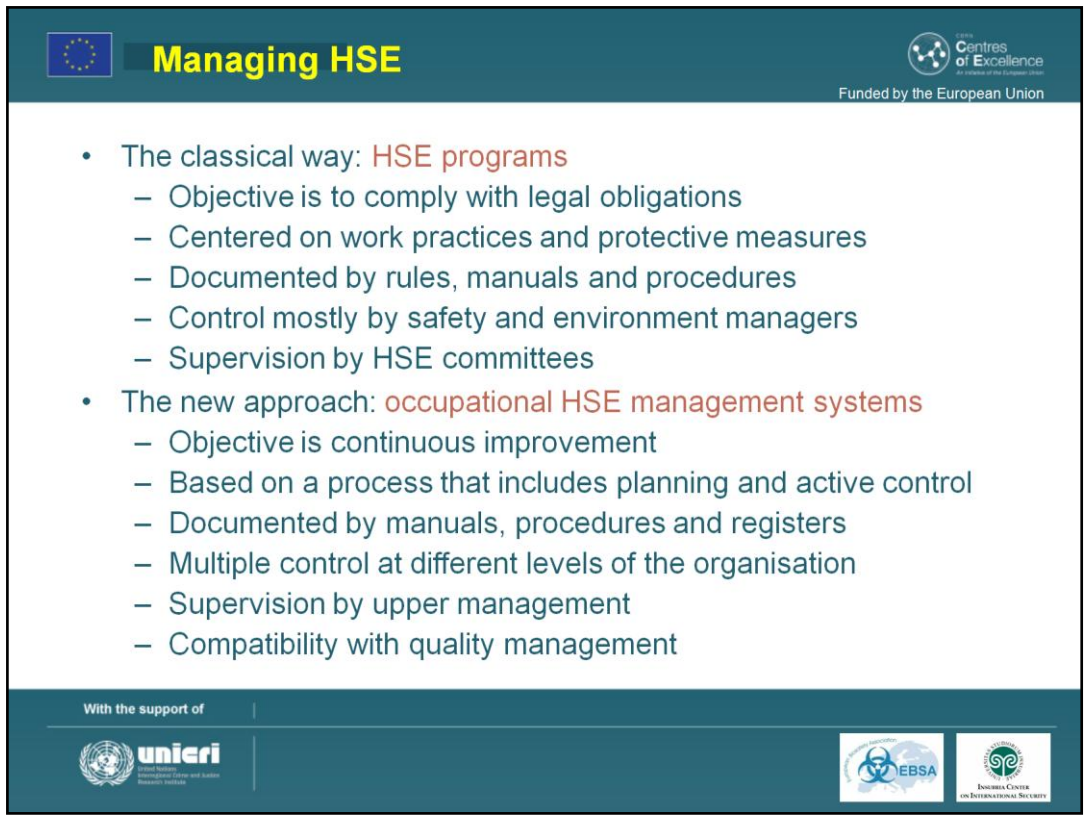

The difference between the two approaches and the management system approach will be described in more details in Module 15 "Biosafety and biosecurity programme management"


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