Biosafety
生物安全

Important Reminder
重要提醒

- **This and other LHSD safety courses only provide basic safety principles**
  LHSD的安全准入课程只说明了基础的实验室安全要求

- **Your supervisor must give you specific safety instructions and hands-on training**
  您的直属主管必须为您提供具体的安全指示与实践操作指导

- **Your rights as a worker:**
  作为工作者，您享有以下权利：

  - To know about hazards in your work and ways to control them
    获知工作岗位中的潜在危险因素及相应防控措施

  - To have a safe and healthy work environment
    获得具备安全保障与健康条件的工作场所

  - To have proper personal protective equipment
    取得符合标准的个人防护装备

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Definition of Biosafety
生物安全的定义

- **What is “Biosafety”?**
  什么是“生物安全”?

  Containment principles, technologies and practices that are implemented to prevent unintentional exposure to biological agents or their inadvertent release.
  生物安全是为防止意外暴露于生物因子或防止生物因子意外泄露而实施的防护原则、技术和实践等。

- **What is “Laboratory Biosafety”?**
  什么是“实验室生物安全”?

  Laboratory biosafety refers to maintaining biosafety conditions and status at or above permissible levels, thereby preventing unacceptable harm to laboratory personnel, visitors, the community, and the environment. Laboratories must ensure compliance with relevant regulations, standards, and requirements pertaining to their biosafety responsibilities.
  实验室生物安全是指实验室的生物安全条件和状态不低于容许水平，可能避免实验室人员、来访人员、社区及环境受到不可接受的损害，符合相关法规、标准等对实验室生物安全责任的要求。

Why is laboratory biosafety important ?
为什么我们要重视实验室生物安全?

◆ **Should a laboratory biosafety incident occur, it may...**
如果发生实验室生物安全事件，可能会...

- Directly causing injury and mortality among laboratory personnel, while concurrently impairing their physical and psychological well-being
  直接导致实验人员伤亡，损害实验人员的身心健康
- The leakage of infectious agents will precipitate public health emergencies
  感染性样本泄漏，引发公共卫生危机
- The accidental discharge of biotoxins into environmental matrices results in persistent contamination of terrestrial and aquatic ecosystems
  生物毒素泄漏到生态环境中，持续污染环境中的土壤/水体

Laboratory biosafety constitutes a critical component of overall biological security. Recognizing the significance of laboratory biosafety safeguards not only personnel's lives and well-being but also protects public health while preventing adverse environmental impacts.

实验室生物安全是生物安全的重要内容之一，重视实验室生物安全不仅是为了保护实验人员的生命安全，也是为了保护公众健康，避免生态环境遭受影响。

Introduction to Biological agent
生物因子的介绍

- **Definition of Biological agent**
  生物因子的定义

  A microorganism, virus, biological toxin, particle or otherwise infectious material, either naturally occurring or genetically modified, which may have the potential to cause infection, allergy, toxicity or otherwise create a hazard to humans, animals, or plants.
  生物因子指的是自然产生或经过基因修饰的微生物、病毒、生物毒素、感染性微粒或材料，其可能对人类、动物或植物造成感染、过敏、中毒等危险。

- **The following are all classified as biological agents:**
  它们都属于生物因子：
  - Pathogenic Microorganisms
    病原微生物
  - Biological toxins
    生物毒素
  - Recombinant DNA molecules
    重组脱氧核糖核酸分子

What are Pathogenic Microorganisms ?
什么是病原微生物?

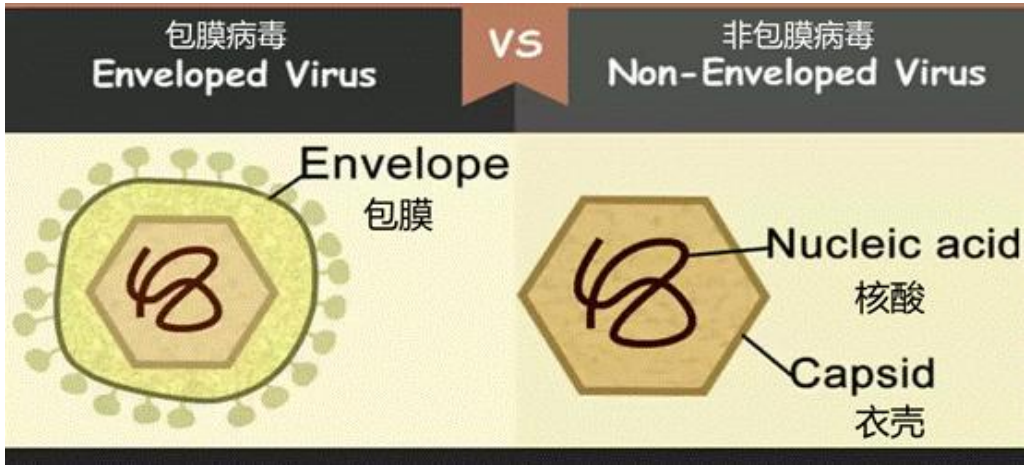
◆ **Definition of Pathogenic Microorganisms**
病原微生物的定义

Pathogenic microorganisms are disease-causing microbes that infect humans, animals or plants.
病原微生物，是指可以侵犯人类、动物或植物引起感染甚至传染病的微生物。

◆ **Classification of Pathogenic Microorganisms**
病原微生物的分类

- **Virus**: Contain proteins, lipids and nucleic acids. Virioids consist of only nucleic acid. These organisms characteristically disassemble after cell entry and then assemble their progeny during replication.
  病毒：病毒由蛋白质、脂质和核酸组成，而类病毒则仅由核酸组成。它们在进入细胞后会解体，然后在复制过程中合成其子代。
- **Prion**: Consist of only a single protein. The infectious form is transmissible as spongiform encephalopathy.
  朊病毒：仅由一种蛋白质组成。其致病形态能引发海绵状脑病。
- **Bacteria**: Including archaea and eubacteria. Unlike eukaryotes, the DNA genomes of prokaryotes are not separated from the cell by a membrane. Unlike viruses, they remain enclosed within their own cell envelope throughout their life cycle.
  细菌：此处的“Bacteria-细菌”指的是广义的“细菌”（原核生物），包含了古细菌（Archaea）和真细菌（Eubacteria）。与真核生物不同，原核生物的核区是裸露的DNA分子，没有核膜包裹。与病毒不同的是，原核生物有细胞膜/细胞壁。
- **Eukaryotes**: Including fungi and protozoa. These organisms have subcellular compartments, including the nucleus.
  真核生物：包括了真菌和原生动物。它们具有由膜包被的亚细胞结构单元，包括胞核。

Introduction to Viruses
病毒的介绍



Source: State Key Laboratory of Virology

- **Classification of Virus**
  病毒的分类

Viruses are classified based on the type (DNA or RNA) and nature (single-stranded or double-stranded, segmented or nonsegmented) of genetic material, and structural features (size, symmetry and presence or absence of a lipid envelope).
我们通常基于遗传物质的类型(DNA或RNA)与性质(单链/双链、分段/非分段)，以及结构特征(尺寸、对称性和有无脂质包膜)来划分病毒的种类。

In virological disinfection taxonomy, viruses are categorized as enveloped viruses and non-enveloped viruses.Enveloped viruses and non-enveloped viruses exhibit different levels of resistance to chemical disinfectants, primarily due to their structural differences. For details, see the section on Decontamination and Waste Management.
在消毒学分类中，病毒通常被分类为包膜病毒（中文也称“亲脂性病毒”）和无包膜病毒（中文也称“亲水性病毒”）。因为结构的不同，亲脂性病毒和亲水性病毒会在面对化学消毒剂时会表现出不同的抗性。我们将在“清除污染和废弃物管理”章节中具体介绍两种病毒的化学消毒剂的选择。

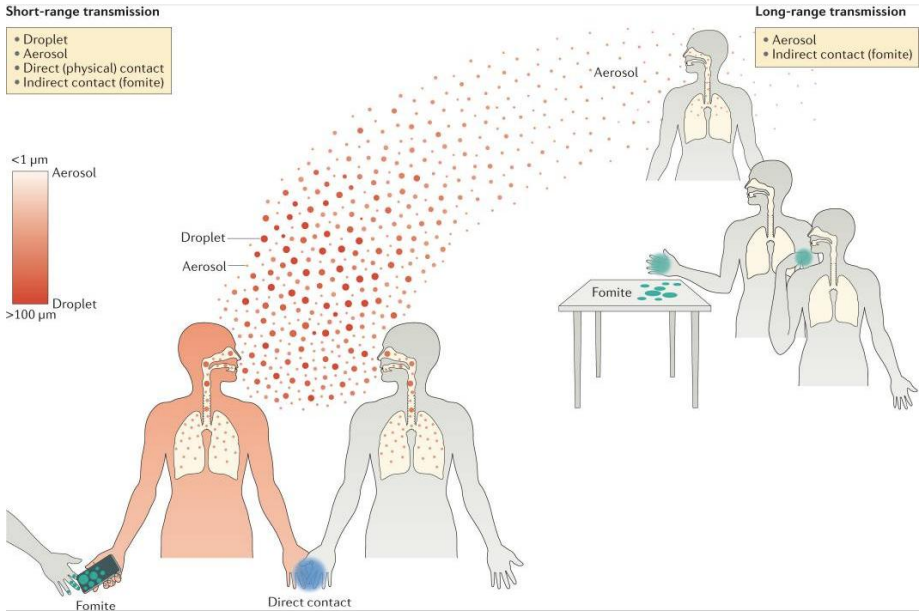
Introduction to Viruses
病毒的介绍

- **Modes of Virus Transmission**

病毒的传播途径

Virus transmission may be ‘horizontal’ or ‘vertical’. The vast majority of transmission is horizontal, that is, between individuals within the population at risk. Modes of horizontal transmission of viruses can be characterized as direct contact, indirect contact, water-borne , food-borne , airborne, iatrogenic, arthropod-borne, and soil-borne. Vertical or transplacental transmission occurs between the mother and her fetus or newborn.

病毒的传播通常可分为水平传播和垂直传播，其中大多数传播方式是水平传播的。水平传播即病原体在易感人群中的个体之间传播，水平传播包括了直接接触传播、间接接触传播、经水传播、经食物传播、经空气传播、医源性传播、经节肢动物传播和经土壤传播。垂直传播则通常发生在母亲与胎儿之间（母婴传播）。



Source: Leung NHL. Transmissibility and transmission of respiratory viruses. Nat Rev Microbiol. 2021 Aug

Direct contact transmission involves pathogen transfer through physical interaction between an infected person/animal and a susceptible host without intermediary agents; representative scenarios encompass kissing and animal bites.

直接接触传播，即在没有任何外界因素参与的情况下，传染源与易感者直接接触而引起疾病的传播，例如亲吻、咬伤等。

Indirect contact transmission arises via exposure of a susceptible host to fomites contaminated by infectious bodily substances, exemplified by improperly disinfected medical instruments.

间接接触传播，即易感者因接触被传染源的排泄物或分泌物污染的物品（如消毒不当的餐具、针头等）所造成的传播。

Introduction to Prions
朊病毒的介绍

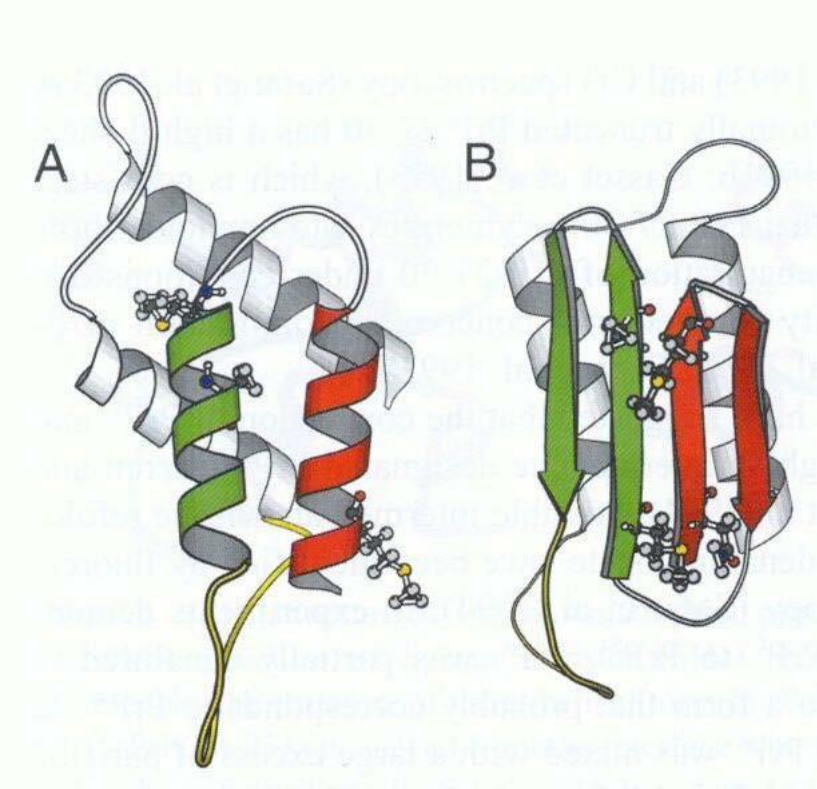
◆ **What is Prion ?**
什么是朊病毒?

- Prions are protein molecules
  朊病毒是一种蛋白质分子
- Prion disease is caused by a modified isoform of a pathogenic prion
  朊病毒病是由错误折叠的朊蛋白导致的
- Some non-pathogenic prions are found to be essential to learning and memory
  一些非致病性的朊蛋白被认为是对我们的学习和记忆有帮助的
- Normal prion is converted into the disease form through a conformational change of the secondary structure (two α-helix regions changed to β-sheet)
  正常的朊蛋白通过二级结构的变化（两个α-螺旋结构变为两个β-螺旋结构）转变为朊病毒

◆ **What pathological effects do prions cause ?**
朊病毒会导致什么病理效应?

- Cause a group of animal and human fatal neurological diseases, e.g. Scrapie (sheep); Bovine Spongiform Encephalopathy ("Mad Cow Disease"); Creutzfeldt-Jakob Disease, Kuru (humans)
  朊病毒会引发一系列致命的神经系统疾病，例如：羊痒病（发生于绵羊的朊病毒病）；牛海绵状脑炎（"疯牛病"）；克雅症、库鲁症（发生于人类的朊病毒病）
- Result in devastating degeneration of the CNS without inflammatory or other immune responses
  朊病毒引发的疾病将导致中枢神经系统发生严重的退行病变, 全程不伴有任何炎性或适应性免疫应答
- Could be genetic, infectious or sporadic
  朊病毒并可能是遗传性的，传染性的或偶发性的

Introduction to Prions
朊病毒的介绍



◆ **Prion Protein Conversion**
朊病毒的结构转化

- A is the normal cellular prion protein with 4 α-helix regions
  左侧例图中，A代表了正常的细胞型朊蛋白，包含了4个α-螺旋结构

- B is the infectious form of the protein with 2 of the α-helix converted to β-sheet (colored red and green)
  B代表了朊蛋白的致病形态（朊病毒），其特征为原本的4个α-螺旋结构中的2个转换成了β-螺旋结构（图例中标注为红色和绿色的部分）

Source: Prusiner, S.B.(Ed) 1999. Prion Biology and Diseases. Cold Spring Harbor Laboratory Press.

Introduction to Prions
朊病毒的介绍

- The converted prion protein has profoundly different physicochemical properties from the normal form, and cause devastating neurodegeneration
  转化后（致病形态的）朊蛋白与其正常形态相比具有截然不同的理化特性，会引发严重的神经退行性病变

- The converted prion protein acts as a template to refold other normal prion proteins into the disease form and thus propagate the disease (a “conformational cascade”)
  此类病原体引发的疾病将导致中枢神经系统发生严重的退行病变, 全程不伴有任何炎性或适应性免疫应答

- **Prion Infection Routes？**
  朊病毒的感染途径是什么？

- Consumption of organs (especially brain) and meat of infected animals
  摄入受感染动物的器官（尤其是脑部）和肉类
- Subsequently data indicated bloodborne transmission
  数据表明，朊病毒存在血源性传播
- Bloodborne transmission risk appears to be related to stage of disease of donor, later the stage, higher the risk
  朊病毒血源性传播的风险似乎与疾病发展的阶段有关，疾病发展越接近晚期，传播的风险越高

Introduction to Bacterias
细菌的介绍

- **Classification of Bacteria**
  细菌的分类

The main groups of bacteria are mostly distinguished by microscopic observation of their morphology and staining reactions. The Gram-staining procedure, which reflects fundamental differences in cell wall structure, separates most bacteria into two great divisions: Gram-positive bacteria and Gram-negative bacteria.
细菌主要通过革兰氏染色法分为了革兰氏阳性菌和革兰氏阴性菌两大类，这一方法反映了这两种细菌细胞壁结构的差异。

In clinical medicine, distinct antibiotic classes are required to treat infections caused by Gram-negative versus Gram-positive bacteria due to their differing pathogenic mechanisms. Bacillus species—classified as Gram-positive bacterias—are capable of forming bacterial endospores with multilayered protective membranes.
在临床医学中，因为革兰氏阴性菌和阳性菌会造成不同类型的感染，因此也需要应用不同类型的抗生素进行治疗。芽孢菌是革兰氏阳性菌，它能形成具有多层膜结构的细菌芽孢。

Introduction to Bacterias
细菌的介绍

- **What are bacterial endospores?**
  什么是细菌芽孢?

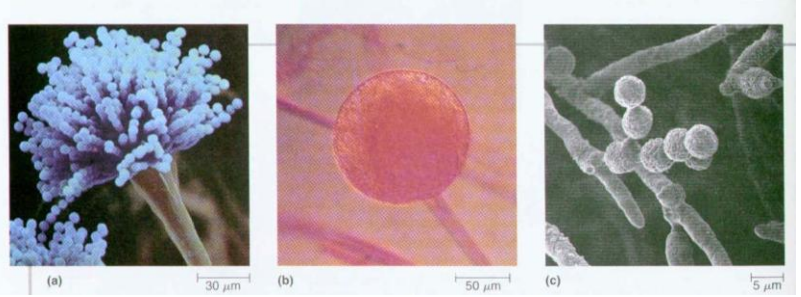
Bacterial endospores are highly resistant, dormant structures (i.e. no metabolic activity) formed in response to adverse environmental conditions.
细菌芽孢是某些细菌在不利条件下形成的高度抗逆的休眠体。

Bacterial endospores, possessing an intrinsically low moisture content, exhibit exceptional resistance to lethal conditions including elevated temperatures, UV radiation, ionizing radiation, and multiple chemical sterilants; these attributes establish them as the biological indicators for sterilization validation protocols—utilizing Geobacillus stearothermophilus spores for monitoring autoclaving efficacy or utilizing employing Bacillus atrophaeus spores in dry heat sterilization verification.
细菌芽孢本身的含水量很低，面对高温、紫外线，电离辐射以及多种化学物质都表现出很强的抵抗力。这样的抗逆性使其成为灭菌效果监测的生物指示剂——比如利用嗜热脂肪杆菌芽孢生物指示剂监测压力蒸汽灭菌程序的灭菌效果，或利用枯草杆菌黑色变种芽孢生物指示剂监测干热灭菌的灭菌效果。

Introduction to Fungi and Protozoa
真菌和原生动物的介绍

- **Introduction to Fungi**
  真菌的介绍

Fungi are eukaryotic microorganisms that can be easily distinguished from bacteria and other prokaryotes by their greater size and the presence of organelles, including nuclei, vacuoles, and mitochondria.
真菌属于真核生物，其体积较细菌等其他原核生物更为庞大且具有包括胞核、液泡及线粒体在内的多种细胞器结构。



Most fungi exist in one of two morphological forms (phenotypes): yeasts that normally grow as single cells, or moulds (filamentous fungi) that consist of apically growing, tandemly attached cells arranged in long branching filaments (hyphae).
多数真菌呈现两种基本形态表型，一种是通常以单细胞形式生长繁殖的酵母态，另一种则是由顶端持续生长的纵向连接胞体构成延伸分支系统（菌丝结构）的霉变态（丝状真菌）。

In contrast to yeast, moulds form copious spores (i.e., conidia) on the surfaces of their filaments that can easily dislodge and become airborne (i.e., readily aerosolized material).
与酵母菌不同，霉菌会在其丝状体表面形成大量孢子（即分生孢子），这些孢子容易脱落并进入空气（即成为易于气溶胶化的物质）。

Introduction to Fungi and Protozoa
真菌和原生动物的介绍

- **Introduction to Protozoa**
  原生动物的介绍

Protozoa are microscopic, unicellular, animal-like eukaryotes. According to the earlier classification system for biological organisms, they constitute a part of the Kingdom Protista.
原生动物是一类微观的、单细胞的、类似动物的真核生物。根据早期生物分类系统，它们属于原生生物界（Protista）的一部分。

Protozoa are spherical, oval, elongated, or flattened organisms (mostly of <50 µm, range 1–150 µm in size) that possess whip-like flagella (so-called flagellates such as Leishmania, Trypanosoma, Giardia, Dientamoeba, and Trichomonas), finger-like pseudopodia (so-called amoebae such as Naegleria, Acanthamoeba, Balamuthia, and Entamoeba), or hair-like cilia (so-called ciliates such as Balantidium) for mobility and also for mechanical breaching of host physical barriers and intrusion into host cells.
原生动物是一类呈球形、椭圆形、细长形或扁平形的生物（大多小于50µm，大小范围为1-150µm），它们具有鞭毛状鞭毛（即所谓的鞭毛虫，如利什曼原虫 Leishmania、锥虫 Trypanosoma、蓝氏贾第鞭毛虫 Giardia、双核阿米巴 Dientamoeba和阴道毛滴虫 Trichomonas）、指状伪足（即所谓的阿米巴原虫，如纳氏虫 Naegleria、棘阿米巴 Acanthamoeba、巴拉姆希阿米巴 Balamuthia和溶组织内阿米巴 Entamoeba）或毛发状纤毛（即所谓的纤毛虫，如结肠小袋纤毛虫 Balantidium）。这些结构既用于运动，也用于机械性突破宿主的物理屏障并侵入宿主细胞。

FIGURE 12-3 ***Balantidium coli,*** **a human intestinal pathogen.** (*a*) Trophozoite form; (*b*) cyst form.

Introduction to Fungi and Protozoa
真菌和原生动物的介绍

◆ Introduction to Protozoa
原生动物的介绍

Pathophysiologies of protozoan infections are dependent on the types of clinical diseases induced, ranging from gastroenteritis, meningoencephalitis, myocarditis, anemia, to cutaneous, mucocutaneous, or visceral infections.
原生动物感染（原虫感染）的病理生理学取决于所诱发的临床疾病类型，其范围涵盖胃肠炎、脑膜脑炎、心肌炎、贫血，以及皮肤、皮肤黏膜或内脏感染。

The severity of protozoan diseases is no doubt impacted by host (e.g., innate and adaptive immune responses, genetic susceptibility, immune status, age, and gender), parasite (e.g., strain virulence), and environmental factors.
原虫疾病的严重程度无疑受宿主因素（如先天性和适应性免疫反应、遗传易感性、免疫状态、年龄和性别）、寄生虫因素（如菌株毒力）及环境因素的影响。

Dominant disease 显性疾病	Protozoan species 引起疾病的原生动物种类
Gastroenteritis 胃肠炎	Giardia duodenalis 蓝氏贾第鞭毛虫
	Cryptosporidium 隐孢子虫
	Balantidium coli 结肠小袋纤毛虫
Meningoencephalitis 脑膜炎	Trypanosoma brucei 布氏锥虫
	Acanthamoeba 棘阿米巴
Myocarditis 心肌炎	Trypanosoma cruzi 克鲁兹锥虫
	Toxoplasma gondii 弓形虫
Anemia 贫血	Babesia microti 巴贝虫
	Plasmodium 疟原虫
Cutaneous, mucocutaneous or visceral infections 皮肤、黏膜或内脏感染	Leishmania 利什曼原虫
	Trichomonas vaginalis 阴道毛滴虫

Classification of Pathogenic Microorganisms
病原微生物的分类

- **Many agencies classify microorganisms according to their degree of hazard :**
  许多机构都有根据微生物的危害程度对其进行分类：

- US Centers for Disease Control and Prevention (CDC)
  美国疾病预防与控制中心（CDC）
- US National Institute of Health (NIH)
  美国国家卫生研究院（NIH）
- Health Canada
  加拿大卫生部

- **Usually four classes/risk groups ranking from low to high hazard**
  通常会将病原微生物从低风险到高风险分为四个类别

- **All lists use similar criteria but there are minor differences in classification**
  所有的表单都使用了相似的标准，但它们在分类上有着细微的差别

- **Primarily based on human pathogenicity**
  通常主要基于对人类的致病性开展分类

- **The lists are dynamic in nature**
  这些病原微生物分类表单都是动态变化的

Classification of Pathogenic Microorganisms in China
中国对病原微生物的分类

As stipulated in *the Biosecurity Law of the People's Republic of China* and *the Regulations on Biosafety Management of Pathogenic Microorganism Laboratories*, the National Health Commission has formulated and issued *The Pathogen Microogranisms List for Human Infectious Diseases*. This list classifies pathogenic microorganisms into four distinct risk categories. Microorganisms categorized under Class 1 and 2 pathogen lists qualify as high-consequence pathogenic microorganisms.
国家卫生健康委根据《中华人民共和国生物安全法》和《病原微生物实验室生物安全管理条例》组织制定了《人间传染病原微生物目录》，该目录将病原微生物分为了四个风险类别。第一类、第二类病原微生物属于高致病病原微生物。

Basis for the Classification of Pathogenic Microorganisms by Risk Group 病原微生物分类依据	
Class 1 第一类	Pathogenic microorganisms capable of inducing critically severe diseases in humans or animals encompass both those unidentified within China's sovereign territory and strains formally certified as eradicated under biosafety protocols 能够引起人类或者动物非常严重疾病的微生物，以及我国尚未发现或者已经宣布消灭的微生物
Class 2 第二类	Pathogenic microorganisms that cause serious diseases in humans/animals with demonstrated human-to-human, animal-to-human, or animal-to-animal transmission potential, exhibiting relatively high direct/indirect transmissibility 能够引起人类或者动物严重疾病，比较容易直接或者间接在人与人、动物与人、动物与动物间传播的微生物
Class 3 第三类	Pathogenic microorganisms associated with human/animal disease that demonstrate low public health risks, typically posing no critical hazards to humans, animals or the environment, exhibiting limited transmission potential, rarely causing severe illness upon laboratory exposure, with established medical countermeasures including effective therapeutics and prophylactic protocols 能够引起人类或者动物疾病，但一般情况下对人、动物或者环境不构成严重危害，传播风险有限，实验室感染后很少引起严重疾病，并且具备有效治疗和预防措施的微生物
Class 4 第四类	Microorganisms universally recognized as non-pathogenic to humans and animals under standard conditions 在通常情况下不会引起人类或者动物疾病的微生物

What are Biological toxins ?
什么是生物毒素?

◆ **Definition of Biological toxins**

生物毒素的定义

Biotoxins, defined as naturally occurring toxic substances produced by living organisms (animals, plants, microorganisms), exhibit extraordinary chemical diversity spanning nearly all compound classes. These complex bioactive agents modulate human physiological functions through dual characteristics: exerting both toxicological and pharmacological effects. Consequently, they serve as critical tool compounds in physiological research while simultaneously constituting essential therapeutic agents in clinical medicine.

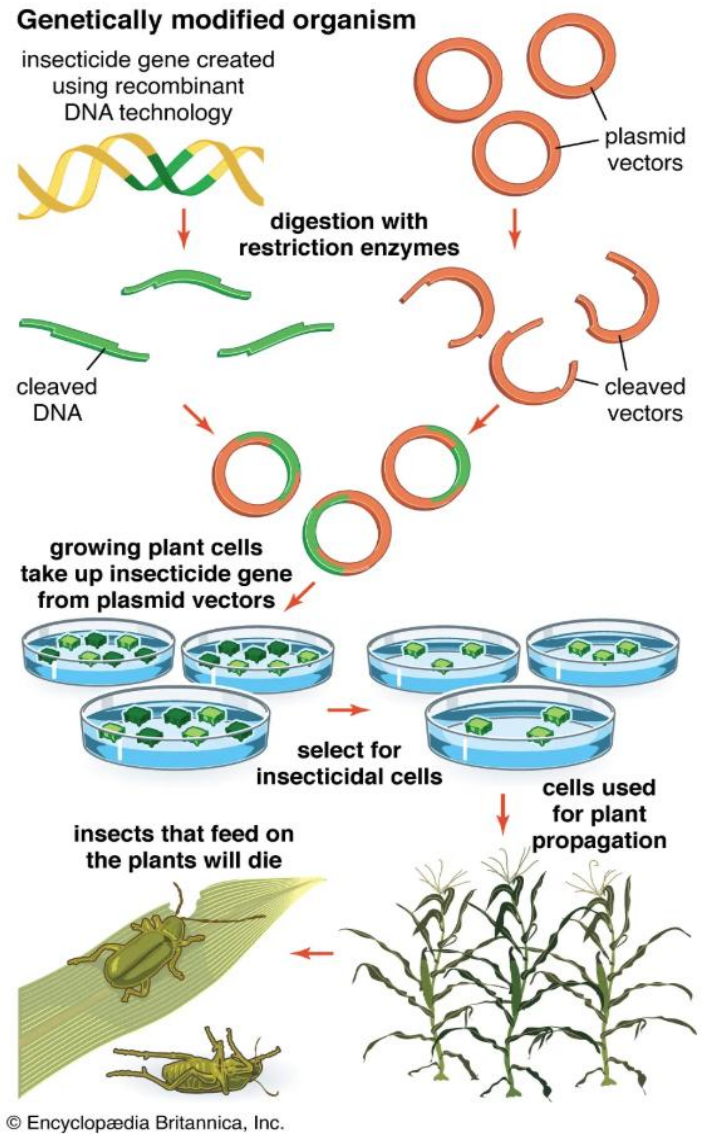
生物毒素是指由生物体（动物、植物或微生物）产生的天然毒性物质，其化学组成极其多样，几乎涵盖所有化合物类别。这些复杂的生物活性物质既具有毒理作用，又具有药理作用。因此，它们既是生理学研究中的重要工具化合物，也是临床医学中不可或缺的治疗药物。

◆ **Classification of Biological toxins**

生物毒素的分类

- Bacterial toxins (botulinum toxin, tetanus toxin)
  细菌毒素（比如肉毒杆菌毒素、破伤风毒素）
- Fungal toxins (aflatoxin)
  真菌毒素（比如黄曲霉素）
- Algal toxins (saxitoxin)
  藻毒素（比如石房蛤毒素）
- Animal toxins (snake venom)
  动物毒素（比如蛇毒）

Introduction to Recombinant DNA Molecules
重组DNA分子的介绍



◆ **When do recombinant DNAs become biosafety risks?**
什么样的重组DNA分子会存在生物危害风险呢?

- Genes encoding biological toxins
  编码生物毒素的基因
- Genes related to virulence of pathogens
  病原体毒力相关基因
- Oncogenes and other genetic materials that may create adverse health effects
  癌基因及其他可能导致不良健康影响的遗传物质
- Promoters and other constructs that lead to over-expression and abnormal secretion, etc
  导致过度表达和异常分泌等的启动子及其他人工构建片段/载体结构体
- Vectors that infect animals and humans
  感染动物和人类的载体
- Transgenic organisms in the environment (transgenic crops)
  转基因动物/植物（如转基因玉米）

How does Laboratory-Acquired Infection occur ?
实验室获得性感染是怎么发生的?

◆ **Four Exposure Routes of Laboratory-Acquired Infections**
实验室获得性感染的四种暴露途径

- ① **Skin or mucosal membrane exposure**: In biological laboratories, personnel are exposed through direct contact of the skin or mucosal membranes with spills, splashes, or contaminated surfaces, and common causes include the following: not wearing or improperly wearing protective equipment, improper handling resulting in contamination of gloves and their contact with mucosal membranes, unclear regulations regarding which equipment may or may not be touched with gloves.
① **皮肤或黏膜接触暴露**：在生物实验室中，人员可能因皮肤或黏膜直接接触溢洒物、飞溅液滴或被污染的表面而发生职业暴露。其主要原因包括：人员没有佩戴或不规范使用防护装备；人员操作不当导致手套沾染污染物后接触身体的黏膜部位（如眼、鼻等）；以及实验室并没有相关规定明确哪些设备应该/不应该佩戴手套触摸。

- ② **Inoculation**: Inoculated infections include blood-borne pathogen infections due to puncture wounds from sharp instruments and animal scratches. Sharps contaminated with blood containing high concentrations of pathogens were the most harmful of the various occupational exposures, and exposure to 0.004 mL could result in infection. In addition to unavoidable errors, improper handling of contaminated sharps waste, such as needles, syringes, blades, or glass can also result in wounds.
② **利器接种暴露**：由利器穿刺创口或动物抓咬导致的血源性病原体职业暴露中，被带有高浓度病原体血液污染的利器危害性居各类职业暴露首位——仅0.004 mL接触剂量即可导致感染。除客观操作失误外，不当处理受污染的利器废弃物（如针头、注射器、手术刀片或玻璃碎屑等）也可能会导致利器刺伤。

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- ③ **Ingestion**: In the laboratory, snacking and oral pipetting are strictly prohibited. Pipettes largely eliminate the risk of ingestion. Ingestion infections caused by oral contact with contaminated hands or materials are mainly due to a lack of awareness about protective measures, bad habits of the laboratory personnel, failure to wear protective masks correctly, or inadequate cleaning.
③ **消化道摄入性暴露：**实验室内严禁进食饮水及口吸移液操作（现代的移液器设计已经在很大程度上消除了此类风险）。因口腔接触受污染的手或材料而导致的经口感染事件的主要原因包括：人员防护意识缺失、人员在实验室内的不良工作习惯以及清洁消毒程序没有执行到位。

- ④ **Inhalation**: Pathogens can remain airborne for a long time and spread through the air, and many unrecognized causes of Laboratory-Acquired Infection are caused by aerosol inhalation. Surveys have shown that it may lead to 35%–65% of cases, mostly because experimenters do not follow required biosafety protection measures.
④**呼吸道吸入性暴露**：病原体可以在空气中长时间滞留并扩散通过空气传播途径实现播散，许多未被溯源的实验室获得性感染均由气溶胶吸入导致。调查表明，该途径可能占职业暴露感染病例的35%–65%，其主要根源是实验人员违反生物安全防护基本规程。

How does Laboratory-Acquired Infection occur ?
实验室获得性感染是怎么发生的?

Possible Exposure Routes of Laboratory-Acquired Infections 实验室获得性感染可能的暴露途径	Common causes 导致暴露的主要原因	
Skin or mucosal Membrane exposure 皮肤或黏膜接触暴露	Droplet splashing 液滴飞溅	Contaminated gloves, lab coats touching 接触受污染的手套或实验服
	Improper wearing of protective equipment 没有正确佩戴个体防护装备	Unclear regulations 缺乏相关安全规范
Inoculation 利器接种暴露	Personnel Improper Operations 人员的错误操作	Animal bites/scratches 动物咬伤/抓伤
	Improper disposal of contaminated sharps waste 利器废弃物处置不当	Inadequate protection 防护措施不足
Ingestion 消化道摄入性暴露	Smoking, eating 在实验室内抽烟或饮食	Hand-mouth contact caused by bad habits 不良习惯导致的手口接触
	Irregular operations, such as oral pipetting 违反安全规范的操作，比如用嘴移液	Not wearing a respiratory protective equipment 没有佩戴呼吸器
Inhalation 呼吸道吸入性暴露	Aerosol-generating operations 导致气溶胶的实验操作	Laboratory environmental pollution 实验室环境受到污染
	Failure to take protective measures, such as not operating at BSC 没有采取正确的防护措施，比如没有在生物安全柜内进行实验操作	Unknown reasons 未知的其他原因

Reference: Risk and countermeasure of laboratory-acquired infection based on pathogen transmission routes,Biosafety and Health,Volume 5, Issue 3,2023

How does Laboratory-Acquired Infection occur ?
实验室获得性感染是怎么发生的?

Examples and possible route of transmission of pathogens associated with different specimen types 不同类别样本中病原体的潜在传播路径示例		
Possible pathogen route of transmission 病原体可能的传播途径	Specimen type 样本类别	Example 病原体示例
Via skin contact (Skin or mucosal Membrane exposure) 皮肤接触传播（皮肤或黏膜接触暴露）	Faeces, urine, biological and environmental swabs, food samples, tissue/cell culture, tissue from biopsy, research animals, injury-prone rusty tools 粪便、尿液、生物和环境拭子、食物样本、组织/细胞培养物、活检组织、实验动物、可能导致受伤的生锈工具	Herpes simplex virus, Treponema pallidum, Staphylococcus aureus, Clostridium tetani 单纯疱疹病毒、梅毒螺旋体、金黄色葡萄球菌、破伤风梭菌
Blood-borne (inoculation) 血源性传播（利器接种暴露）	Whole blood, serum, plasma, tissue/cell culture, research animal, sputum,respiratory lavage, endotracheal aspirate, faeces, urine, biological swab, tissue from biopsy 全血、血清、血浆、组织/细胞培养物、实验动物、痰液、呼吸道灌洗液、气管内吸出物、粪便、尿液、生物拭子、活检组织	HIV, hepatitis B virus, hepatitis C virus, Plasmodium falciparum, rabies virus, Klebsiella spp. 艾滋病病毒、乙型肝炎病毒、丙型肝炎病毒、恶性疟原虫、狂犬病病毒、克雷伯氏菌属
Via faecal-oral (ingestion) 粪-口传播（消化道摄入性暴露）	Faeces, urine, respiratory lavage, endotracheal aspirate, spinal fluid,environmental swab, food samples, research animals, tissue/cell culture, tissue from biopsy 粪便、尿液、呼吸道灌洗液、气管内吸出物、脑脊液、环境拭子、食物样本、实验动物、组织/细胞培养物、活检组织	Escherichia coli, Bacillus anthracis, Bacillus cereus, Brucella melitensis, Campylobacter jejuni, Salmonella spp., Shigella spp., Vibrio cholerae 大肠杆菌、炭疽杆菌、蜡样芽孢杆菌、布鲁氏菌、空肠弯曲菌、沙门氏菌属、志贺氏菌属、霍乱弧菌
Via droplets or aerosols (inhalation, intranasal) 通过液滴或气溶胶传播（呼吸道吸入性暴露）	Respiratory lavage, endotracheal aspirate, faeces, biological and environmental swabs, research animals, tissue/cell culture, tissue from biopsy 呼吸道灌洗液、气管内吸出物、粪便、生物和环境拭子、实验动物、组织/细胞培养物、活检组织	Bacillus anthracis, Bordetella pertussis, Chlamydia pneumoniae, Corynebacterium diphtheriae, Coxiella burnetii, Haemophillus influenzae, Klebsiella spp., Mycobacterium tuberculosis and bovis, Histoplasma capsulatum, Streptococcus pneumoniae, respiratory syncytial virus, adenovirus, influenzas, rhinoviruses, coronaviruses, measles virus, human parainfluenza viruses 炭疽杆菌、百日咳杆菌、肺炎衣原体、白喉棒状杆菌、伯氏考克斯氏体（Q热）、流感嗜血杆菌、克雷伯氏菌属、结核分枝杆菌和牛分枝杆菌、荚膜组织胞浆菌、肺炎链球菌、呼吸道合胞病毒、腺病毒、流感病毒、鼻病毒、冠状病毒、麻疹病毒、人类副流感病毒

Reference: A guide for the practical implementation of the WHO Laboratory Biosafety Manual (Fourth Edition)

What is Aerosol?
什么是气溶胶?

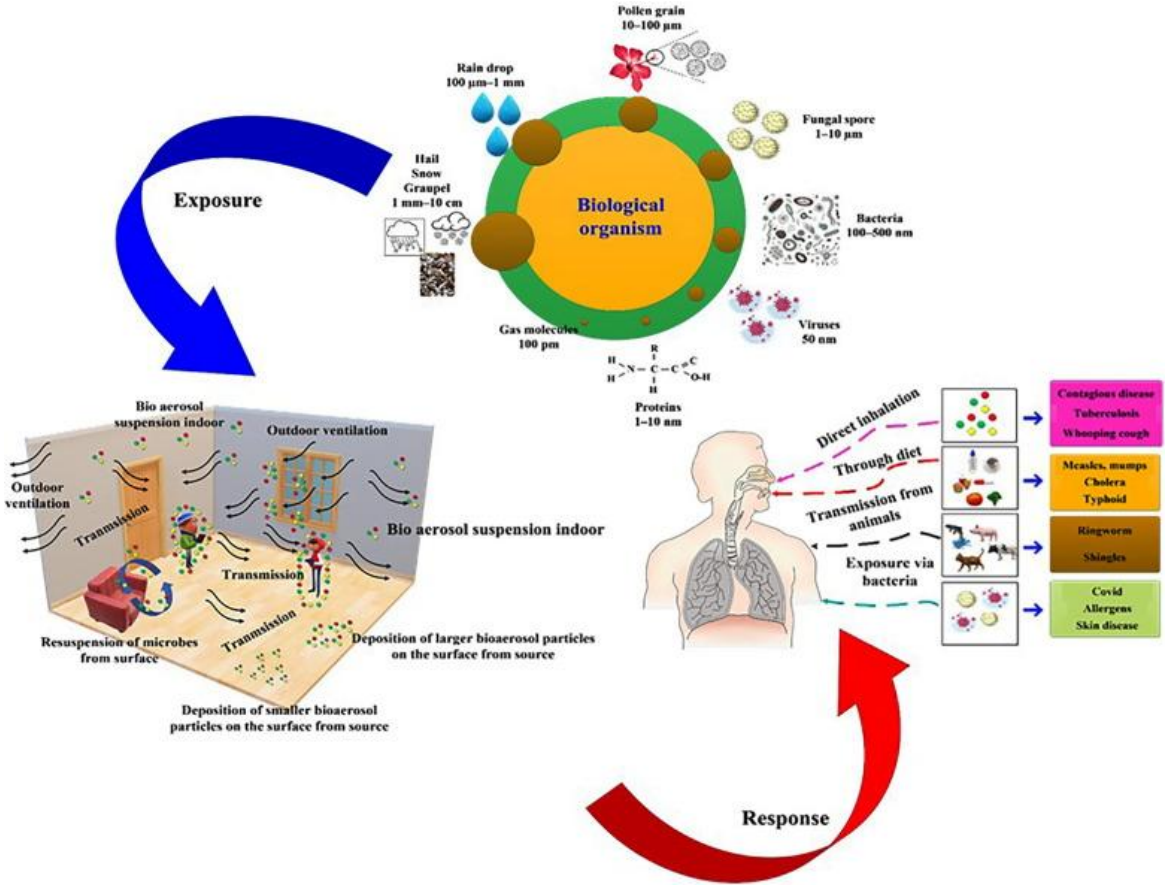
- **Definition of Aerosol**
  气溶胶的定义
  Biological materials suspended in air, which may be hazardous to human health.
  气溶胶指的是悬浮在空气中可能对人体健康有危害的生物材料
  Generated by various processes, animals and humans
  气溶胶由多种途径产生
  Range in size - 0.5 to 100 μm
  气溶胶微粒的大小通常在0.5到100μm

- **Nature of Aerosols Found in Indoor Environment**
  室内环境中气溶胶的组成
  - Dirt and debris
    灰尘等污物碎屑
  - Respiratory pathogens
    经呼吸道传播的病原体
  - Skin flakes
    皮肤碎屑
  - Dust mite and insect parts and excreta
    尘螨、昆虫的残骸及其排泄物
  - Animal shedding and excreta
    动物的粪便
  - Fungal spores & hyphae
    真菌孢子和菌丝

What is Aerosol?
什么是气溶胶?

- **Potential Hazards of Aerosols**
  气溶胶的潜在危害
  Respiratory distress
  呼吸困难
  Microbial infection
  微生物感染
  Allergic reaction
  过敏反应
  Respiratory sensitization
  呼吸性过敏
  Toxicological reaction
  毒性反应

- **Particle Deposition in Human Airway**
  颗粒物在人体呼吸道中的沉积情况
  - >10 μm - removed in nasal passage
    > 10μm - 颗粒将在呼吸道中停留
  - 5 - 10 μm - deposit in upper respiratory tract
    5 - 10 μm - 颗粒将在上呼吸道中沉积
  - <5 μm - deposit in deeper region in lung
    < 5μm - 颗粒将在肺部更深层的地方沉积



A schematic representation of composition, dispersion, and health risks of bioaerosols
气溶胶的组成、扩散和健康风险示意图

Why should we care more about bioaerosol transmission ?
为什么我们要重视气溶胶的传播?

- Respiratory route estimated to accountfor 35-65% of all occupational infection cases
  呼吸道感染约占所有职业感染病例的35 ~ 65%
- When things are airborne they spread easily and are difficult to contain
  在空气中的物质更容易传播且更难控制
- We can stop eating and drinking, but not breathing
  我们可以停止吃喝，但无法停止呼吸

◆ **Many Laboratory Operations Generate Aerosols**
实验室中的很多操作都会导致气溶胶的产生

- Blending
  混匀
- Centrifugation
  离心
- Pipetting
  移液
- Opening screw cap containers
  打开螺旋盖的容器（比如螺旋盖离心管）
- Withdrawing material from vacuum bottles
  从真空瓶中取出材料
- Streaking with wire loop
  平板划线
- Lyophilization procedures
  冻干
- Flow cytometer operations
  流式细胞仪相关操作
- Improper use of biosafety cabinets
  没有正确使用生物安全柜

What strategies can be implemented to control biosafety risks ?
为了控制生物安全风险，我们可以采取哪些控制策略?

- There are a number of different strategies that may be used to reduce and control risks. Often, more than one risk control strategy may need to be applied in order to reduce the risks effectively.
  我们可以采取的风险控制策略有很多种，通常我们需要同时采取多种不同的控制控制策略以控制工作环境中的风险。

◆ **Elimination**
消除

"Elimination" refers to eliminate the hazard, such as:
"消除"指的是消除危险的源头，比如说：

- Use an inactivated biological agent
  使用灭活的生物因子开展实验
- Use a harmless surrogate
  使用无害的替代品开展实验

◆ **Reduction**
降低

"Reduction" refers to reduce the risk, such as:
"降低"指的是降低危险源本身的风险，比如说：

- Substitute with an attenuated or less infectious biological agent
  使用减毒或传染性较低的生物因子替代高风险的生物因子
- Reduce the volume/titre being used
  减少生物因子的用量/滴度
- Change the procedure for one that is less hazardous, such as polymerase chain reaction rather than culture
  改用风险较低的操作程序，比如用聚合酶链反应（PCR）代替培养

What strategies can be implemented to control biosafety risks ?
为了控制生物安全风险，我们可以采取哪些控制策略?

◆ **Engineering Controls**
工程控制

Isolate or reduce the risk through engineered measures such as modifying equipment or workspaces, implementing protective barriers, and installing ventilation systems, such as:
通过改造设备或工作空间、使用防护屏障、通风等工程措施将风险隔离或减小，比如说:

- Isolate biological agents within a primary containment device
  将生物因子隔离在初级防护装置内
- Biological Safety Cabinets (BSCs)
  生物安全柜
- Special ventilation, e.g. pressure regime, air locks, HEPA filtered air exhaust
  特殊的通风设施，比如压力控制设施、气锁、HEPA空气高效过滤器
- Special drainage, e.g. holding tanks
  特殊的排水系统，比如储水箱
- Waste disinfection facilities
  洗消间
- UV lamp
  紫外消毒灯

- Engineering control strategies represent the most effective and prioritized approach in risk management hierarchies.
  在风险控制体系中，工程控制是最有效、优先级最高的策略。

What strategies can be implemented to control biosafety risks？
为了控制生物安全风险，我们可以采取哪些控制策略?

- **Administrative Controls**
  行政控制

  Have administrative controls and effective biosafety programme management in place, such as:
  建立行政管理措施和实施有效的生物安全管理计划，比如说：
  - A comprehensive biosafety management system has been institutionalized
    建立了完善的生物安全管理体系
  - Good Microbiological Practice and Procedure(GMPP) observed by personnel
    人员遵守良好的微生物学操作程序（GMPP）
  - Good communication of hazards, risks and risk control measures
    有关于实验室风险及其控制措施的良好沟通机制
  - Appropriate training
    合适的安全培训
  - Clear SOPs
    清晰明了的SOP
  - An established safety culture
    建立了良好的生物安全文化氛围

- The effectiveness of administrative controls is directly proportional to procedural adherence.
  行政控制策略的有效程度与人员是否遵循管理规定相关。

What strategies can be implemented to control biosafety risks ?
为了控制生物安全风险，我们可以采取哪些控制策略?

- **Personal Protective Equipment (PPE)**
  个人防护装备（PPE）

  A collection of wearable gear/clothing donned by personnel, providing an added barrier between users and processed biological agents, such as:

  个人防护装备是人员穿戴的一系列服装和/或装备，可以在他们和正在处理的生物因子之间建立一道额外的屏障，比如：

  - Hand protection--gloves
    手部防护——比如手套
  - Eye/face protection--goggles, face shields
    眼部/脸部防护——比如护目镜、面罩
  - Respiratory protection
    呼吸防护
  - Body protection--lab coats
    身体防护——比如实验服

- Personal protective equipment (PPE) serves as the last line of defense and may be employed for additional protection.
  在风险控制体系中，个人防护装备（PPE）是最后一道保护防线，有时它也是额外的保护措施。

Introduction to Biosafety Level
生物安全防护等级的介绍

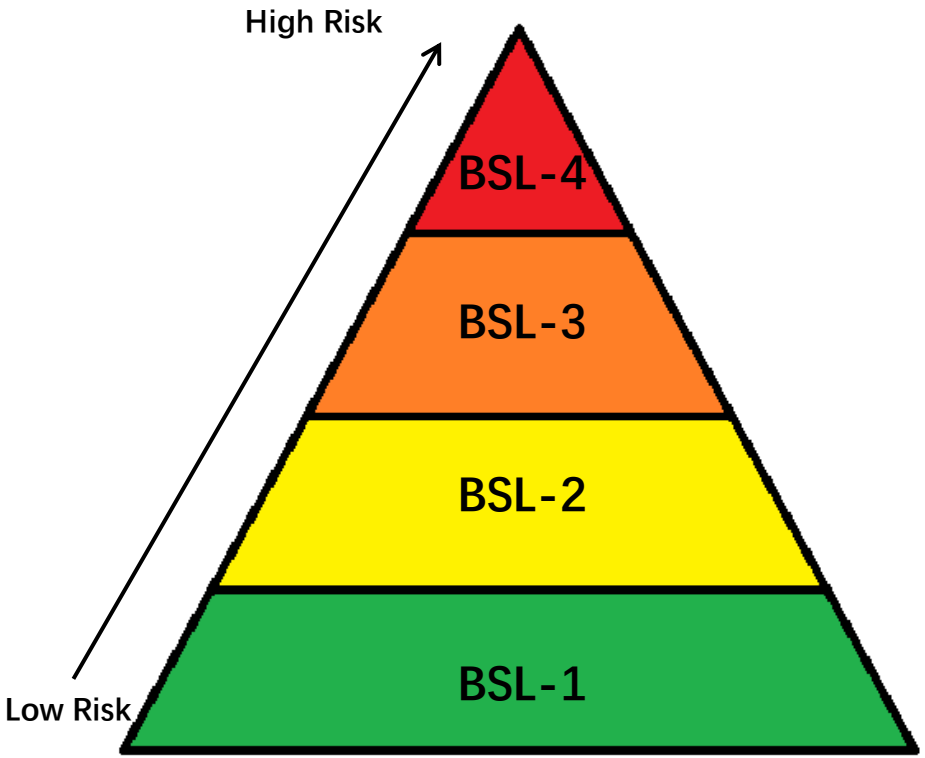
- The globally recognized biosafety level (BSL) classification system was established by US CDC and NIH.
世界通用的生物安全防护等级标准是由美国疾病控制中心(CDC)和美国国家卫生研究院(NIH)建立的。

- Laboratories conducting in vitro work are classified by biosafety levels designated as BSL-1, BSL-2, BSL-3 and BSL-4 (Biosafety Level).
我们以BSL-1、BSL-2、BSL-3、BSL-4 （Biosafety level, BSL）来表示从事体外操作的实验室的相应生物安全防护水平

- Facilities performing live animal manipulation adopt corresponding classifications labeled as ABSL-1, ABSL-2, ABSL-3 and ABSL-4 (Animal Biosafety Level).
以ABSL-1、ABSL-2、ABSL-3、ABSL-4 （Animal Biosafety level, ABSL） 来表示包括从事动物活体操作的实验室的相应生物安全防护水平

- Each level builds on the previous level.
每一个生物安全防护等级都比前一个等级的防护水平高

- Laboratory requirements for facility engineering controls, personnel protective equipment (PPE), and procedural protocols are incrementally enhanced with ascending biosafety levels.
随着生物安全防护等级的提高，对实验室设施设计、人员防护装备和实验操作规范的要求也会越来越高。



Introduction to Biosafety Level
生物安全防护等级的介绍

- In China, Higher-risk lab procedures including virus culture, live bacterium handling, or animal inoculations generally demand an inverse relationship between pathogen risk class and biosafety level: Most of the Class 1 pathogens mandate maximum-containment facilities (BSL-4/ABSL-4); most of the Class 2 pathogens require high-containment labs (BSL-3/ABSL-3).
在我国，对于生物安全风险较高的实验活动，比如病毒培养、活菌操作或动物感染实验，生物安全防护等级与实验操作的病原微生物的分级通常是相反的：大多数第一类病原微生物对应生物安全防护的最高级别BSL/ABSL-4，大多数第二类病原微生物对应生物安全防护的次高级别BSL/ABSL-3。

- The required biosafety level (BSL) for working with pathogenic microorganisms can be determined by consulting *the Pathogen Microogranisms List for Human Infectious Diseases*.
可以通过查阅《人间传染的病原微生物名录》来确定开展病原微生物实验操作所需要的生物安全防护等级。

人间传染的病原微生物目录

中华人民共和国国家卫生健康委员会制定

二零二三年八月十八日

表 1. 病毒分类目录

序号	病毒名称		分类学地位	危害程度分类	实验活动所需实验室等级					运输包装分类[f]		备注
	中文名	英文名			病毒培养[a]	动物感染实验[b]	未经培养的感染材料的操作[c]	灭活材料的操作[d]	无感染性材料的操作[e]	A/B	UN编号	
1	类天花病毒	*Alastrim virus*	痘病毒科	第一类	BSL-4	ABSL-4	BSL-3	BSL-2	BSL-1	A	UN2814	
2	天花病毒	*Variola virus*	痘病毒科	第一类	BSL-4	ABSL-4	BSL-3	BSL-2	BSL-1	A	UN2814	有疫苗。
3	猴痘病毒[g]	*Mpox virus*	痘病毒科	第一类	BSL-3	ABSL-3	BSL-2	BSL-2	BSL-1	A	UN2814	
4	亨德拉病毒	*Hendra virus*	副黏病毒科	第一类	BSL-4	ABSL-4	BSL-3	BSL-2	BSL-1	A	UN2814	
5	尼帕病毒	*Nipah virus*	副黏病毒科	第一类	BSL-4	ABSL-4	BSL-3	BSL-2	BSL-1	A	UN2814	
6	希普尔病毒	*Hypr virus*	黄病毒科	第一类	BSL-4	ABSL-4	BSL-3	BSL-2	BSL-1	A	UN2814	
7	库姆灵厄病毒	*Kumlinge virus*	黄病毒科	第一类	BSL-4	ABSL-4	BSL-3	BSL-2	BSL-1	A	UN2814	
8	卡萨诺尔森林病病毒	*Kyasanur Forest disease virus*	黄病毒科	第一类	BSL-4	ABSL-4	BSL-3	BSL-2	BSL-1	A	UN2814	

Introduction to Biological Safety Cabinet
生物安全柜的介绍

- **What is a Biological Safety Cabinet (BSC) ?**
  什么是生物安全柜（BSC）？

A Biological Safety Cabinet (BSC) is basically a leak tight box containing HEPA Filters and a motor/blower system to provide controlled air movement through the box and filters. A BSC provides an enclosed, ventilated workspace that serves as a primary containment device in laboratories. The BSC protects personnel, the laboratory environment, and/or experimental materials from exposure to infectious aerosols and splashes generated during procedures involving biohazardous agents

生物安全柜（BSC）基本是一个内置HEPA高效空气过滤器和电机/风机系统的基本密封的设备，它通过箱体和高效过滤器的协同作用实现定向气流控制。BSC能提供封闭的、通风的工作空间，可在实验室中用作基本防护装置。BSC可保护操作人员、实验室环境和/或实验材料免受操作含有生物因子的材料时可能产生的感染性气溶胶和飞溅物的影响。

BSC is the most commonly used primary containment device, and three different classes of BSC exist. These cabinets differ by the type and level of protection their directional airflow provides for laboratory personnel (device operators), the environment and/or the work materials inside and whether external fans and ductwork are required for proper operation of the primary containment device.

生物安全柜是最常用的安全防护设备，有三个不同级别的生物安全柜，它们的不同之处在于为实验室人员（设备操作人员）、环境和/或内部实验材料提供保护的定向气流的类型和级别不同，以及是否需要配备外部风扇和管道系统而不同。

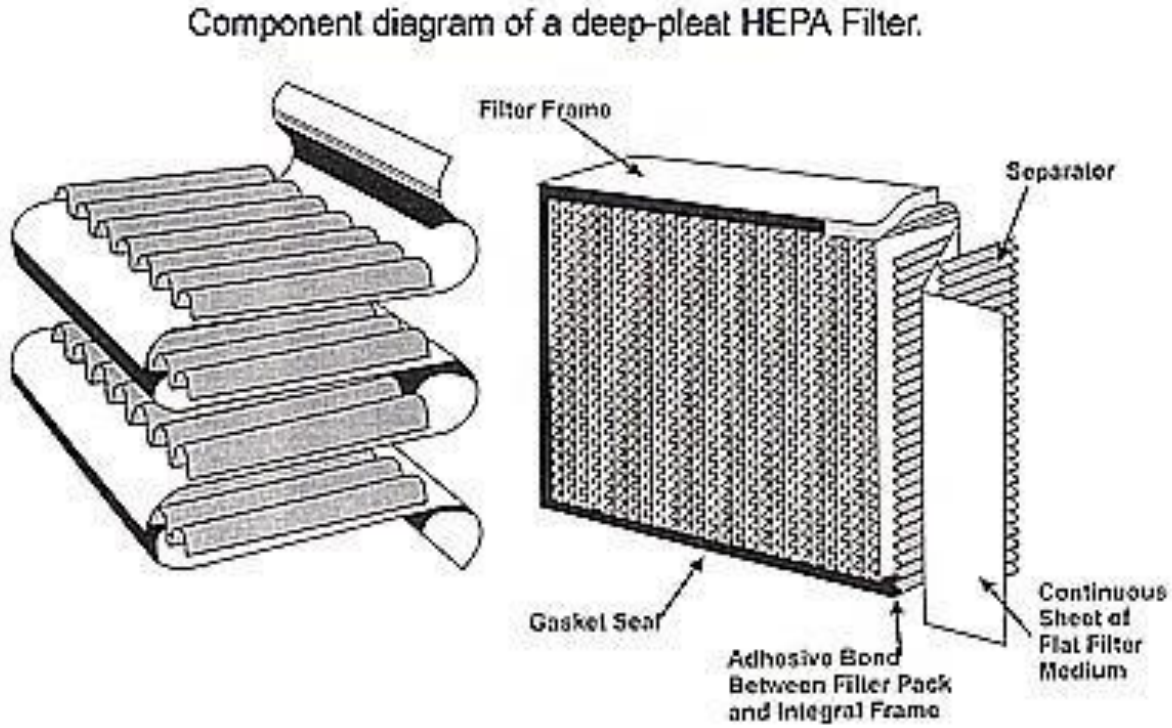
Introduction to Biological Safety Cabinet
生物安全柜的介绍

◆ **What is a HEPA filter ?**
HEPA高效过滤器是什么?

A throw-away extended/pleated medium dry-type filter with:
HEPA高效过滤器是一种一次性的延展式/褶皱型干式过滤器:

- Rigid casing enclosing the full depth of the pleats
  其拥有环绕褶皱整个深度的刚性外壳

- Through the combination of the filtering mechanisms, HEPA filters are capable of capturing small particles that pass through them, including biological agents.
  通过多种不同粒子捕获机制的结合，HEPA过滤器能够捕获通过它们的小颗粒，包括生物因子。



一款深褶式HEPA过滤器的结构分解示意图

Introduction to Biological Safety Cabinet
生物安全柜的介绍

◆ **Particulate capture mechanisms of HEPA filter**
HEPA高效过滤器的粒子捕获机制

- **Inertial impaction**: as large particles flow through the air towards the fibres, their size prohibits them from effectively adjusting to the altered airflow around the fibre, causing them to impact the fibre directly.
惯性碰撞：当大颗粒随着空气流向纤维时，颗粒较大无法随着气流绕开纤维而直接碰撞到纤维上。

- **Interception**: smaller particles flow less than one-particle diameter away from the fibres, close enough to touch and adhere to them.
截留：当较小的颗粒从纤维孔隙穿过时，足够接近纤维（如不到一个颗粒直径）时，小颗粒将接触并粘附在纤维上。

- **Diffusion**: collision, especially of the smallest particles being filtered, occurs with other air/gas molecules, altering the path of motion of the particle. This diffusion of energy between particles impedes and delays their path through the filter and increases the probability that they will be stopped either by interception or impaction.
扩散：特别适用于最小的颗粒，它们与其他空气/气体分子相互碰撞改变了粒子的运动路径，粒子间的能量扩散阻碍和延迟了它们通过过滤器的路径，从而增加了它们被截留或撞击到纤维上的可能。

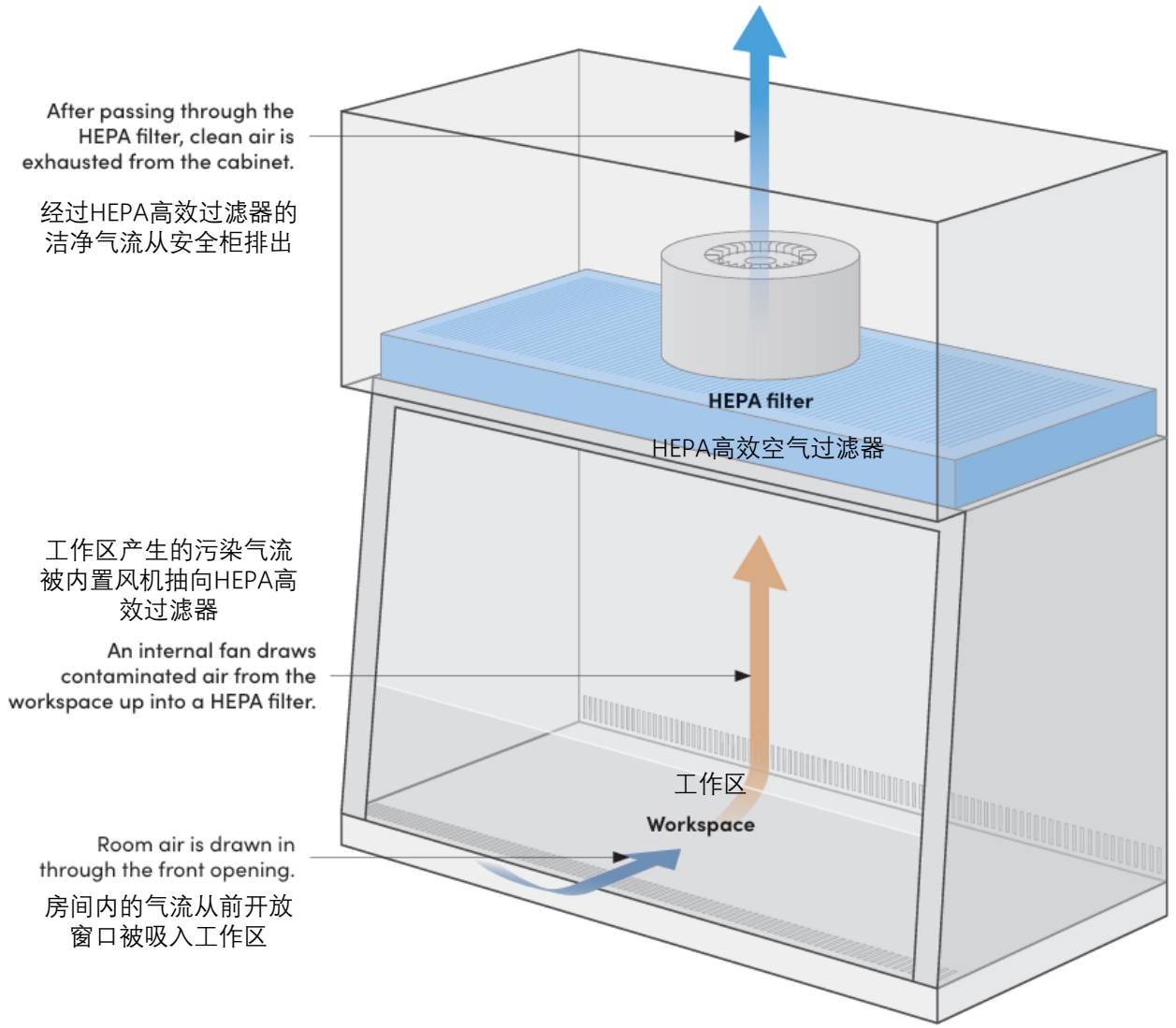
- Most HEPA filters have a filtering efficiency of more than 99.97% for particles of 0.3 μm in diameter, the most penetrating particle size. Particles with a lower or higher diameter will be removed with a higher efficiency.
大多数HEPA过滤器对于直径为0.3μm的颗粒（穿透性最强的颗粒尺寸）的过滤效率超过99.97%，对于直径较小或较大的颗粒的过滤效率将更高。

Introduction to Biological Safety Cabinet
生物安全柜的介绍

◆ **Class I BSCs**
I 级生物安全柜

Open-fronted enclosures that draw an inward airflow across the work surface through the front opening. The air passes upwards through a high efficiency particulate air (HEPA) filter before being exhausted. They provide personnel and environmental protection, but do not offer product protection for materials located in the work area.

I 级生物安全柜的前面是开放式外壳，向内的气流通过前面开口穿过工作区。空气通过高效空气（HEPA）过滤器从上方排放。这个类型BSC为操作人员和环境提供保护，但不保护工作区内的实验材料。



Introduction to Biological Safety Cabinet
生物安全柜的介绍

- **Class II BSCs**
  II 级生物安全柜

The Class II BSC is designed to provide personnel and environmental protection as well as protection for work surface materials from potentially contaminated room air. The airflows inside Class II BSCs are considerably more complex than in other BSC classes because of the addition of airflows designed to provide product protection. HEPA filtered air is driven as a downward airflow from the top of the cabinet onto the work surface. This is in addition to the inward flow of air at the front opening, which provides operator protection in a similar way to Class I BSCs. This system often involves partial recirculation of air within the cabinet; filtered air is divided between an exhaust and the downward flow mechanism.
II级BSC旨在保护操作人员和环境，同时保护工作区内的实验材料免受室内潜在污染空气的影响。因为增加了对实验材料保护的气流，II级BSC内部气流比其他型号的BSC内部的复杂很多。除了从前开口处向内的气流以外，经HEPA过滤的空气作为向下气流从安全柜顶部进入工作台面，该气流以类似于I级BSC的方式为操作人员提供保护。安全柜内过滤后的空气部分再循环，作为向下气流重新回到安全柜，其余被直接排出。

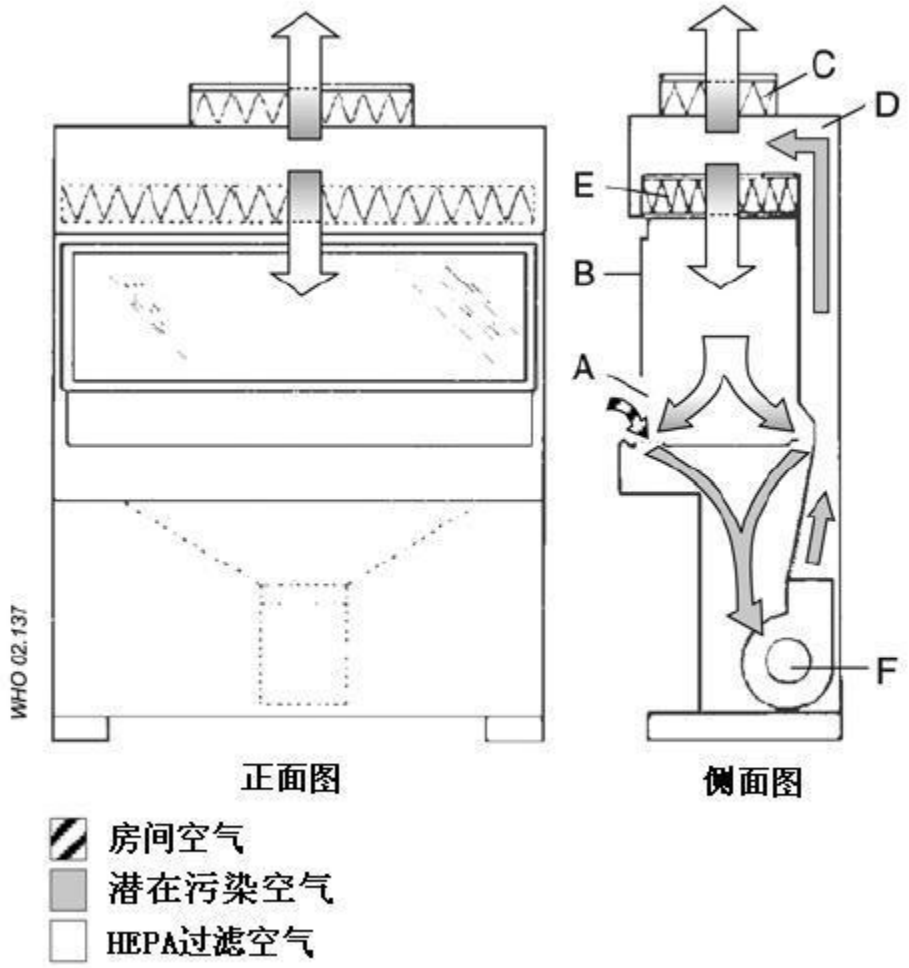
According to *Biological Safety Cabinets* (GB 41918), Class II BSCs are categorized into four types—A1, A2, B1 and B2—based on the percentage of exhaust air relative to total system airflow and their internal design configurations. *Biological Safety Cabinets* (GB 41918) states that Class II cabinets should be designed to have all biologically contaminated ducts and plenums under negative pressure or surrounded by negative pressure ducts and plenums.
根据国标《生物安全柜》（GB 41918），我国按照排放气流占系统总流量的比例及BSC内部设计结构将II级BSC分为了四种类型：A1、A2、B1、B2。《生物安全柜》（GB 41918）规定：“II级生物安全柜应确保所有生物污染部位均处于负压状态，或被负压的管道和负压风系统包围”。

Introduction to Biological Safety Cabinet
生物安全柜的介绍

◆ **Class II A1 BSCs**
II 级A1生物安全柜

Class II type A1 cabinets are no longer widely used, in part due to the lower inward airflow requirements and, more importantly, because older models do not meet the negative pressure design requirements outlined earlier.
II级A1型生物安全柜型安全柜不再广泛使用，部分原因是其对向内气流要求较低。更重要的是，部分这个型号的安全柜不完全符合负压设计要求。

Class II type A1 BSCs shall not be used for conducting microorganisms experiments involving microscale volatile toxic chemicals or trace radionuclides as adjuncts.
II 级A1型生物安全柜不得用于进行以挥发性有毒化学品和痕量放射性核素为辅助剂的微生物实验。



A：前开口　B：视窗　C：HEPA高效过滤器　D：生物安全柜后方的压力排风系统
E：供风段HEPA过滤器　F：风机

Introduction to Biological Safety Cabinet
生物安全柜的介绍

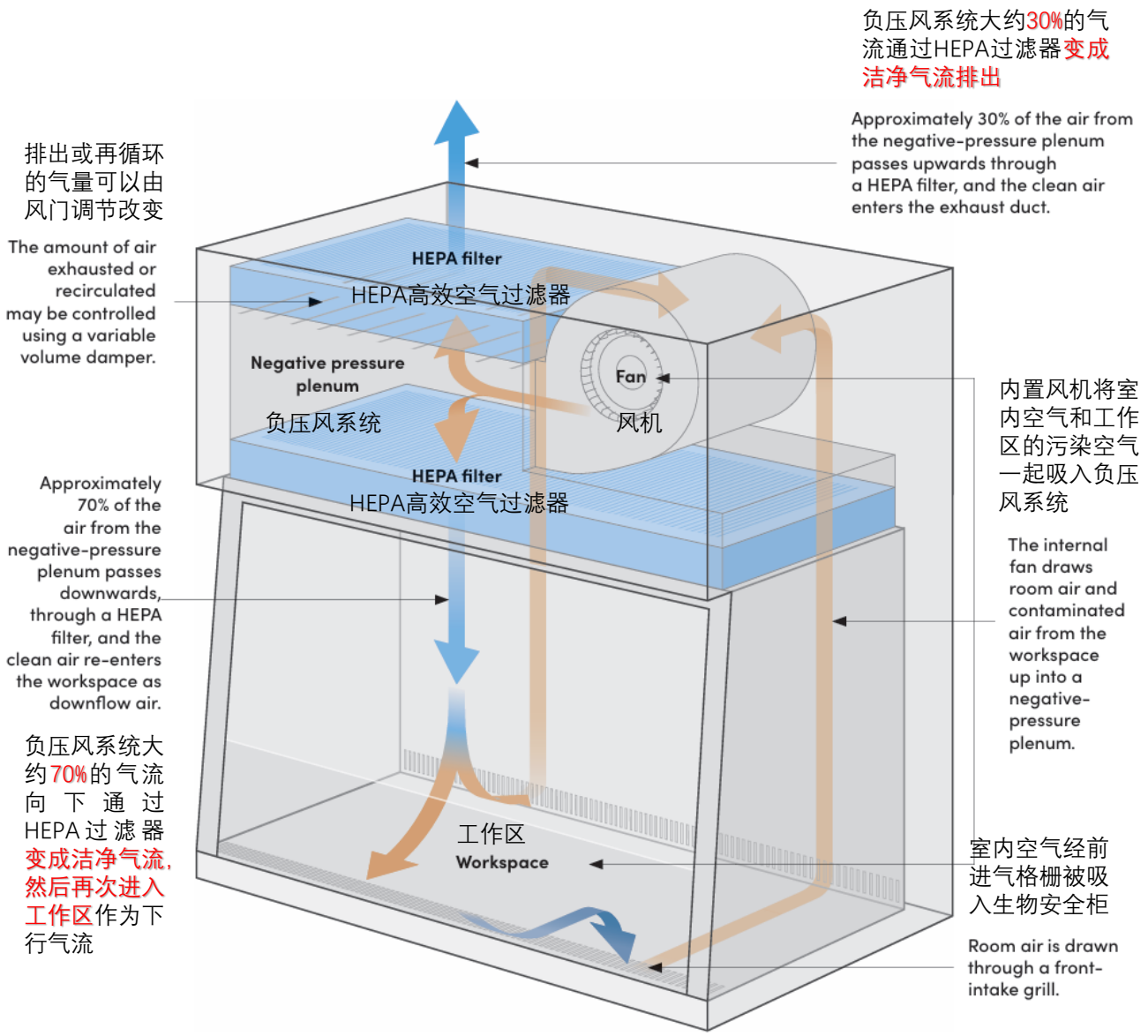
◆ Class II A2 BSCs
II 级A2生物安全柜

Class II type A2 BSCs are the most widely used Class II BSCs globally because their use of a negative-pressure plenum on the exterior of the BSC acts an additional safety feature. Figure right illustrates the operational principles of a Class II A2 BSC.

II级A2型生物安全柜是使用最广泛的II级生物安全柜，它能在全球被广泛使用是因为它的负压风系统可以提供额外的安全防护。右图展示了II级A2型生物安全柜的工作原理。

When performing microbiological procedures involving trace volatile toxic chemicals or radionuclides as ancillary agents, Class II A2 BSCs must be ducted to an appropriately engineered exhaust system.

II 级A2型生物安全柜用于进行以微量挥发性有毒化学品和痕量放射性核素为辅助剂的微生物实验时，应连接功能合适的排气罩。

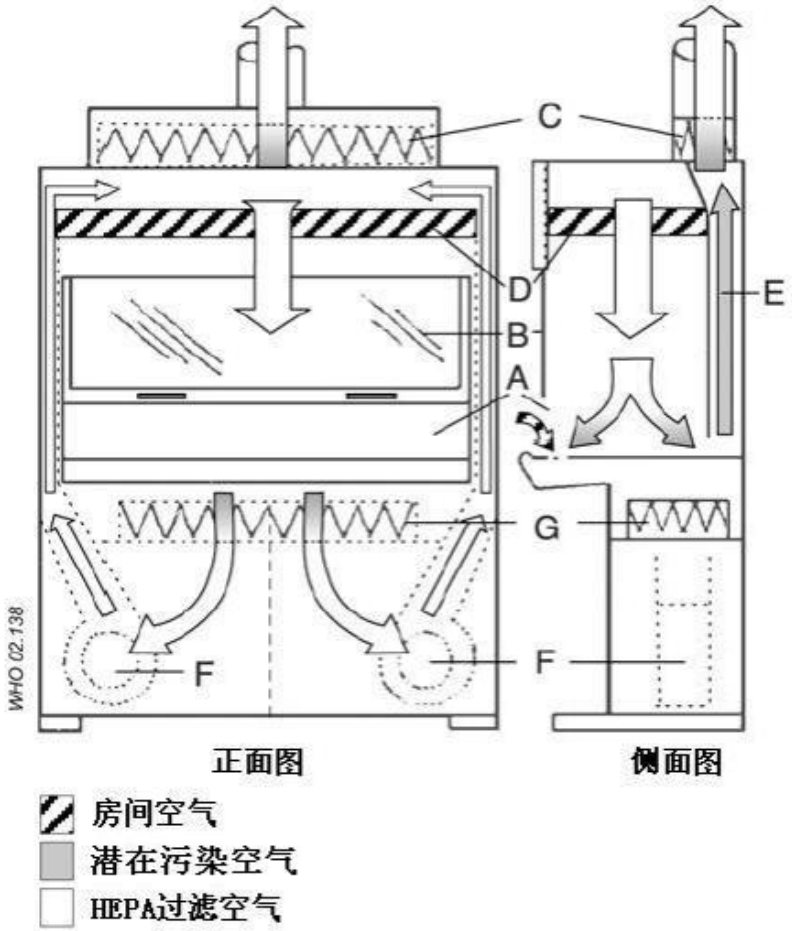


Introduction to Biological Safety Cabinet
生物安全柜的介绍

◆ **Class II B1 BSCs**
II 级B1生物安全柜

Class II type B1 BSCs use a primarily single-pass airflow whereby air removed from the workspace is not mixed and recirculated as downward airflow. The proportion of air recirculated in type B1 cabinets varies between models but is typically less than 50%.
II级B1型安全柜主要使用单向气流，因此从工作区排出的空气通常不会混合作为向下气流再循环。B1型安全柜中再循环的空气比例因机型而异，但通常小于50%。

Class II, Type B1 BSCs may be used for microorganisms experiments with microscale volatile toxic chemicals or trace radionuclides as adjuncts, provided these substances do not interfere with operations through air recirculation or if the work is conducted within their direct exhaust area.
如果挥发性有毒化学品或放射性核素随空气循环不影响实验操作或实验在BSC的直接排气区域进行，II级B1型BSC可以用于微量挥发性有毒化学品和痕量放射性核素为辅助剂的微生物实验。



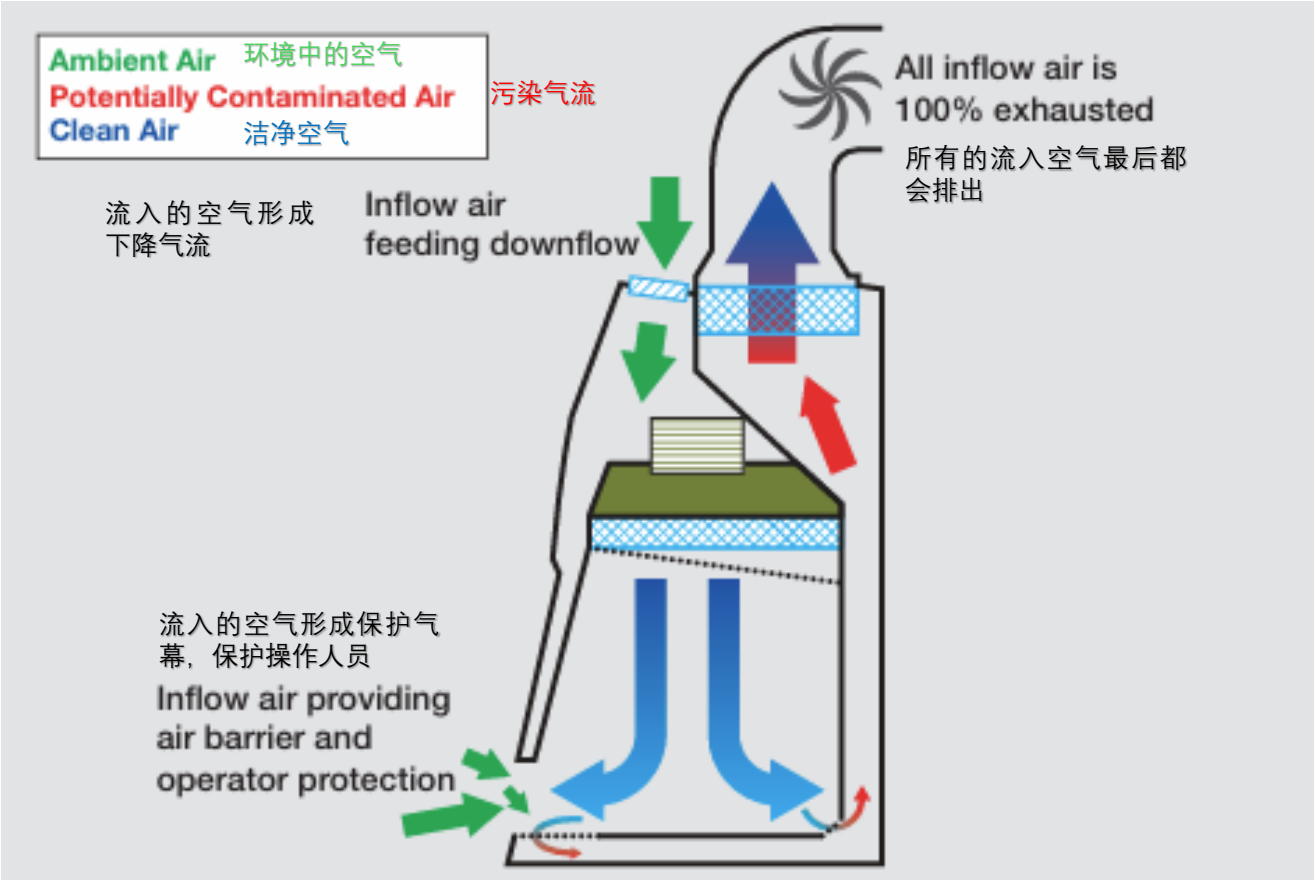
A：前开口　B：视窗　C：HEPA高效过滤器　D：供风段HEPA过滤器
E：负压压力排风系统　F：风机　G：送风段HEPA过滤器

Introduction to Biological Safety Cabinet
生物安全柜的介绍

◆ **Class II B2 BSCs**
II 级B2生物安全柜

Class II type B2 BSCs employ total single-pass airflow; consequently, inflow and downflow air within these cabinets pass through HEPA filters and are exhausted via a hard-ducted system to the atmosphere. This air shall not return to the interior of the BSC or re-enter the laboratory.
II级B2型生物安全柜完全使用单向气流，因此这类BSC的流入气流和下降气流经过HEPA filter过滤后通过排气管排到大气中，不允许回到BSC内和实验室中。

Class II type B2 BSCs are suitable for microorganisms experiments involving volatile toxic chemicals or radionuclides as adjuncts.
II级B2型生物安全柜可以用于挥发性有毒化学品和放射性核素为辅助剂的微生物实验。

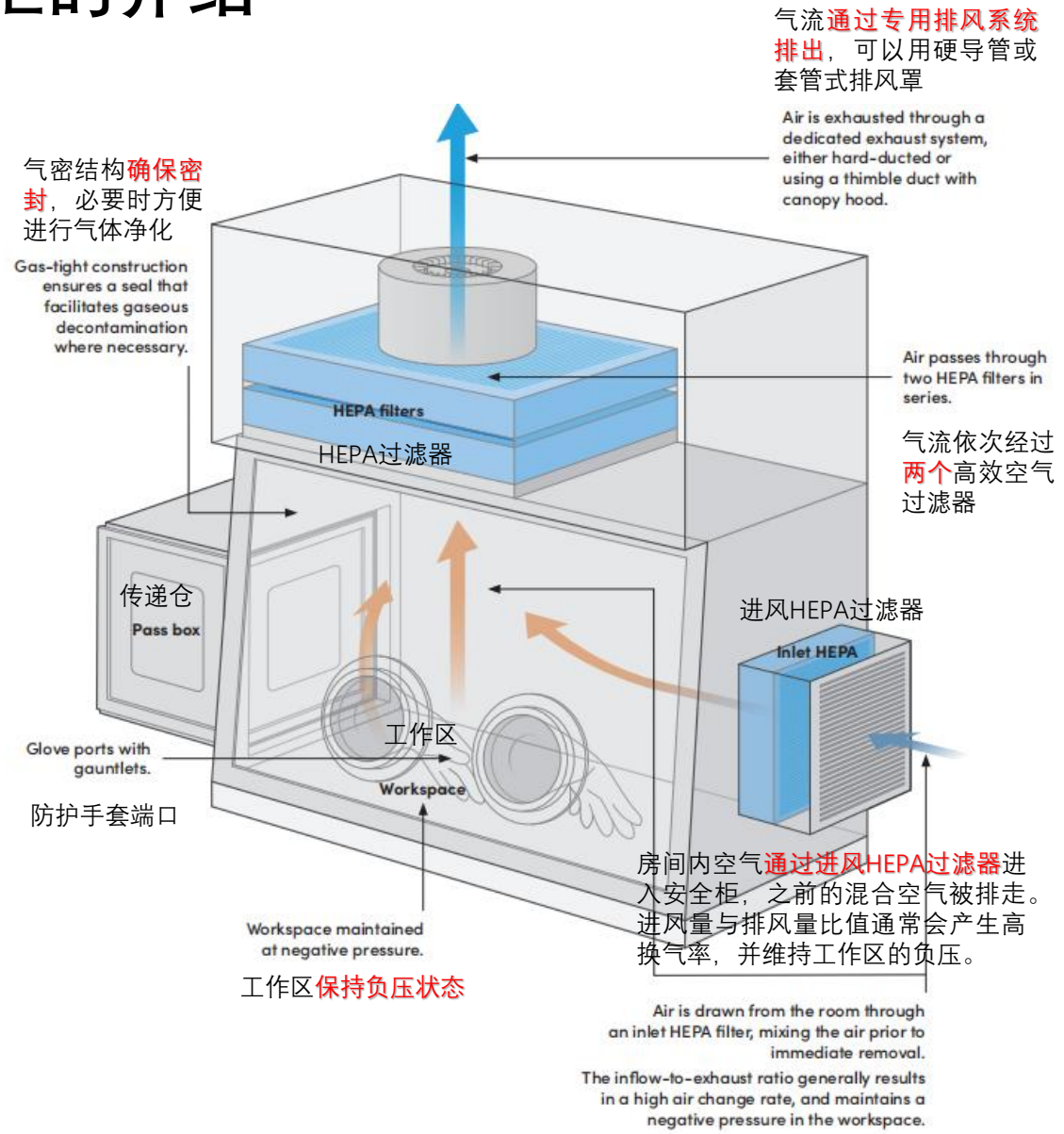


Introduction to Biological Safety Cabinet
生物安全柜的介绍

◆ **Class III BSCs**
III 级生物安全柜

The Class III BSC is designed to provide the highest level of protection to personnel. These cabinets are leak-proof and will be stringently tested to check leakage rates for the completed system at commissioning and installation.
III级BSC旨在为人员提供最高级别的保护。这些安全柜完全密封，在调试和安装时必须进行严格测试，以检查整个系统的泄漏情况。

The Class III BSC provides complete separation between the material being handled and the operator, laboratory and surrounding environment. The only potential for breach of containment is through damage to the integrated gloves or through the movement of materials in and out of the cabinet.
三级生物安全柜可将操作对象与操作人员、实验室和周围环境完全隔离。一体式手套损坏或材料进出安全柜的活动是破坏安全柜密封性的唯一可能。



Characteristics of different biological safety cabinets
不同类型生物安全柜的特点

BSC Type 生物安全柜类型	Minimum Average Inflow Velocity (m/s) 最小平均进风流速（m/s）	Recirculated Air (%) 循环气流（%）	Exhaust Air (%) 排出气流（%）	Indications for the use of toxic chemicals and radio-nuclides 有毒化学品和放射性核素的使用说明
Class I BSC I级生物安全柜	0.20 - 0.50 m/s (EN 12469:2000)	0	100	Can be used to handle small amount of radionuclides and toxic chemicals 可用于操作为了放射性核素和挥发性有毒化学品 Provide personnel and environmental protection, but do not offer product protection for materials located in the work area 可以保护操作人员和环境，但无法保护样品
Class II type A1 BSC II级A1型生物安全柜	0.40m/s (GB 41918-2022)	70	30	Work does not include toxic chemicals or radionuclides 不得用于进行以挥发性有毒化学品和放射性核素为辅助剂的微生物实验
Class II type A2 BSC II级A2型生物安全柜	0.50m/s (GB 41918-2022)	≈70	≈30	Must be ducted to an appropriately engineered exhaust system 应连接功能合适的排气罩才能开展挥发性有毒化学品和放射性核素的实验
Class II type B1 BSC II级B1型生物安全柜	0.50m/s (GB 41918-2022)	< 50	> 50	Can be used to handle small amount of radionuclides and toxic chemicals 可用于操作微量放射性核素和挥发性有毒化学品 provided these substances do not interfere with operations through air recirculation or if the work is conducted within their direct exhaust area 前提是挥发性化学品和放射性核素随空气循环不影响实验操作或实验在BSC的直接排气区域进行
Class II type B2 BSC II级B2型生物安全柜	0.50m/s (GB 41918-2022)	0	100	Can be used to handle small amount of radionuclides and toxic chemicals 可用于操作微量放射性核素和挥发性有毒化学品 Not suitable for dusty environment 不适合多尘环境
Class III BSC III级生物安全柜	NA 不适用	0	100	Can be used to handle small amount of radionuclides and toxic chemicals 可用于操作微量放射性核素和挥发性有毒化学品

Introduction to Biological Safety Cabinet
生物安全柜的介绍

◆ **BSCs Need Periodic Testing**
生物安全柜需要定期进行检测

- Annual testing (GB 41918-2022)
  年度检验

a. Appearance
   生物安全柜外观
b. Integrity of HEPA filters
   高效过滤器完整性
c. Downdraft flow rate
   下降气流流速
d. Flow rate of inflow air
   流入气流流速
e. Air flow pattern
   气流模式

- Tests also required after each relocation or filter change
  当生物安全柜更换过滤器和内部部件维修后，也要进行维护检验

- Fumigation to decontaminate unit before servicing or filter change
  在维修或更换过滤器前，对设备进行熏蒸消毒

HEPA filters integrity test
HEPA高效过滤器完整性测试

Good Microbiological Practice and Procedure
良好的微生物学操作和程序

◆ **What is a Good Microbiological Practice and Procedure (GMMP)？**
什么是良好的微生物学操作和程序（GMPP）？

GMPP is a term given to a set of standard operating practices and procedures, or a code of practice, that is applicable to all types of activities with biological agents. This includes both general behaviours, best working practice and technical procedures that should always be observed in the laboratory and conducted in a standardized way.
GMPP是指一组标准的操作和程序或一种操作规范的术语，适用于使用生物因子的所有活动类型，内容包括一般行为、最佳工作实践和技术程序，实验室人员应始终遵守GMPP，并以标准化的方式执行。

The implementation of standardized GMPP serves to protect laboratory personnel and the community from infection, prevent contamination of the environment, and provide product protection for the work with the biological agents in use.
标准化GMPP的实施有助于保护实验室人员和社区免受感染，防止环境污染，并为正在使用生物因子的工作提供产品保护（保护实验对象）。

- GMPP are the most essential risk control measures because human error, suboptimallaboratory techniques and improper use of equipment have been found to cause themost laboratory injuries and laboratory-associated infections.

  GMPP是最基本的风险控制措施，目前已发现多数实验室伤害和实验室相关感染都是由于人为错误、实验技术不佳和设备使用不当而导致。

GMPP -- Best pratice
GMPP —— 最佳实践

- **Best practice describes behaviours that are essential to facilitate safe work practices and control biological risks. Examples of laboratory best practice are outlined below.**
  最佳实践描述了对促进安全工作实践和控制生物风险非常重要的行为。实验室最佳实践的例子总结如下：

✖ Never store food or drink or personal items in the laboratory. Eating, drinking, chewing gum, smoking, mobile phone use, putting on contact lenses or applying cosmetics are strictly forbidden in the laboratory.
绝不在实验室储存食物、饮料，或存放外套和袋子等个人物品。进食、喝水、吸烟和护肤化妆等活动只能在实验室外进行。

✖ Never put anything in your mouth while inside the laboratory.
在实验室里绝不要把任何物品放入口内。

O Thoroughly wash your hands (if water and soap are not available, use a hand sanitizer with at least 60% alcohol content), after handling any biological material, before leaving the laboratory or any time contamination is known or suspected on your hands.
处理完生物材料和/或动物后，或者在离开实验室前，或是在已知或认为手已经被污染时，要彻底洗手，最好使用流动的温水和肥皂。

O Ensure that open flames or heat sources are never placed near flammable supplies and are never left unattended.
确保绝不将明火或热源放置在易燃品附近，且明火或热源绝不能无人看管。

Fig. 1. Do not eat or drink symbol

禁止饮食标志

Fig. 2. Handwashing station symbol

洗手台标志

GMPP -- Best pratice
GMPP —— 最佳实践

◆ **Best practice (Continue)**
最佳实践（接上一页）

- Ensure that waterproof coverings are placed over any cuts or broken skin prior to entering the laboratory.
  进入实验室前，应确保伤口或破损的皮肤已经遮盖好。

- Ensure that supplies of laboratory equipment and consumables, including reagents, PPE and disinfectants, are sufficient and appropriate for the activities being performed.
  进入实验室前，应确保有足够的实验室设备和消耗品供应，包括试剂、个体防护装备和消毒剂，且这些物品应符合预期的活动要求。

- Ensure that supplies are stored appropriately (according to storage instructions) and safely to reduce the chance of accidents and incidents such as spills, trips or falls.
  确保将相关物资按照储存说明安全存放，以减少相关事故和事件，如溢洒、绊倒或跌倒。

- Ensure proper labelling of all biological agents, chemical and radioactive materials.
  确保所有生物因子、化学品和放射性物质都贴上了合适的标签。

- ✖ Avoid removing documents from the laboratory to other areas. If unavoidable, written documents can be protected from contamination using barriers (such as plastic coverings), so that they can be cleaned and decontaminated before being removed from the laboratory.
  尽可能避免从实验室内拿走文件。如无法避免，使用隔离物（如塑料外壳）保护书面文件免受污染，这样可以在离开实验室前对这些文件进行清洁和消毒。

GMPP -- Best pratice
GMPP —— 最佳实践

◆ **Best practice (Continue)**
最佳实践（接上一页）

- Ensure that work is performed with care, in a timely manner and without rushing. Working when fatigued should be avoided.
  确保谨慎工作，不匆忙。疲劳时应避免工作。

- Keep the work area tidy, clean and free of clutter.
  保持工作区整齐、清洁，没有非必要的物品和材料。

- ✖ Prohibit the use of earphones, which can distract personnel and prevent equipment or facility alarms from being heard.
  禁止使用耳机，这会分散人的注意力，且会妨碍其听到设备或设施的报警声。

- Cover or remove any jewellery, which could tear gloves, easily become contaminated or act as a fomite. Items that cannot be removed, such as glasses, should be decontaminated at the end of each activity and before leaving the laboratory.
  遮盖或取掉任何可能撕破手套、易污染或成为污染物的珠宝首饰。如果经常佩戴首饰或眼镜，应考虑对其进行清洁并去除污染。

- Keep mobile electronic devices in areas where they cannot easily become contaminated or act as fomites. Refrain from using them when not specifically required. Where usage is unavoidable, ensure that they are either protected by a physical barrier or decontaminated before leaving the laboratory.
  将便携式电子设备存放在不容易被污染或成为污染物传播感染的区域。如果这类设备不可避免地要接近生物因子，则应确保用物理屏障进行保护，或是在带离实验室前去除污染。

- Know where the fire extinguishers, fire exits, emergency meeting point, spill kits, first aid kits, emergency eye wash and drenches are located.
  了解灭火器、消防出口、紧急集合点、泄漏应急包、急救箱、紧急洗眼器和紧急喷淋装置的位置。

GMPP -- Best pratice
GMPP —— 最佳实践

- **Best practice (Continue)**
  最佳实践（接上一页）

- Keep access to emergency equipment clear so that they can be easily used in case of an emergency
  请确保应急设备的通道时刻保持通畅，以便在紧急情况下能够迅速投入使用。

- Periodically check fire extinguisher's expiry date, and that heat and smoke detection and fire suppression equipment are working properly.
  定期检查灭火器的有效期限；并确保热感/烟雾探测器及自动灭火装置均处于正常运作状态。

- Conduct a fire drill for the premises, at least annually. Ensure that all laboratory personnel are aware of the rules around fire safety and know how to properly use fire suppression equipment.
  每年至少组织一次消防演练。确保全体实验室人员熟知消防安全守则并能正确操作灭火救援设备。

- Test eye wash stations and emergency showers at least once a week to ensure that they are working properly and water is clean, if needed, in an emergency. Each test should be documented.
  每周至少测试一次洗眼器和紧急喷淋装置，确保其功能正常且水源洁净可供应急使用，每次测试后应在测试卡上留下书面记录。

- Conduct medical monitoring on laboratory personnel to evaluate any adverse health effect, any pre-existing or newly acquired medical condition and any required vaccination.
  对实验人员实施职业健康监护：评估职业病损效应、既有/新发健康状况及强制免疫接种合规性。

GMPP -- Best pratice
GMPP —— 最佳实践

Figure 3. Symbols you should recognize and be able to identify to work safely in a laboratory

为了确保您能在实验室安全工作，您需要认识这些标志：

Harmful
低水平毒性

Harmful to health
健康危害

Toxic
急性毒性

Corrosive
腐蚀性

Oxidizing
氧化剂

Flammable
可燃物

Compressed Gas
带压气瓶

Environmental
环境危害

Electrical
电力

Biological hazard
生物危害

Radioactive
放射性物质

Fire extiguisher
灭火器

Fire exit
安全出口

Meeting point
紧急集合点

First aid
急救箱

Emergency eye wash
洗眼器

GMPP -- Technical procedures
GMPP —— 技术程序

Technical procedures are a special subset of GMPP which relate directly to controlling risks through safe conduct of laboratory techniques. These technical procedures,when executed correctly, allow work to be performed in a manner that minimizes the likelihood of cross contamination (that is contamination of other specimens, or previously sterile substances or objects as well as surface contamination) and also help prevent exposure of the laboratory personnel to biological agents.

技术程序是GMPP的一个特殊子集，通过实验室技术的安全实施直接控制风险。正确执行这些技术程序，可以使工作中交叉污染（即其他标本、无菌物质/物体的污染以及表面污染）的可能性最小化，也有助于防止实验室人员暴露于生物因子。

- **Avoiding inhalation of biological agents**
  避免生物因子的吸入性暴露

Use good techniques to minimize the formation of aerosols and droplets when manipulating specimens. This includes refraining from forcibly expelling substances from pipette tips into liquids, over-vigorous mixing, and carelessly flipping open tubes. Where pipette tips are used for mixing, this must be done slowly and with care. Brief centrifuging of mixed tubes before opening can help move any liquid away from the cap.
在处理标本时，采用良好的技术尽量减少气溶胶和飞沫的形成。包括避免强行将移液器枪头中的物质打到液体中、避免过度剧烈的混合和不小心翻转开口管。在用移液器枪头进行混合时，必须小心缓慢地进行。刚做完混合的试管在打开前，可以先短暂离心，以移除管盖上的液体。

Avoid introducing loops or similar instruments directly into an open heat source(flame) as this can cause spatter of infectious material. Where possible, use disposable transfer loops, which do not need to be resterilized. Alternatively, an enclosed electric microincinerator to sterilize metal transfer loops can also be effective.
避免将接种环或类似器材直接放入开放热源（火焰），因为这样可能会导致感染性物质的飞溅。如可能，应使用无需再次消毒的一次性接种环。或者，也可用封闭的电动微焚烧炉消毒金属接种环。

GMPP -- Technical procedures
GMPP —— 技术程序

◆ **Avoiding ingestion of biological agents and contact with skin and eyes**
避免生物因子摄入及接触皮肤和眼部

- ⭕ Wear disposable gloves at all times when handling specimens known or reasonably expected to contain biological agents. Disposable gloves must not be reused.
在处理已知或合理预期含有生物因子的标本时，应始终佩戴一次性手套。一次性手套不得重复使用。

- ✖ Avoid contact of gloved hands with the face.
避免戴着手套的手与脸接触。

- ⭕ Remove gloves aseptically after use and wash hands.
使用后以无菌的方式取下手套，并洗手。

- ⭕ Shield or otherwise protect the mouth, eyes and face during any operation where splashes may occur, such as during the mixing of disinfectant solutions.
在任何可能发生飞溅的操作中，如在混合消毒剂时，可通过屏蔽或其他方式保护口腔、眼部和面部。

- ⭕ Secure hair to prevent contamination.
保护头发，防止污染。

- ⭕ Cover any broken skin with a suitable dressing.
用合适的敷料覆盖破损皮肤。

- ✖ Prohibit pipetting by mouth.
禁止用嘴移液。

GMPP -- Technical procedures
GMPP —— 技术程序

- **Avoiding injection of biological agents**
  避免生物因子接种性暴露

  - Wherever possible, replace any glassware with plastic-ware.
    尽可能使用塑料器皿代替玻璃器皿。
  - If required, use scissors with blunt or rounded ends rather than pointed ends
    如需要使用剪刀，应使用圆头剪刀，而非尖头剪刀。
  - If glassware must be used, check it on a regular basis for integrity and discard it if anything is broken, cracked or chipped.
    如果必须使用玻璃器皿，请定期检查其完整性，如有破碎、裂缝或缺损，应及时丢弃。
  - Use ampoule openers for safe handling of ampoules.
    使用安瓿瓶开启器安全处理安瓿瓶。

Ampoule opener
安瓿瓶开启器

use scissors with blunt
使用圆头剪刀

GMPP -- Technical procedures
GMPP —— 技术程序

◆ **Avoiding injection of biological agents (Continue)**
避免生物因子接种性暴露（接上一页）

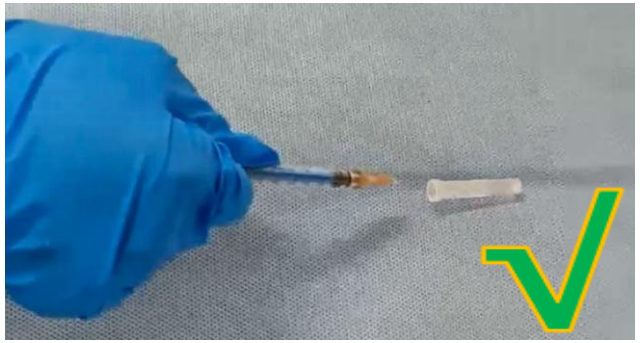
- Minimize the risk associated with the use of syringes or needles by using blunt syringe needles, alternative devices or engineered sharp safety devices where possible. However, be aware that sharp safety devices also pose a risk when not handled properly.
  尽量使用钝头针、替代器具或特殊设计的利器安全装置，减少与针具使用相关的风险。但是需要注意，利器安全装置在处理不当时也会造成风险。

- ✖ Never use syringes with needles as an alternative to pipetting devices.
  不要用带针头的注射器代替移液器。

- ✖ Aviod recapping, cliping or removing needles from disposable syringes. If recapped, use the one-hand “scoop” technique.
  避免夹、取或回套针帽。如需回套针帽，应使用”单手舀“方法操作。

- Dispose of any sharps materials (for example, needles, needles combined with syringes, blades, glass slide) in puncture-proof or puncture-resistant containers fitted with sealed covers. Disposal containers must be puncture-proof/-resistant, must not be filled to capacity (three-quarters full at most), must be never reused.
  将所有利器（例如针头、有针头的注射器、刀片、玻片）放置在配有密封盖的防刺穿或耐穿刺的利器盒中。利器盒必须是防/耐穿刺的，不得装满（最多装四分之三容量），不得重复使用。

Never recap needles using both hands
不要双手回套针帽



One-hand ‘scoop’ technique
”单手舀“方式回套针帽

GMPP -- Technical procedures
GMPP —— 技术程序

- **Preventing dispersal of biological agents**
  防止生物因子扩散

  - Discard specimens and cultures for disposal in leak-proof containers with tops appropriately secured before disposal in dedicated waste containers.
    将标本和培养物丢弃在防泄漏容器中，将容器丢弃至专用垃圾桶前应把顶部封好。

  - Place waste containers, preferably unbreakable (such as plastic, metal), at every workstation.
    在每个工作区放置垃圾桶，垃圾桶最好是不易破损（如塑料、金属）的材料。

  - Ensure all waste is properly labelled.
    定期清空垃圾桶，妥善处理废弃物。

  - Ensure all waste is properly labelled.
    确保所有废弃物都有合适的标签。

  - Consider opening tubes with disinfectant-soaked pad/gauze.
    考虑用消毒剂浸泡过的衬垫/纱布打开试管。

  - Decontaminate work surfaces with a suitable disinfectant if any material is spilled.
    如果发生材料溢洒，应使用合适的消毒剂为工作台表面去除污染。

  - When disinfectants are used, ensure the disinfectant is active against the agents being handled and is left in contact with waste materials for the appropriate time, according to the disinfectant being used.
    使用消毒剂时，应确保其对被处理的生物因子有效，并根据所使用的消毒剂种类，使其在废弃物上作用足够的时间。

GMPP -- BSCs
GMPP —— 生物安全柜的使用

- **Preparing for Work in a BSC**
  在生物安全柜开展工作前的准备

1. Put on peersonal protective equipments (PPE) according to your laboratory Standard Operating Procedure (SOP).
   根据实验室的标准操作规程（SOP）穿戴了合适的个人防护装备（PPE）。

2. Turn UV light OFF (if used).
   如果紫外灯还在运行，应先关闭紫外灯。

3. Turn fluorescent light ON.
   打开生物安全柜的照明灯。

4. Turn the cabinet ON, allow it to run for 5 minutes (or manufacturer's recommended time) to purge the BSC of particulates.
   打开生物安全柜风机，让风机至少运行5分钟（或生产厂家推荐的时长）以完成内部的气流置换。

5. Verify proper sash height and that sash alarm is ON.
   确认前开口视窗处于正确高度位置并确保BSC的高度报警功能已开启。

6. Verify drain valve underneath the cabinet is closed (valve handle is perpendicular to valve body).
   检查并确认位于BSC底部的排水阀已完全关闭。

7. Check cabinet's certification sticker expiration date is within 1 year.
   检查张贴在BSC上的检验贴纸，确认这台BSC的上次检验日期在1年内。

8. Schedule uninterrupted work time, if possible.
   如可能，尽量规划一段连续无中断的实验操作时段。

9. Decontaminate all surfaces of the cabinet, according to your laboratory SOP.
   确认前开口视窗处于正确高度位置并确保BSC的高度报警功能已开启。

GMPP -- BSCs
GMPP —— 生物安全柜的使用

◆ **Safety use of a BSC :**
安全使用生物安全柜：

- Apparatus and materials in the BSC must be kept to a minimum. Air circulation at the rear plenum must not be blocked.
安全柜内应尽量少放置器材或样本，不能影响后部压力排风系统的气流循环。

- All work must be carried out in the middle or rear part of the working surface and be visible through the viewing panel.
所有工作必须在工作台面的中后部进行，并能够通过玻璃观察挡板看到。

- Traffic behind the operator should be minimized.
尽量减少操作者身后的人员活动。

- The operator should not disturb the airflow by repeated removal and reintroduction of his or her arms.
操作者不应反复移出和伸进手臂以免干扰气流。

- Air grills must not be blocked with notes, pipettes or other materials, as this will disrupt the airflow causing potential contamination of the material and exposure of the operator.
不要使实验记录本、移液管以及其他物品阻挡空气格栅，因为这将干扰气体流动，引起物品的潜在污染和操作者的暴露。

- One person at a time should work in a BSC.
每次只能有一人在生物安全柜内进行操作。

- The BSC fan should be run for at least 5 min after completion of work in the BSC.
在生物安全柜内结束工作后，至少让风机继续运行5分钟。

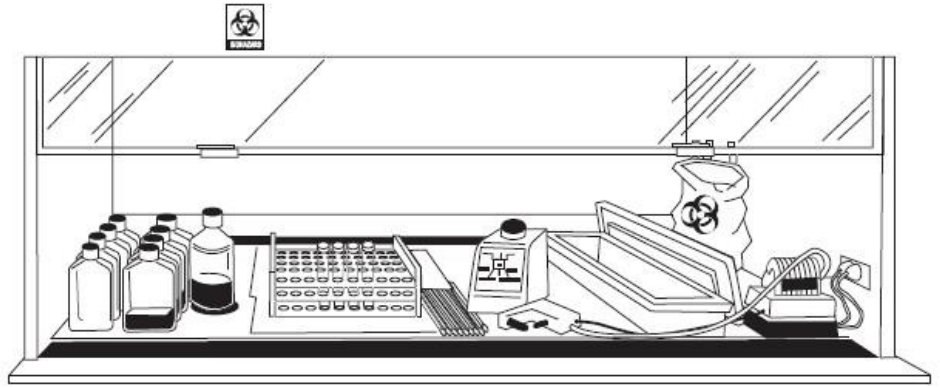


Figure 11. A typical layout for working “clean to dirty” within a Class II BSC. Clean cultures (left) can be inoculated (center); contaminated pipettes can be discarded in the shallow pan and other contaminated materials can be placed in the biohazard bag (right). This arrangement is reversed for left-handed persons.

这是一张展示如何在 II 级生物安全柜 (BSC) 中实现 "从洁到污"工作流程的标准布局图。洁净培养物置于左侧区域，可以在中央区域开展实验操作；使用过的、受污染的移液管等可放在右侧的生物危害垃圾桶中。
（图示中的布局适合惯用右手的操作人员；如操作人员惯用左手，则所有物品的位置应镜面对调）

GMPP -- Pipettes
GMPP —— 移液枪的使用

- To prevent the generation of aerosols, pipettes must not be used to blow air or forcibly expel liquids/solutions that contain biological agents.
为了防止气溶胶产生，移液枪不能用来吹空气或强制排出含有生物因子的液体/溶液。

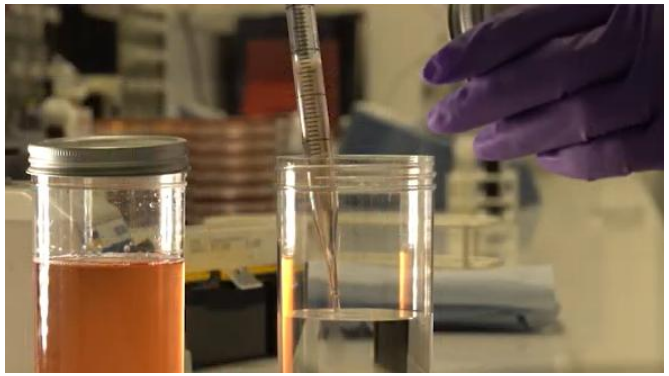
- Pipettes and/or the pipette tips should have cotton plugs to reduce contamination of pipetting devices.
移液器和/或移液器枪头应配有棉塞，以减少对移液装置的污染。

- To avoid further dispersion of any biological agents that might be dropped from a pipette tip, an absorbent material may be placed on the working surface and disposed of as infectious waste after use.
为了避免可能从移液枪头滴落的生物因子的进一步扩散，可以在工作台上放置吸收性材料，在使用后作为感染性废物处理。

- Contaminated pipettes or tips can be completely submerged in a suitable disinfectant in an unbreakable container.
受污染的移液器或枪头可以完全浸在盛有合适的消毒剂的不易碎的容器中。

- Pipette tips are normally autoclaved, but pipettes are unlikely to withstand the autoclaving process.
移液器枪头通常可以高压灭菌，但移液器不太可能承受高压灭菌过程。

Check pipette and filter for contamination
使用前检查移液器及其过滤器的污染情况



Draw up, transfer, and expel the liquid slowly
缓慢吸取和排出液体

GMPP -- Centrifuges
GMPP —— 离心机的使用

- All centrifuges must be operated and serviced according to manufacturers' instructions and serviced by appropriately qualified personnel.
离心机必须按照制造商的说明操作和使用，由有资质的人员进行维修。

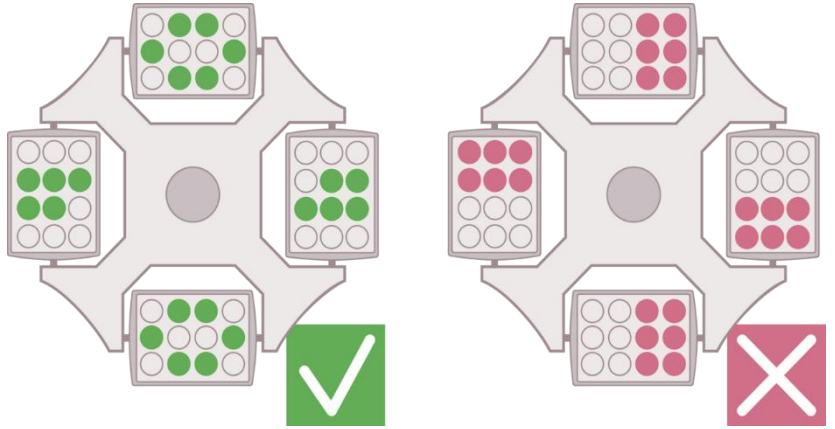
- Where safety buckets are available for a centrifuge, these must be used.
如果离心机有安全桶，则必须使用安全桶。

- Sealing rings for buckets must be checked regularly for integrity and replaced if cracks appear.
必须定期检查桶的密封圈是否完整，在出现裂纹时进行更换。

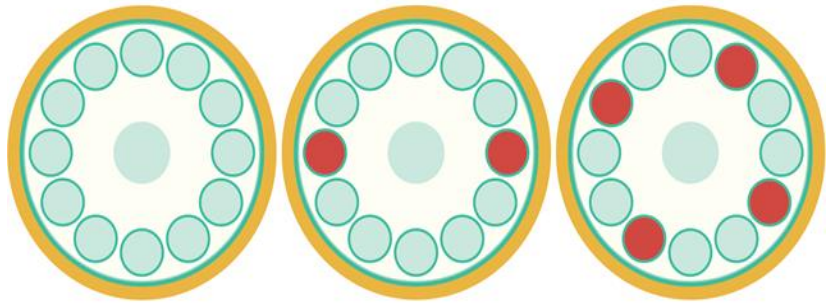
- When using centrifuges, the contents of centrifuge tubes must be filled to the same level and placed in the centrifuge at opposite locations to make sure the centrifuge is balanced during operation.
使用离心机时，必须将离心管的内容物填充到相同水平，并放置在离心机中相对的位置，确保离心机在运行过程中保持平衡。

- Centrifuges must be cleaned and disinfected regularly, or immediately decontaminated after a spill, with an appropriate disinfectant.
必须定期清洗和消毒离心机，或在泄漏后立即用合适的消毒剂去除污染。

- When using angle-head centrifuge rotors, care must be taken to ensure that the tube is not overloaded as it might leak.
使用固定角转子时，必须小心不能将离心管装得过满，否则可能会导致漏液。



Centrifuge Balancing Diagram
离心机配平示意图



GMPP -- Tissue grinders, Homogenizers, Shakers, Blenders and Sonicators
GMPP —— 组织研磨器、匀浆器、摇床、搅拌器和超声处理器的使用

◆ **Use of tissue grinders**
安全使用组织研磨器

- Glass grinders should be held in absorbent material in a gloved hand. Plastic (PTFE) grinders are safer.
拿玻璃研磨器时应戴上手套并用吸收性材料包住。塑料（聚四氟乙烯，polytetrafluoroethylene，PTFE）研磨器更加安全。

- Tissue grinders should be operated and opened in a biological safety cabinet.
操作和打开组织研磨器时应当在生物安全柜内进行。

◆ **Use of homogenizers, shakers, blenders and sonicators**
安全使用匀浆器、摇床、搅拌器和超声处理器

- Domestic (kitchen) homogenizers should not be used in laboratories as they may leak or release aerosols. Laboratory blenders and stomachers are safer.
实验室不能使用家用（厨房）匀浆器，因为它们可能泄漏或释放气溶胶。使用实验室专用搅拌器和消化器更为安全。

- Pressure builds up in the vessel during the operation of homogenizers, shakers and sonicators. Aerosols containing biological agents may escape from between the cap and the vessel. Plastic, in particular, polytetrafluoroethylene (PTFE) vessels are recommended because glass may break, releasing biological agents and possibly wounding the operator.
在使用匀浆器、摇床和超声处理器时，容器内会产生压力，含有生物因子的气溶胶就可能从盖子和容器间隙逸出。由于玻璃可能破碎而释放生物因子并伤害操作者，建议使用塑料容器，尤其是聚四氟乙烯（PTFE）容器。

- At the end of the operation the containers should be opened in a BSC.
操作结束后，应在生物安全柜内打开容器。

- Caps and cups or bottles should be in good condition and free from flaws or distortion. Caps should be well-fitting and gaskets should be in good condition.
盖子、杯子或瓶子应当保持正常状态，没有裂缝或变形。盖子应能封盖严密，衬垫也应处于正常状态。

GMPP -- Refrigerators and Freezers
GMPP —— 冰箱和冷藏设备的使用

- Refrigerators and freezers must be spark-proof if they are to store flammable solutions. Notices to this effect must be placed on the outside of the doors.
如果要用冰箱储存易燃液体，那么冰箱必须是防火花设计的。必须将相应标识贴在冰箱门外侧。

- All containers stored inside refrigerators and freezers must be clearly labelled so that they can be easily identified
所有储存在冷藏箱和冰柜内的容器都必须有清晰的标签，以方便识别。

- Unlabelled materials must be assumed to be infectious and must be decontaminated and discarded using appropriate waste channels.
必须假定未标记的材料具有感染性，使用适当的废物处理渠道去除污染并丢弃。

GMPP -- Cryogenic Liquids
GMPP —— 低温液体的使用

- Appropriate PPE must be worn when handling specimens from cryogenic storage, for example, thermal protective apron and gloves, as well as face and eye protection when placing specimens in or removing them from liquid nitrogen.
在处理低温储存的样本时，必须穿戴适当的PPE，例如防护围裙和手套，从液氮中取放标本时，必须保护面部和眼部。

- When storing, dispensing, or using cryogenic liquids (such as liquid nitrogen), operations should be performed in well-ventilated areas. Nearby doors may be left open during operation.
储存、分装和使用低温液体（比如液氮）时，应在通风良好的环境下进行，操作时可将附近的房门处于打开状态。

- When retrieving materials from Dewar flasks, never immerse cryogenic gloves in liquid nitrogen. Tools such as tongs may be used to handle items chilled by liquid nitrogen.
从杜瓦瓶中取样品时，切勿将低温手套伸进液氮中。可以借助其他工具，如钳子，来操作接触过液氮的物品。

- When returning materials to Dewar flasks, lower them slowly to minimize violent boiling and splashing caused by thermal shock. Simultaneously ensure secure positioning of the metal hook.
将样品放回杜瓦瓶中时，应缓慢将其放入，避免液氮飞溅溢出，确保金属钩牢固固定。

An acceptable use of a face shield to protect against cryogen splashes
防低温液体飞溅的面部防护示例

Cryogen gloves
低温防护手套

GMPP -- Cryovials
GMPP —— 冻存管的使用

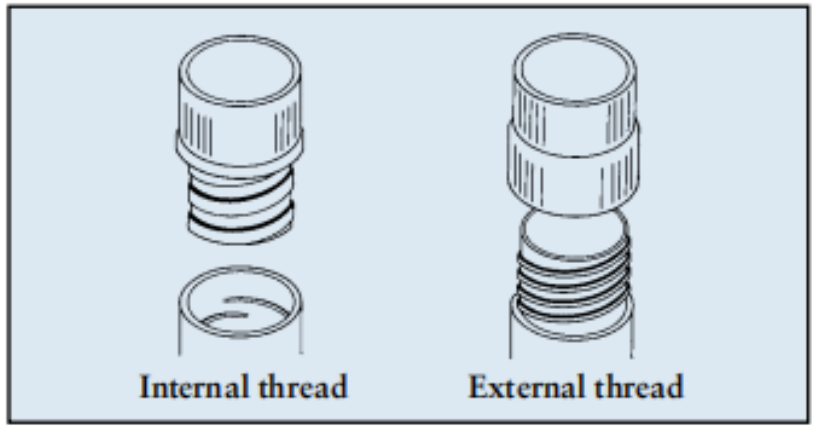
- Cryovials should not be overfilled, as this may increase the risk of cracking.
不要过度填充冻存管，这可能会增加冻存管破裂的风险。

- If at all possible, store cryovials in the vapor phase of liquid nitrogen freezers. Most manufacturers of cryovials do not recommend liquid-phase storage.
尽可能将冻存管至于液氮的气相中保存，市面上大多数的冻存管生产商并不推荐将

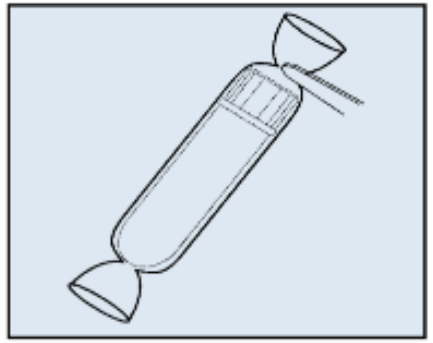
- Use cryovials with internal threads and male caps when possible.
尽可能选择内螺纹设计的冻存管。

- If cryovials are stored in the liquid phase of liquid nitrogen, using cryogenic heat shrink tubing to fully encase them is strongly recommended.
如果需要将冻存管至于液氮的液相中储存，推荐使用热封保护套将冻存管包起来。

- If it is necessary to immerse cryovials in the liquid phase of liquid nitrogen, they should be immediately placed into a sealed and unbreakable plastic container before thawing to prevent an explosion in case liquid nitrogen enters the cryovials; alternatively, the cryovials may be slowly transferred from the liquid phase to the gaseous phase of liquid nitrogen 24 to 48 hours before removal.
如果需要将无热封保护套的冻存管浸入液氮液相中，应在冻存管解冻前立即将其放入密封且不易碎的塑料容器中，以防液氮进入冻存管发生爆炸；或在取出冻存管前24至48小时将冻存管从液氮的液相缓慢转移至气相。



Internal vs. External vial thread design
内螺纹设计和外螺纹设计的冻存管示意图



cryogenic heat shrink tubing
冻存管热封保护套

GMPP -- Ampoules containing infectious materials
GMPP —— 装有感染性物质安瓿瓶的使用

- Ampoules containing infectious materials should never be immersed in liquid nitrogenbecause cracked or imperfectly sealed ampoules may break or explode on removal. If very low temperatures are required, ampoules should be stored only in the gaseous phase above the liquid nitrogen.
装有感染性物质的安瓿不能浸入液氮中，因为这样会造成有裂痕或密封不严的安瓿在取出时破碎或爆炸。如果需要低温保存，安瓿应当储存在液氮上面的气相中。

- Infectious materials should be stored in mechanical deep-freeze cabinets or on dry ice. Laboratory workers should wear eyes and hands protection when removing ampoules from cold storage.
感染性物质应储存在低温冰箱或干冰中。当从冷藏处取出安瓿时，实验室工作人员应当进行眼睛和手的防护。

- The outer surfaces of ampoules stored in these ways should be disinfected when the ampoules are removed from storage.
以上述方式储存的安瓿在取出时应对外表面进行消毒。

- Care should be taken when ampoules of freeze-dried materials are opened, as the contents may be under reduced pressure and the sudden inrush of air may disperse some of the materials into the atmosphere. Ampoules should always be opened in a BSC.
应该小心打开装有冻干物的安瓿，因为其内部可能处于负压，突然冲入的空气可能使一些物质扩散进入空气。安瓿应该在生物安全柜内打开。

GMPP -- Ampoules containing infectious materials
GMPP —— 装有感染性物质安瓿瓶的使用

◆ **Opening of ampoules containing lyophilized infectious materials:**
安全开启装有冻干感染性物质的安瓿：

1. First decontaminate the outer surface of the ampoule.
首先，应清除安瓿瓶外表面的污染。

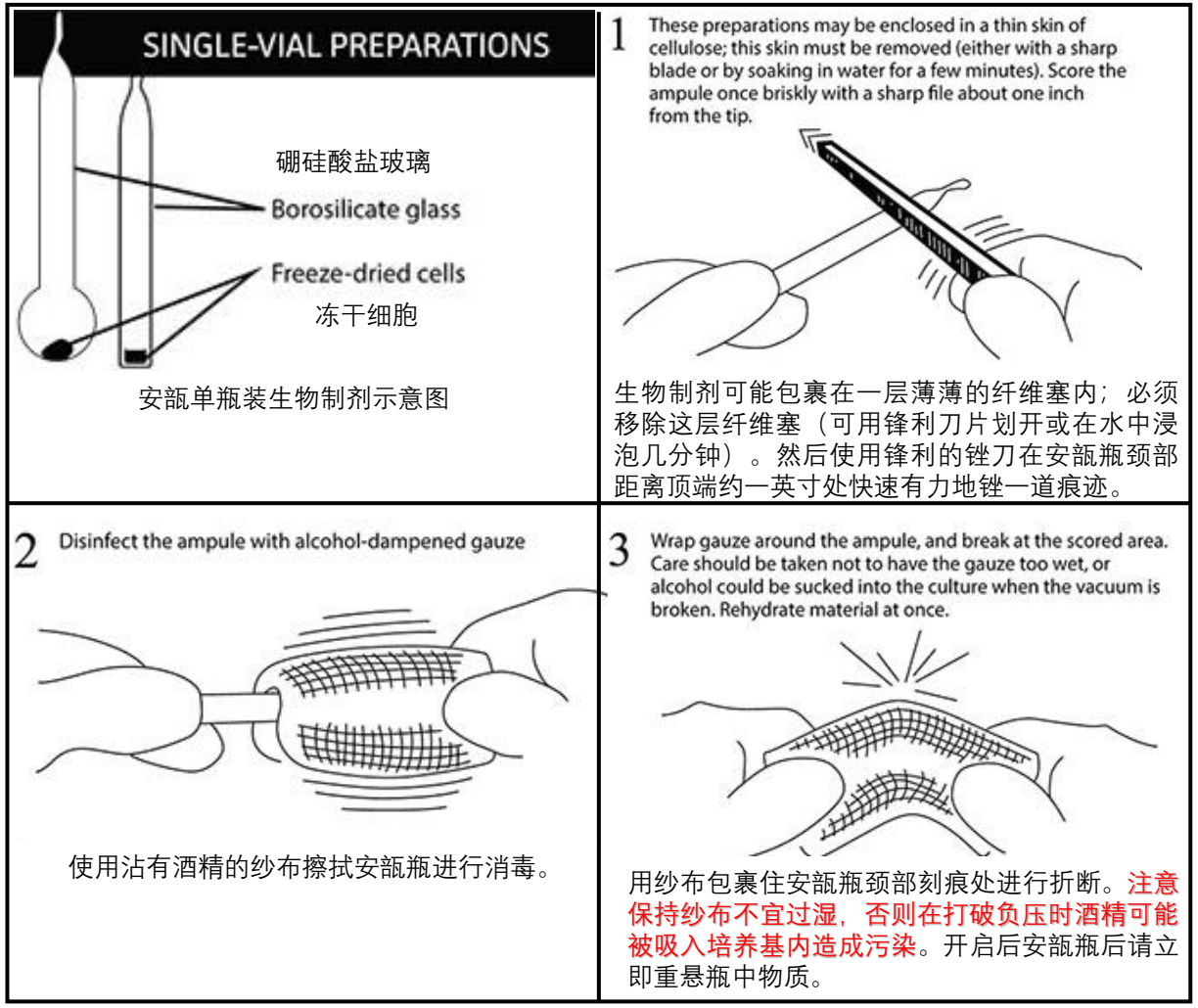
2. Make a file mark on the tube near to the middle of the cotton or cellulose plug, if present.
如果管内有棉花或纤维塞，可以在管上靠近棉花或纤维塞的中部锉一痕迹。

3. Hold the ampoule in alcohol-soaked cotton to protect hands before breaking it at a file scratch.
用一团酒精浸泡的棉花将安瓿包起来以保护双手，然后手持安瓿从标记的锉痕处打开。

4. Remove the top gently and treat as contaminated material.
将顶部小心移去并按污染材料处理。

5. If the plug is still above the contents of the ampoule, remove it with sterile forceps.
如果塞子仍然在安瓿上，用消毒镊子除去。

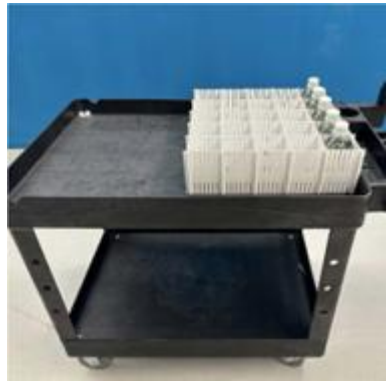
6. Add liquid for resuspension slowly to the ampoule to avoid frothing.
缓慢向安瓿中加入液体来重悬冻干物，避免出现泡沫。



GMPP -- Transfer and Transportation
GMPP —— 生物因子的转移

◆ **Transfer within the laboratory :**
在实验室内转移：

Moving biological agents within the laboratory, for example, from a BSC to an incubator, should be undertaken following GMPP to prevent incidents of cross contamination and inadvertent spillage.
在实验室内转移生物因子，例如从BSC到培养箱，应该遵循相关的GMPP，以防止交叉污染和意外溢洒事件。



- Use sealed containers, such as screw-capped tubes. Snap-cap lids should be avoided as they are less secure.
使用密封容器，如带螺旋盖的试管。应避免使用卡扣盖，因为其不够安全。

- Use deep-sided and leak-proof trays or boxes made of smooth impervious material (for example, plastic or metal), which can be effectively cleaned and disinfected. Locking plastic containers and storage containers are an option.
使用可以有效清洁和消毒的、由光滑防渗漏的材料（例如塑料或金属）制成的深边防漏托盘或盒子。也可以选择可锁闭的塑料容器和存储容器。

GMPP -- Transfer and Transportation
GMPP —— 生物因子的转移

◆ **Transfer within the laboratory :**
在实验室内转移：

- If using racks, vials or tubes, trolleys can be used for more stable transport, as they are less likely to result in multiple spillages if a personnel trips or falls.
如果使用支架、小瓶或试管，为了更稳定的运输，可以使用手推车，因为如果人员绊倒或跌倒，手推车不太可能导致多个容器溢洒。

- If using trolleys, ensure they are loaded so that substances cannot fall off, for example, by securing the load or using some form of guard rail or raised sides.
如果使用手推车，应确保装载方式可以防止物品掉落，例如，固定负载物、使用某种形式的护栏或将四周加高。

- Make sure spill kits are readily available for use in the event of a spillage during transfer.
转移过程中发生溢洒时，确保可以随时使用溢洒处理工具包。

GMPP -- Transfer and Transportation
GMPP —— 生物因子的转移

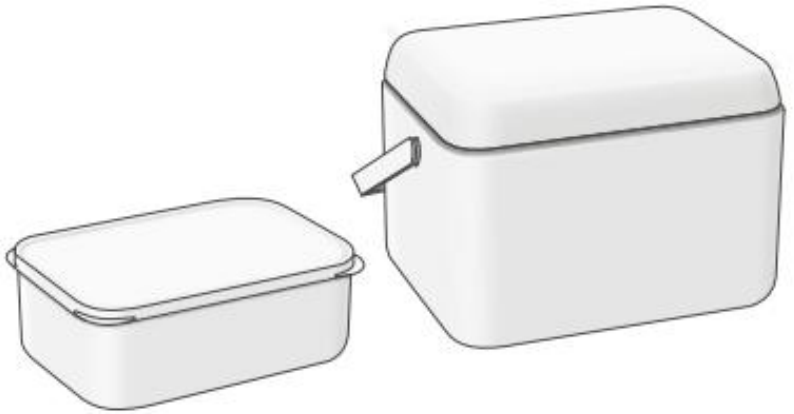
◆ **Transfer within a building :**
在同一楼栋内转移：

- Transfer containers must be suitably labelled to identify their contents, and surfaces decontaminated before leaving the laboratory. Biohazard symbols should be used on containers as a heightened control measure, if the biological agent being handled is associated with a higher likelihood of infection.
为了方便识别内容物，转移容器必须贴有适当的标签，离开实验室前应对容器表面进行消毒。如果转移的生物因子具有较高的感染性，则应在容器上使用生物危害标识作为强化控制措施。

- Sealable plastic bags, plastic screw-top tubes and locking plastic containers can all be used in the transfer of biological aigents between buildings.
可密封塑料袋、带螺旋盖的塑料管和可锁闭的塑料容器均可用于在建筑物之间转移生物因子。

- Absorbent materials should be used between layers of packaging to absorb all biological agents, if there were leakage.
如果有渗漏，应在包装层之间使用吸附性材料吸收所有生物因子。

- A plastic box or small plastic ice chest is one option for the transport of infectious substances between buildings on the same site, as they are secure and easily decontaminated.
在同一楼栋内运输生物因子，可以选择塑料箱或小型塑料冷藏箱，因为它们比较安全且容易去污。



Containers for transfer of biological agents between buildings on the same site
同一楼栋内转移生物因子的可用容器

GMPP -- Transfer and Transportation
GMPP —— 生物因子的转移

- **Triple packaging of infectious materials :**
  感染性物质的三层包装：

Using redundant layers of packaging is a common method for controlling any leakage or breach of containment of an infectious substance to reduce the likelihood of exposure and/or release during transport.
使用冗余包装是控制感染性物质泄漏或防止包装破坏的常用方法，以减少转移过程中暴露和/或泄漏的可能性。

Primary receptacle
主容器
Watertight, leak-proof or siftproof receptical wrapped in absorbent material
防水、防渗漏或防筛漏容器，用吸附性材料包裹

Secondary packaging
辅助容器
Watertight, leak-proof packaging
防水、防渗漏或防筛漏容器

Third layer
第三层包装
Protective packaging
最外层的保护性包装

Example of triple packaging for infectious materials
感染性物质三层包装示例图

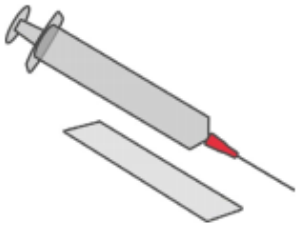
Waste Management
废弃物管理

During laboratory activities, different contaminated materials and liquids will be generated. A large part of those materials will be disposed of as waste. A large part of those materials will be disposed of as waste. The overriding principle is that all contaminated materials or liquids leaving the laboratory should either be treated onsite to allow further safe handling.
实验室活动会产生不同的受污染材料和液体，这些材料的很大一部分将作为废弃物处理。废弃物管理的首要原则是，离开实验室的所有受污染材料或液体应在实验室内进行处理，以便安全开展进一步的处置。

Examples of waste generated in laboratories 实验室产生的废物举例	
Sharp Wastes 利器废弃物	Needles, broken glass, slides and cover slips, syringes, scalpels 针头、碎玻璃、载玻片和盖玻片、注射器、解剖刀
Solid Biological Wastes 固态生物废弃物	Pipette tips, petri dishes, flasks, tubes, gloves 移液枪头、培养皿、烧瓶、离心管、手套
Liquid Biological Wastes 液态生物废弃物	Cell culture media/broth, blood, bodily fluids, animal blood 细胞培养基、血液、体液、动物血液
Chemical Waste 化学废弃物	Fixatives; formaldehyde, xylene, toluene, methanol, methylene chloride and other solvents 固定剂；甲醛、二甲苯、甲苯、甲醇、二氯甲烷等溶剂
Non-hazardous or General Waste 无特殊危害的废弃物	Uncontaminated packaging, paper, plastic containers 未经污染的包装、纸、塑料容器
Note: For the classification requirements of laboratory waste, please refer to *HKUST(GZ) Hazardous Waste Management* and the university's orientation course *Hazardous Waste Management*. 注：如果您需要详细了解学校关于实验室废弃物分类的要求，可查阅《香港科技大学（广州）危险废物管理暂行办法》和学校的准入培训课程《危险废物管理》	

Some Laboratory-Generated Waste Disposal Flowchart
部分实验室废弃物处理流程图

Sharp Wastes
利器废弃物



Sharps bin
利器盒

Medical waste temporary storage room
转移至医疗废物暂存间

Solid Biological Wastes
固态生物废弃物

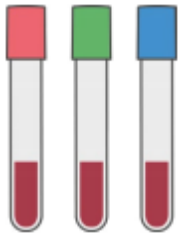
Medical waste bag
装入医疗废物垃圾袋待高压灭菌

Autoclave
高压灭菌

Medical waste temporary storage room
灭菌后转移至医疗废物暂存间

Some Laboratory-Generated Waste Disposal Flowchart
部分实验室废弃物处理流程图

Blood, serum, secretions, etc
血液、血清、分泌物等

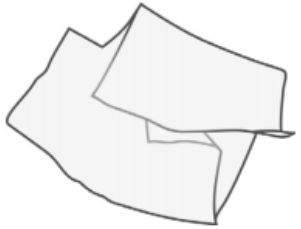


Medical waste bag
装入医疗废物垃圾袋待高压灭菌

Autoclave
高压灭菌

Medical waste temporary storage room
灭菌后转移至医疗废物暂存间

Non-hazardous or General Waste
无特殊危害的废弃物



General waste bin
生活垃圾桶

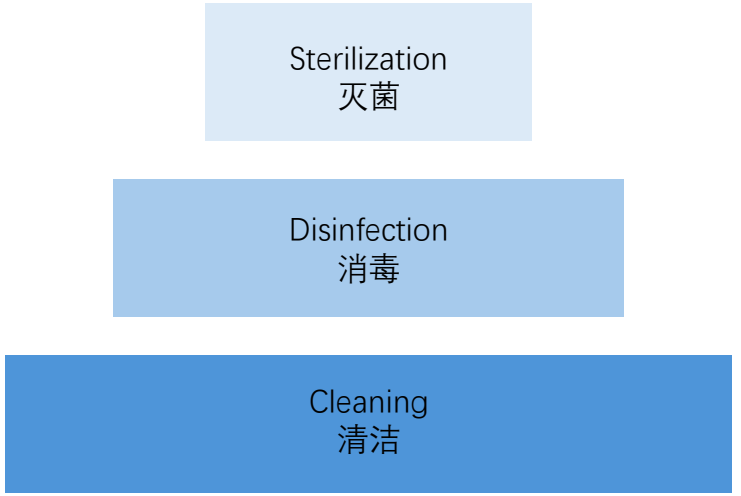
Decontamination
清除污染

Depending on the level of decontamination that needs to be achieved, processes such as cleaning, disinfection or sterilization can be used.
我们可以根据需要达到的清除污染水平，选择使用清洁、消毒或灭菌等方式来清除实验室污染。

- **Sterilization**
  灭菌
  A process that eliminates or destroys all forms of microbial life on laboratory instruments, apparatuses, and materials.
  杀灭或清除实验器械、器具和物品上一切微生物的处理。

- **Disinfection**
  消毒
  The process of eliminating or killing pathogenic microorganisms on environmental surfaces/media, rendering them non-infectious.
  清除或杀灭传播媒介上病原微生物，使其达到无害化的处理。

- **Cleaning**
  清洁
  The process of removing organic matter, inorganic matter, and visible soils from object surfaces.
  去除物体表面有机物、无机物和可见污染物的过程。



Levels of decontamination
清除污染的水平示意图

Decontamination -- Cleaning
清除污染的方式 —— 清洁

Cleaning, in general, is the removal of any matter from an item that is not part of the item itself. Cleaning in the context of laboratory biosafety has two functions:
一般来说，清洁是指去除不属于物品本身的任何物质。在实验室生物安全范围内的清洁有两个功能：

1. It can remove dirt and organic matter from an item that would inactivate chemical disinfectants or impede them making contact with biological agents within the item.
   它可以清除物品上的污垢和有机物，防止污垢和有机物使化学消毒剂失去活性或阻碍它们与物品内的生物因子接触。

2. It can remove a high proportion of biological agents, making reduction to safe levels by subsequent chemical disinfection more effective.
   清除大部分生物因子，通过随后的化学消毒更有效地将其降低到安全水平。

- Cleaning includes brushing, vacuuming, dry dusting, washing or damp mopping preferably with warm water. Using a laboratory dishwasher is also a cleaning method.
  清洁方法包括刷洗、吸尘、干法除尘、洗涤或湿拖，最好用温水。使用实验室洗瓶机也是一种清洁方法。

- The addition of cleaning agents (surfactant that lowers surface tension, detergent) increases the effectiveness of cleaning.
  添加清洁剂(降低表面张力的表面活性剂、清洁剂)可提高清洁效果。

- Examples of common cleaning agents include soda solution (3 kg sodium carbonate (Na2CO3) per 100 L of hot water), soap solution (3 kg soap per 100 L of hot water) or commercial preparations.
  常用清洁剂包括苏打溶液（每100L热水中含3kg碳酸钠（Na2CO3）、肥皂溶液（每100L热水中含3kg肥皂）或市面上售卖的其他清洁剂。

Decontamination -- Hand hygiene
清除污染的方式 —— 手卫生

While suitable gloves provide the wearer with a high degree of protection, they do not give complete protection and hands must be washed after gloves are removed.
虽然合适的手套为佩戴者提供了高度的保护，但它们并不能提供完全的保护，必须在取下手套后洗手。

◆ **Handwashing**
洗手

A short (about 20 seconds) but thorough handwash with soap and running water will efficiently remove laboratory-acquired contamination.
用肥皂和自来水进行短时间（约20秒）但彻底的洗手可有效去除实验室获得的污染物。

- Hands should be washed in running water.
  应使用自来水洗手。
- A hands free method (infrared-operated switch, or foot, knee or elbow operated tap/faucet) is an advantage.
  非手触式开关（红外操作开关、或用脚、膝或肘操作水龙头）更值得推荐。
- If taps/faucets need to be turned on and off by hand, a clean paper towel should be used to turn them off. Hands should be dried with single-use paper towels and the towels should properly discarded after use in a designated waste bin.
  如果需要用手打开和关闭水龙头，应使用干净的一次性擦手纸将其关闭，擦手纸使用后应妥善丢弃在指定的垃圾箱中。

Handwashing -- recommended procedure
洗手的推荐流程

1.

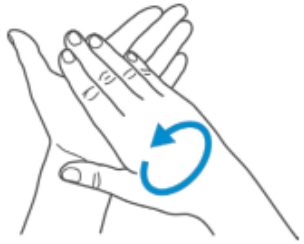
Apply soap to one hand.

将肥皂涂在一只手上

2.

Wet the other hand using a hands-free tap or use a paper towel to turn a standard tap on and off.

打开非手触式龙头打湿另一只手，如龙头为手触式，可以用纸巾包住手来打开水龙头



3.

Rub hands, palm to palm.

If jewellery cannot be removed during laboratory work, it should be cleaned thoroughly when washing hands.

掌心相对摩擦

如果首饰在工作时未被摘除，应一起被清洗

4.

Right palm over back of left hand with interlaced fingers and vice versa.

右手掌置于左手背上方，手指交错，反之亦然

5.

Palm to palm with fingers interlaced.

手掌对手掌，手指交错

6.

Backs of fingers to opposing palms with fingers interlocked.

指背对掌，手指互锁

7.

Rotational rubbing of left thumb clasped in right palm and vice versa.

左手拇指紧握在右手掌中旋转摩擦，反之亦然

8.

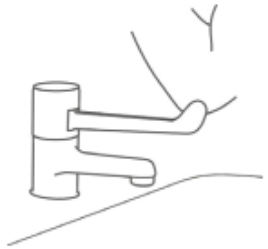
Rotational rubbing, backwards and forwards with clasped fingers of right hand in left palm and vice versa.

用右手紧握的手指在左手掌上前后旋转摩擦，反之亦然

9.

Rinse hands with water.

用水冲洗手



10.

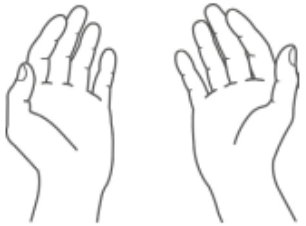
Use elbow to turn off hands-free taps or use a paper towel for standard taps to avoid direct contact between the tap and your hand.

关闭水龙头，如龙头为手触式，可以使用纸巾包住手，避免双手接触龙头

11.

Dry hands thoroughly with a single-use towel and dispose of the towel in the appropriate waste bin.

用一次性擦手纸彻底擦干双手



12.

Hands are clean.

双手已洗干净

Decontamination -- Hand hygiene
清除污染的方式 —— 手卫生

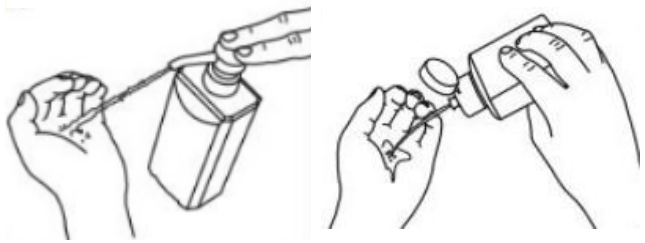
◆ **Alcohol hand rub**
酒精手消

Alcohols (ethanol, propanol or isopropanol) at concentrations between 60% and 95% applied to the hands and rubbed to dryness can be effective in removing microbial contamination acquired during laboratory work.
将浓度为60%至95%的醇类（乙醇、丙醇或异丙醇）涂抹在手上并摩擦至干燥，可有效去除实验室工作中获得的微生物污染。

- Alcohols are poor at penetrating proteins or protein-containing matter, so they should only be used on visibly clean hands.
  醇类对于蛋白质或含有蛋白质的物质的穿透力很弱，因此应仅在明显清洁无污染的手上使用。
- Alcohols have no activity against spores and poor activity against non-enveloped viruses; if hand contamination with these biological agents is likely, handwashing should be used instead of alcohol hand rubs.
  醇类对芽孢无活性，对无包膜病毒活性差；如果双手可能被这些生物因子污染，应该洗手而不是用含醇消毒剂手消。

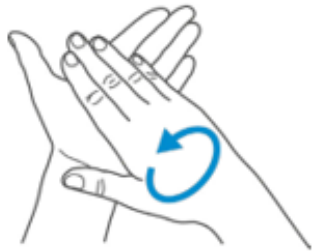
Alcohol hand rub -- recommended procedure
酒精手消的推荐流程

1.



Take adequate alcohol-based handrub with a cupped hand.
取足量醇类消毒洗手液。

2.



Rub hands, palm to palm.
掌心相对摩擦。

3.

Right palm over back of left hand with interlaced fingers and vice versa.
右手掌置于左手背上方，手指交错，反之亦然。

4.

Palm to palm with fingers interlaced.
手掌对手掌，手指交错。

5.

Backs of fingers to opposing palms with fingers interlocked
指背对掌，手指互锁。

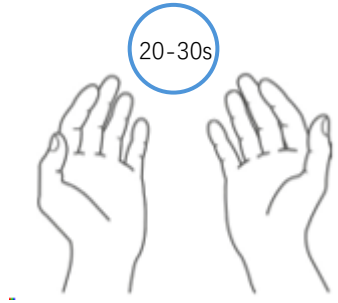
6.

Rotational rubbing of left thrumb clasped in right palm and vice versa.
左手拇指紧握在右手掌中旋转摩擦，反之亦然。

7.

Rotational rubbing, backwards and forwards with clasped fingers of right hand in left palm and viece versa.
用右手紧握的手指在左手掌上前后旋转摩擦，反之亦然。

8.



Once dry, your hands are clean.
待消毒液干透，双手就干净了。

Decontamination -- Disinfection
清除污染的方式 —— 消毒

According to the *Hygiene Standard for Disinfection in Hospitals* (GB 15982), China categorizes disinfection processes into three levels—high-level, intermediate-level, and low-level disinfection.
根据国标《医院消毒卫生标准》（GB 15982），我国将消毒分为了高水平消毒、中水平消毒和低水平消毒三个等级。

- **High level disinfection**
  高水平消毒
  A process that kills all bacterial propagules (including mycobacteria), viruses, fungi and their spores, as well as the vast majority of bacterial endospores.
  杀灭一切细菌繁殖体包括分枝杆菌、病毒、真菌及其孢子和绝大多数细菌芽孢。
- **Middle level disinfection**
  中水平消毒
  A process that kills various pathogenic microorganisms (including mycobacteria) but excluding bacterial endospores.
  杀灭除细菌芽孢以外的各种病原微生物包括分枝杆菌。
- **Low level disinfection**
  低水平消毒
  A process involving chemical methods that kill bacterial propagules (except mycobacteria) and enveloped viruses, along with mechanical microbial removal techniques such as ventilation and rinsing.
  能杀灭细菌繁殖体（分枝杆菌除外）和亲脂病毒的化学消毒方法以及通风换气、冲洗等机械除菌法。

Disinfection 消毒剂	Bacterial endospores 细菌芽孢	Mycobacteria 分枝杆菌	Non-enveloped and small-sized viruses 无包膜和小型病毒	Fungi (Fruitingbody and fungal spores) 真菌（繁殖体和真菌孢子）	Bacterial propagules 细菌繁殖体	Enveloped viruses 包膜病毒
High level disinfection 高水平消毒	○	√	√	√	√	√
Middle level disinfection 中水平消毒	×	√	○	○	√	√
Low level disinfection 低水平消毒	×	×	×	○	√	√

The symbol "√" indicates that the disinfectant is typically capable of inactivating such microorganisms; "○" signifies efficacy may be contingent upon the formulation and active ingredients; "×" denotes the agent is generally ineffective against these pathogens.
"√"代表该类消毒剂通常能杀灭此类微生物；"○"代表消毒剂能否杀灭该类微生物可能与消毒剂组分和有效成分有关；"×"代表该类消毒剂通常对此类微生物无效。

Decontamination -- Disinfection
清除污染的方式 —— 消毒

Microbial Resistance to Disinfectants and Sterilants 微生物对消毒、灭菌剂抗性一览表		
Categories of Microorganisms 微生物类型	Example 类型举例	Resistance 抗性高低
Prions 朊病毒	/	High 最高抗性
Bacterial endospores 细菌芽孢	Geobacillus stearothermophilus, Bacillus cereus, Clostridioides difficile 嗜热脂肪土壤芽孢杆菌、蜡样芽孢杆菌、艰难拟梭菌（艰难梭菌）	
Protozoan Parasites and Helminths (Infective Stages) 原虫和寄生蠕虫（休眠形态）	Cryptosporidium parvum oocysts, Giardia duodenalis cysts, Enterobius vermicularis eggs 隐孢子虫（虫卵囊）、贾第虫（包囊）、蛲虫（虫卵）	
Mycobacteria 分枝杆菌	Mycobacterium tuberculosis complex 结核分枝杆菌	
Non-enveloped viruses 非包膜病毒	Parvoviruses, Human Papillomaviruses (HPVs) 细小病毒、乳头瘤病毒（HPVs）	
Fungi (resting body) 真菌（休眠形式）	Aspergillus spores 曲霉孢子	
Gram-negative bacteria 革兰阴性菌	Escherichia coli, Pseudomonad 大肠埃希菌、假单胞菌	
Fungi (fruitingbody) 真菌（繁殖体）	Mold (Trichophyton，Penicillium), Saccharomyces (Candida albicans) 霉菌（毛癣菌、青霉菌）、酵母菌（白念珠菌）	
Gram-positive bacteria 革兰阳性菌	Streptococcus, Staphylococcus 链球菌、葡萄球菌	Low 最低抗性
Enveloped viruses 包膜病毒	Influenza viruses 流感病毒	

Decontamination -- Disinfection
清除污染的方式 —— 消毒

◆ **Fundamental Principles of Disinfection and Sterilization**
消毒和灭菌的基本原则

1. **The appropriate level of disinfection or sterilization shall be determined based on the potential infection risk posed by contaminated items.**
应评估物品污染后感染风险的高低选择相应的消毒、灭菌方法。

   Items posing high infection risk shall undergo sterilization; those with moderate infection risk require at least intermediate-to-high level disinfection.
   感染风险高的，应采用灭菌方法处理污染；感染风险中等的，应采用达到中水平消毒以上的效果的消毒方法处理。

2. **Selection of disinfection or sterilization methods must be based on the category and bioburden level of contaminating microorganisms.**
应根据物品上污染微生物的种类、数量选择消毒、灭菌方法。

   a) Due to differential microbial resist patterns, verification of disinfectant efficacy against specific contaminating microorganisms is imperative.
   不同种类的微生物对消毒剂的抗性是有差异的，因此应确保使用的消毒剂对污染微生物是有效的。

Decontamination -- Disinfection
清除污染的方式 —— 消毒

◆ **Fundamental Principles of Disinfection and Sterilization (Continue)**
消毒和灭菌的基本原则（接上一页）

2. Selection of disinfection or sterilization methods must be based on the category and bioburden level of contaminating microorganisms.
应根据物品上污染微生物的种类、数量选择消毒、灭菌方法。

b) Items contaminated with pathogenic bacterial spores, fungal spores, mycobacteria, or bloodborne pathogens (e.g., HBV, HCV, HIV) shall undergo high-level disinfection such as chlorine-based disinfectants or sterilization.
对受到致病菌芽孢、真菌孢子、分枝杆菌和经血传播病原体（如乙型肝炎病毒、丙型肝炎病毒、艾滋病病毒等）污染的物品，应采用高水平消毒（如使用含氯消毒剂等进行消毒）或灭菌。

c) Items contaminated with fungal agents, hydrophilic viruses, spirochetes, mycoplasma, chlamydia or similar pathogenic microorganisms require disinfection achieving at minimum intermediate-level efficacy.
对受到真菌、亲水病毒、螺旋体、支原体、衣原体等病原微生物污染的物品，应采用中水平以上的消毒方法。

Decontamination -- Disinfection
清除污染的方式 —— 消毒

◆ **Fundamental Principles of Disinfection and Sterilization (Continue)**
消毒和灭菌的基本原则（接上一页）

2. Selection of disinfection or sterilization methods must be based on the category and bioburden level of contaminating microorganisms.
应根据物品上污染微生物的种类、数量选择消毒、灭菌方法。

d) Items contaminated with bacteria or enveloped viruses (excluding bloodborne pathogens such as HBV and HIV) shall undergo low-to-intermediate level disinfection.
对受到一般细菌和亲脂病毒（除经血传播的亲脂病毒，如乙型肝炎病毒、艾滋病病毒等）等污染的物品，应采用达到中水平或低水平的消毒方法。

e) When inactivating microorganisms shielded by organic material, the applied disinfectant concentration shall be increased and/or contact time.
杀灭被有机物保护的微生物时，应加大消毒剂的使用剂量和（或）延长消毒时间。

f) When microbial contamination on disinfected items is particularly severe, the dosage of disinfectant should be increased and/or the disinfection time extended.
消毒物品上微生物污染特别严重时，应加大消毒剂的使用剂量和（或）延长消毒时间。

Decontamination -- Disinfection
清除污染的方式 —— 消毒

◆ **Fundamental Principles of Disinfection and Sterilization (Continue)**
消毒和灭菌的基本原则（接上一页）

3. **Disinfection or sterilization methods should be selected based on the nature/properties of the items.**
应根据物品的性质选择消毒、灭菌方法。

a) Moisture- and heat-resistant instruments, utensils, and items should undergo autoclaving (pressure steam sterilization) as the first-line method.For heat-stable oil-based preparations, dry powders, or similar substances, dry heat sterilization may be used.
耐湿、耐热的器械、器具和物品，应首选压力蒸汽灭菌处理；耐热的油剂类和干粉类等物体可采用干热灭菌的方法处理。

b) Items that are not heat- or moisture-tolerant should undergo low-temperature sterilization methods, such as ethylene oxide (ETO) sterilization.
不耐热、不耐湿的物品，宜采用低温灭菌方法如环氧乙烷灭菌等方法处理。

Decontamination -- Disinfection
清除污染的方式 —— 消毒

◆ **Fundamental Principles of Disinfection and Sterilization (Continue)**
消毒和灭菌的基本原则（接上一页）

3. **Disinfection or sterilization methods should be selected based on the nature/properties of the items.**
应根据物品的性质选择消毒、灭菌方法。

   c) For surface disinfection, the nature of the material must be considered. Smooth surfaces should be disinfected using an appropriate disinfectant wipe or close-range irradiation with a UV-C device. Porous material surfaces should undergo immersion or spray disinfection methods.
   物体表面消毒，应考虑其表面性质，光滑表面宜选择合适的消毒剂擦拭或紫外线消毒器近距离照射消毒；多孔材料表面宜采用浸泡或喷雾消毒法处理。

4. **Risks associated with different disinfection and sterilization methods must be assessed, and appropriate risk control measures implemented.**
应评估不同的消毒、灭菌方法带来的风险，并采取适宜的风险控制措施。

Ultraviolet Disinfection
紫外线消毒

- Three ranges:
  紫外线根据波长的不同，分为三类：
  1. UV-A: 315 - 400nm
  2. UV-B: 280 - 315 nm
  3. UV-C: 100 - 280nm

- Most effective for killing or inactivating microbes is UV-C, with 260 nm being the best.
  波长为260nm的C波段紫外线（UV-C）的杀菌/使微生物失活的效力最强

- Applying UV-C for control of microbes aka Ultraviolet Germicidal Irradiation (UVGI).
  应用短波紫外线（UV-C）杀灭微生物的技术称为紫外杀菌辐照（UVGI）。

- UVGI kills or inactivates microbes by damaging their DNA.
  紫外杀菌辐照（UVGI）通过破坏微生物的脱氧核糖核酸（DNA），实现其杀灭或不可逆失活。

◆ **Applications**
紫外线消毒的应用

1. Healthcare
   医疗领域
2. Commercial buildings
   商业建筑
3. Residential
   住宅
4. Laboratories
   实验室
5. Pharmaceutical
   制药领域
6. Food industry
   食品工业领域

Ultraviolet Disinfection
紫外线消毒

◆ Advantages of UV
紫外线消毒技术的优点

- Proven technology for effective killing of microbes, in use for decades for air and surface sterilization in hospital & laboratories.
  紫外线消毒技术是经证实可有效杀灭微生物的技术，已在医院和实验室场景下应用于空气和物体表面消毒数十年。

- No airflow resistance (unlike HEPA filter) .
  紫外线消毒不需要考虑气流影响（与HEPA高效过滤器不同）。

- Can be a good substitute to chemical disinfectants, to avoid fumigation, soaking or wiping.
  可以作为化学消毒剂的良好替代，避免熏蒸、浸泡或擦拭。

- A physical agent, will not disperse like chemical disinfectants, therefore more controllable and pose less risk to human if properly isolated.
  相比化学消毒剂，紫外线消毒作为物理消毒更容易控制（更难扩散），如果隔离措施得当，对人员的风险会更小。

Ultraviolet Disinfection
紫外线消毒

◆ Disadvantages of UV
紫外线消毒技术的缺点

- Variable effectiveness for different microbes, may need to couple with other disinfecting agent.
  对不同微生物的杀灭效果不一，可能需要与其他消毒剂配合使用。

- To be effectively killed by UV-C, germs must be irradiated directly.
  要被UV-C有效杀灭，微生物必须受到直接照射。

- Lamp soiling and aging: Dust can accumulate on UV lamp, usage also decreases lamp efficiency.
  灯管污垢和老化：灰尘会积聚在紫外线灯管上，会降低紫外灯管的消毒效率。

- Adverse health effect: exposure to UV rays can burn skin and eyes.
  对健康的不良影响：暴露于紫外线会灼伤皮肤和眼睛。

- Material deterioration, VOC off-gasing under prolonged UV irradiation.
  材料劣化，在长时间紫外线照射下释放挥发性有机化合物（VOC）。

Chemical disinfection
化学消毒剂

- The activity of the chemical disinfectant against the biological agent being handled in the laboratory is the first factor to consider when selecting a chemical disinfectant.
  选择化学消毒剂时，首先要考虑化学消毒剂对实验室所处理的生物因子的活性。

- Spores and prions require a more rigorous decontamination process before disposal.
  孢子和朊病毒在处置前需要更严格的清除污染过程。

- The organic load (amount of organic matter mixed with the biological agents) must be considered because most chemical disinfectants, including hypochlorites, are inactivated by organic matter.
  必须考虑有机负荷(与生物因子混合的有机物量)，因为大多数化学消毒剂(包括次氯酸盐)都能被有机物灭活。

- Before the chemical disinfection of any solution, the other chemicals in the liquid must be taken into account in order to avoid the adverse effects of mixing incompatible chemicals.
  在对任何溶液进行化学消毒之前，必须考虑液体中的其他化学品，以避免混合不相容的化学品产生不良影响。

Chemical disinfection
化学消毒剂

Overview of Active Levels of Chemical Disinfectants 化学消毒剂活性水平一览		
Disinfectant 消毒剂名称	Recommended Dilution Ratio or Concentration for Activity 具有活性应有的稀释比例或浓度	Activity Level 活性水平
Peracetic acid 过氧乙酸	0.20%	High level 高水平
Phthalate 邻苯二甲醛	0.50%	High level 高水平
Formaldehyde 甲醛	1% ~ 8%	High level 高水平
Quaternary ammonium compounds 季铵盐类消毒剂	Type containing alcohol 含酒精	High level 高水平
Chlorine compounds 含氯消毒液	500–10000 mg/L, adjust pH to 7 500 ~ 10000mg/L，pH调节至7	Middle level -- High level, effective against bacterial spores 中水平-高水平，可有效杀灭芽孢
Hydrogen peroxide 过氧化氢	3% ~ 6%	Middle level -- High level 中水平-高水平
Glutaraldehyde 戊二醛	Variable 可变	Middle level -- High level 中水平-高水平
Alcohols 醇类消毒剂	70% ~ 80%	Middle level 中水平
	0.5% ~ 3%	Low level -- Middle level 低水平-中水平
Iodine compounds 碘化合物	30–50 mg/L free iodine; available iodine up to 10000 mg 30 ~ 50mg/L游离碘；有效碘可达10000mg	Low level -- Middle level 低水平-中水平
Quaternary ammonium compounds 季铵盐类消毒剂	0.1% ~ 0.2% (1000 ~ 2000mg/L)	Low level 低水平

Disinfectant -- Chlorine compounds
化学消毒剂 —— 含氯化合物

- Hypochlorites are chlorine-based disinfectants but the active component is oxygen loosely bound to chlorine; this oxygen is readily lost to become available to oxidize other compounds.
  次氯酸盐是基于氯的消毒剂，但活性成分是与氯松散结合的氧；这种氧容易损失而可用于氧化其它化合物。

- These disinfectants are solutions with a variety of components in equilibrium but the most active chemical species are usually sodium hypochlorite (NaOCl), the hypochlorous ion (OCl–) and hypochlorous acid (HOCl) .
  这些消毒剂是含有各种平衡组分的溶液，但最活跃的化学物质通常是次氯酸钠(NaOCl)、次氯酸离子(OCl–)和次氯酸(HOCl)。

- The oxidizing capacity of hypochlorite solutions is expressed as either percentage of available chlorine, or parts per million of available chlorine (ppm av Cl).
  次氯酸盐溶液的氧化能力通常用有效氯的百分比或有效氯的百万分之一(ppm av Cl)表示。

- There can be uncertainty about the available chlorine content of chlorine-based disinfectants because liquid hypochlorites decay on storage.
  含氯消毒剂的有效氯含量存在不确定性，因为液体次氯酸盐在储存时会衰变。

Disinfectant -- Chlorine compounds
化学消毒剂 —— 含氯化合物

- The speed of that decay depends on storage conditions, mainly temperature.
  衰变的速度取决于储存条件，主要是温度。

- Chlorine-based disinfectants should be prepared immediately before use.
  含氯消毒剂应现配现用。

- The combination of formaldehyde solutions and sodium hypochlorite generates a mix of toxic gases, including hydrochloric acid, chlorine and formic acid.
  甲醛溶液和次氯酸钠的组合会产生多种有毒气体，包括盐酸、氯气和甲酸。

- The combination of ethanol and solutions containing sodium hypochlorite generates chloroform.
  乙醇与含次氯酸钠的溶液混合生成氯仿。

- Mixing of a solution containing guanidine thiocyanate and sodium hypochlorite generates a toxic gas mixture of hydrochloric acid and hydrogen cyanide.
  将含有硫氰酸胍和次氯酸钠的溶液混合，会产生盐酸和氰化氢的有毒气体混合物。

- Contact between chlorine-based disinfectants and acids can produce toxic chlorine gas fumes.
  含氯消毒剂与酸接触会产生有毒的氯气烟雾。

Disinfectant -- Chlorine compounds
化学消毒剂 —— 含氯化合物

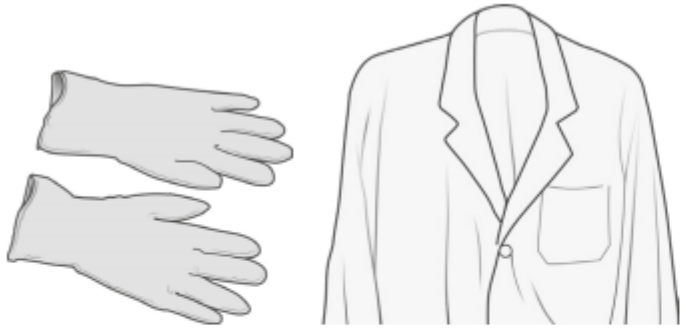
Recommended concentration for chlorine-based disinfectants 含氯消毒剂的推荐浓度		
Decontamination procedures 消毒方法	Contaminant Category 污染物类型	
Immersion Disinfection 浸泡法	Bacterial propagules 细菌繁殖体	Bloodborne Pathogens, Mycobacteria, Bacterial endospores 经血液传播的病原体、分枝杆菌、细菌芽孢
	500 mg/L, > 10 min	2000 mg/L ~ 5000 mg/L, > 30 min
Wiping Disinfection 擦拭法	Bacterial propagules 细菌繁殖体	Bloodborne Pathogens, Mycobacteria, Bacterial endospores 经血液传播的病原体、分枝杆菌、细菌芽孢
	500 mg/L, > 10 min	2000 mg/L ~ 5000 mg/L, > 30 min
Spray Disinfection 喷洒法	一般污染	Bloodborne Pathogens, Mycobacteria, Bacterial endospores 经血液传播的病原体、分枝杆菌、细菌芽孢
	400 mg/L ~ 700 mg/L, 10 min ~ 30 min	2000 mg/L, > 60 min
Dry Powder Disinfection 干粉消毒法	Secretions, Excreta 分泌物、排泄物	
	10000 mg/L	

Disinfectant -- Chlorine compounds
化学消毒剂 —— 含氯化合物

Hypochlorite solutions can be prepared from a number of different starting agents such as liquid bleach.
次氯酸盐溶液可由多种不同的起始试剂制备，如液体漂白剂。

DO NOT use bleach in areas where lysis buffer, Trizol or solutions containing thiocyanate salts have been used. The mixing of sodium hypochlorite in bleach with the thiocyanate salts in lysis buffer will produce toxic gas.
在曾使用裂解液、Trizol或含硫氰酸盐溶液的区域严禁使用漂白剂。漂白剂中的次氯酸钠与裂解液中的硫氰酸盐混合会产生剧毒气体。

- **How to make 0.5% bleach solution from household bleach (5000 mg/L)**
  如何使用家用液体漂白剂配置有效氯含量0.5%的消毒剂？（5000 mg/L）

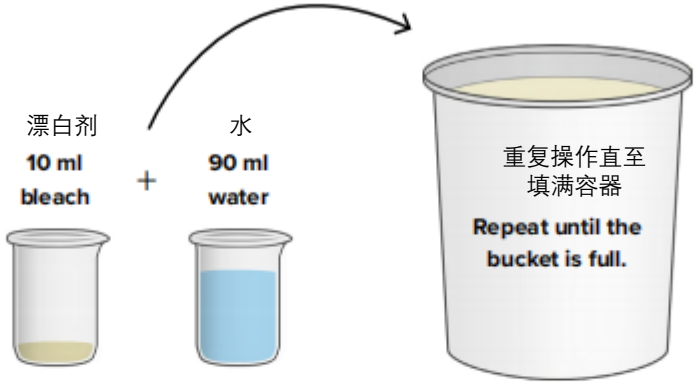


1. Before you begin 开始配置前的准备工作

Wear gloves and a laboratory coat.

Prepare solution in a well-ventilated area if a fume hood is not available.

戴手套和穿实验服。
如通风柜无法使用，应在通风良好的环境中配置消毒剂。



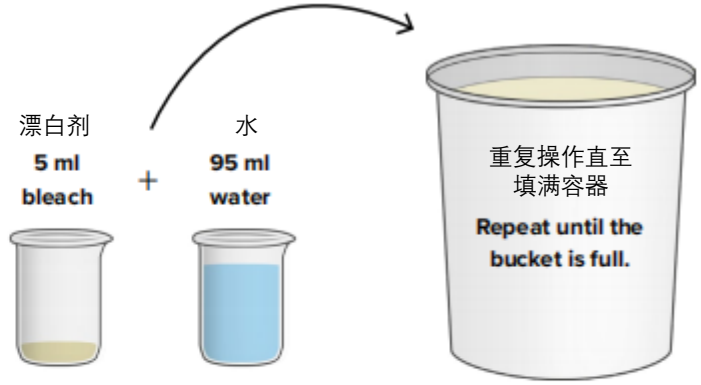
2a. From 5% bleach 如果你使用的是有效氯含量5%的家用漂白剂

Pour 10 ml bleach and 90 ml water into a bucket.

Repeat until the bucket is full.

Stir well for 10 seconds.

在空桶中加入10mL的液体漂白剂和90mL的水，重复该操作直至填满空桶。
搅拌10秒使其混合均匀。



2b. From 10% bleach 如果你使使用的是有效氯含量10%的家用漂白剂

Pour 5 ml bleach and 95 ml water into a bucket.

Repeat until the bucket is full.

Stir well for 10 seconds.

在空桶中加入5mL的液体漂白剂和95mL的水，重复该操作直至填满空桶。
搅拌10秒使其混合均匀。

Disinfectant -- Chlorine compounds
化学消毒剂 —— 含氯化合物

- **How to make 0.5% bleach solution from household bleach (5000 mg/L) (Continue)**
  如何使用家用液体漂白剂配置有效氯含量0.5%的消毒剂？（5000 mg/L）（接上一页）

3. Labelling　做好标记

Label the bucket 0.5% bleach solution.

Write the date when the solution was made.

在桶身上做好标记，标记应包含消毒剂的配制时间。

4. Storage　储存配置好的消毒剂

Cover the bucket with a lid.

DO NOT store in direct sunlight.

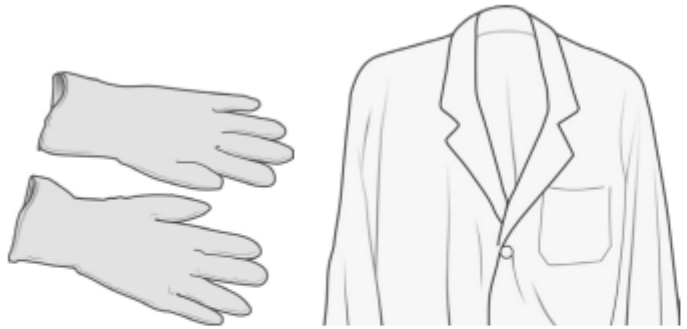
Only prepare enough bleach solution for one day. Throw away any leftover bleach solution from the day before.

盖上桶盖。
请勿将含氯消毒剂储存在阳光直射的地方。
仅在使用当天配置适量的含氯消毒剂，将当天未用完的消毒剂当作废液处理。

Disinfectant -- Chlorine compounds
化学消毒剂 —— 含氯化合物

DO NOT use bleach in areas where lysis buffer, Trizol or solutions containing thiocyanate salts have been used. The mixing of sodium hypochlorite in bleach with the thiocyanate salts in lysis buffer will produce toxic gas.
在曾使用裂解液、Trizol或含硫氰酸盐溶液的区域严禁使用漂白剂。漂白剂中的次氯酸钠与裂解液中的硫氰酸盐混合会产生剧毒气体。

- **How to make 0.5% bleach solution from chlorine powder (5000 mg/L)**
  如何使用漂白粉配置有效氯含量为0.5%的消毒剂？（5000 mg/L）

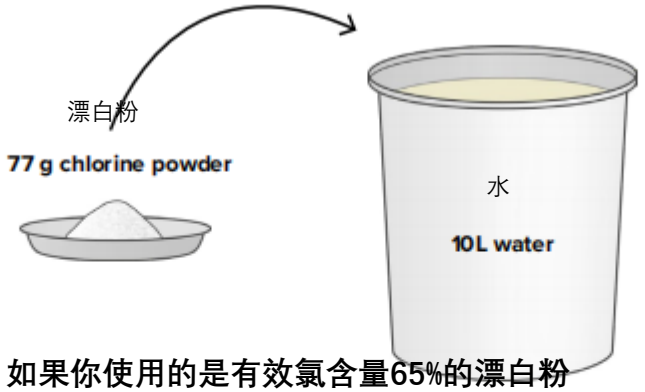


1. Before you begin　开始配置前的准备工作

Wear gloves and a laboratory coat.

Prepare solution in a well-ventilated area if a fume hood is not available.

戴手套和穿实验服。
如通风柜无法使用，应在通风良好的环境中配置消毒剂。



如果你使用的是有效氯含量65%的漂白粉

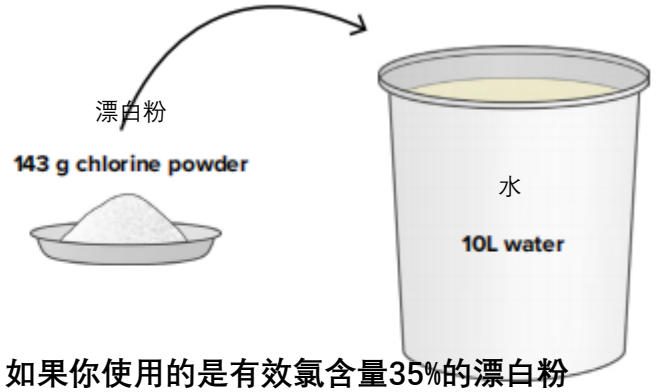
2a. From 65% chlorine powder

Add 77 g powder to 10L water in a bucket.

Stir well until the powder dissolves.

WAIT for 30 minutes before use.

将77g漂白粉添加到10L水中。
搅拌直至漂白粉完全溶解。
在开始使用前静置30分钟。



如果你使用的是有效氯含量35%的漂白粉

2b. From 35% chlorine powder

Add 143 g powder to 10L water in a bucket.

Stir well until the powder dissolves.

WAIT for 30 minutes before use.

将143g漂白粉添加到10L水中。
搅拌直至漂白粉完全溶解。
在开始使用前静置30分钟。

Disinfectant -- Chlorine compounds
化学消毒剂 —— 含氯化合物

- How to make 0.5% bleach solution from household bleach (5000 mg/L) (Continue)
  如何使用漂白粉配置有效氯含量为0.5%的消毒剂？（5000 mg/L）（接上一页）

3. Labelling　做好标记

Label the bucket 0.5% bleach solution.

Write the date when the solution was made.

在桶身上做好标记，标记应包含消毒剂的配制时间。

4. Storage　储存配置好的消毒剂

Cover the bucket with a lid.

DO NOT store in direct sunlight.

Only prepare enough bleach solution for one day. Throw away any leftover bleach solution from the day before.

盖上桶盖。
请勿将含氯消毒剂储存在阳光直射的地方。
仅在使用当天配置适量的含氯消毒剂，将当天未用完的消毒剂当作废液处理。

Disinfectant -- Alcohols
化学消毒剂 —— 醇类消毒剂

- Alcohols used for laboratory disinfection are either ethanol (usually denatured by the addition of methylated spirits, making it unsuitable for consumption), propanol (propan-1-ol) or isopropanol (propan-2-ol).
  用于实验室消毒的醇类有乙醇（通常通过添加甲基化酒精而变性，因此不适合饮用）、丙醇（丙-1-醇）或异丙醇（丙-2-醇）。

- The normal concentration for use is 70%, although, depending on which alcohol is used, anywhere between 60% and 90% can be effective.
  正常使用浓度为70%，但根据所用的醇的不同，60%至90%之间的任何浓度都有效。

- The activity of the three alcohols is broadly similar; they are effective against a wide range of bacteria in non-spore form and enveloped (lipid-containing) viruses. They have variable activity against non-enveloped viruses and no activity against bacteria spores.
  三种醇的活性大致相似；它们有效地对抗广泛的非孢子形式的细菌和包膜(含脂质)病毒。它们对无包膜病毒的活性不同，对细菌孢子无活性。

Disinfectant -- Alcohols
化学消毒剂 —— 醇类消毒剂

- While alcohols are not inactivated by organic matter, their activity is unreliable in the presence of proteins; they can coagulate proteins, forming a barrier against their further penetration to layers inside.
虽然醇类不会被有机物灭活，但在蛋白质存在的情况下，它们的活性并不可靠；它们可以凝结蛋白质，形成屏障阻止它们进一步渗透到内层。

- Alcohols evaporate quickly which make them convenient to use as surface disinfectants. However, their quick evaporation also reduces the exposure time and therefore their effectiveness.
醇类消毒剂蒸发迅速，因此常被用作表面消毒剂。然而，它们的快速蒸发也会缩短接触时间，从而降低有效性。

Recommended concentration for alcohols disinfectants 醇类消毒剂的推荐浓度		
Decontamination procedures 消毒方法	Recommended concentration (V/V) 推荐浓度（体积比）	Contact time 作用时间
Skin surface disinfection 皮肤表面消毒	70% ~ 80%	3 min, 2 times 3 min，2次
Wiping Disinfection 物体的擦拭消毒	70% ~ 80%	3 min, 2 times 3 min，2次
Immersion Disinfection 物体的浸泡的消毒	70% ~ 80%	⩾30 min

Disinfectant -- Peroxides
化学消毒剂 —— 过氧化物

◆ Hydrogen peroxide (H2O2)
过氧化氢

- Hydrogen peroxide acts as an oxidizing agent by producing hydroxyl free radicals that attack essential cell components, including lipids, proteins and DNA.
过氧化氢作为氧化剂，通过产生羟基自由基攻击细胞的基本成分，如脂质、蛋白质和DNA。

- It has a wide range of bactericidal, viricidal and fungicidal activity, although activity is variable against bacterial spores and mycobacteria.
尽管过氧化氢对细菌孢子和分枝杆菌的活性不尽相同，它具有广泛的杀菌、杀病毒和杀真菌活性。

- Hydrogen peroxide is considered environmentally friendly because it can rapidly degrade into the harmless products – water and oxygen. It is, however, a severe irritant to the skin, eyes and respiratory system.
过氧化氢被认为是环境友好型的消毒剂，因为它可以快速降解为无害的产物——水和氧气。但是，它对皮肤、眼睛和呼吸系统有严重的刺激性。

Disinfectant -- Peroxides
化学消毒剂 —— 过氧化物

◆ **Peracetic acid (C2H4O3)**
过氧乙酸

- Peracetic acid is made by mixing acetic acid with hydrogen peroxide and a strong acid catalyst. It is a stronger disinfectant than hydrogen peroxide.
过氧乙酸是由乙酸、过氧化氢和强酸催化剂混合而成。

- Peracetic acid is highly sporicidal, bactericidal, viricidal and fungicidal at low concentrations (< 0.3%).
它是一种比过氧化氢更强的消毒剂。过氧乙酸在低浓度(<0.3%)下具有很强的杀孢子、杀菌、杀病毒和杀真菌作用。

- Peracetic acid also decomposes to safe by-products (acetic acid and oxygen) and has the added advantages of not being decomposed by peroxidases, unlike hydrogen peroxide, and remaining active in the presence of organic loads.
过氧乙酸也分解为安全的副产物(乙酸和氧气)，并且具有过氧化氢不具备的不被过氧化物酶分解的附加优点，并且在存在有机物负载时保持活性。

- However, as with hydrogen peroxide, peracetic acid is a severe irritant to the skin, eyes and respiratory system.
但是，与过氧化氢一样，过氧乙酸对皮肤、眼睛和呼吸系统有严重的刺激性。

Disinfectant -- Quaternary ammonium compounds
化学消毒剂 —— 季铵化合物

- Quaternary ammonium compounds and similar compounds, such as triamines, are a varied family of molecules, some of which can be used as disinfectants.
季铵化合物和类似的化合物，如三胺，是一个多种多样的分子家族，其中一些可用作消毒剂。

- They have activity against bacteria in non-spore forms and enveloped (lipid containing) viruses.
它们对非孢子形式的细菌和包膜（含脂质）病毒具有活性。

- They are effective against a smaller range of biological agents than either hypochlorites or phenolic compounds, and have limited effectiveness against non-enveloped viruses, most Mycobacterium species and spores.
与次氯酸盐或酚类化合物相比，它们对较小范围的生物因子有效，对无包膜病毒、大多数分枝杆菌物种和孢子的效力有限。

In laboratories, the commonly used '新洁尔灭' (benzalkonium bromide) is one type of quaternary ammonium compound disinfectant and is classified as a low level disinfectant.

实验室中常见的“新洁尔灭”（苯扎溴铵）是季铵盐消毒剂中的一种，属于低水平消毒剂。

Disinfectant -- Quaternary ammonium compounds
化学消毒剂 —— 季铵化合物

- However, for extended use in solutions containing mostly enveloped viruses, quaternary ammonium compounds may be the best disinfectant to use.
  对主要含有包膜病毒的溶液，季铵化合物可能是最佳的消毒剂。

- If being considered for laboratory use, both potential inactivation and the range of biological agents they would be expected to act against need to be considered in the risk assessment.
  如果考虑将其再实验室使用，则在风险评估中需同时考虑潜在的灭活作用和期望其针对的生物因子范围。

Recommended concentration for quaternary ammonium compounds 季铵盐消毒剂的推荐浓度		
Categories of disinfection targets 消毒对象类型	Recommended concentration 推荐浓度	Contact time 作用时间
Skin surface disinfection 皮肤表面消毒	Compound quaternary ammonium disinfectant stock solution 复方季铵盐消毒剂原液	3 min ~ 5 min
Disinfection of the environment and object surfaces 环境及物品表面的消毒	1000 mg/L ~ 2000 mg/L	15 min ~ 30 min
Mucosal disinfection 黏膜消毒	1000 mg/L ~ 2000 mg/L	Follow the contact time specified in the product instructions 按照产品使用说明中的要求执行

Gaseous disinfection
气体消毒

- Good penetration of hard-to-reach areas.
  气体消毒对一般消毒方法（如喷洒消毒、擦拭消毒、紫外线消毒等）难以覆盖的区域有良好的渗透性。

- Must have sealable facility to prevent leakage and potential harmful effects to human.
  必须确保气体消毒区域的密封，防止消毒气体泄漏，对人员健康造成危害。

- This is a hazardous process that requires specially trained personnel.
  气体消毒是一个危险的过程，需要经过专门培训的人员操作。

- With all methods of fumigation, the area must be properly ventilated after fumigation before any personnel are allowed to enter.
  无论采用何种气体熏蒸消毒方法，熏蒸后必须经适当通风人员方可进入。

- In emergency situations, appropriate respiratory protective equipment, fit tested and with the correct filter fitment, must be worn by anyone entering the room before it has been ventilated.
  在紧急情况下，任何人在未通风之前进入熏蒸的房间，都必须穿戴适当的经过测试的呼吸防护装备，并配有正确的过滤器配件。

Gaseous disinfection
气体消毒

Types of gaseous disinfectants 常见的气体消毒方式	
Hydrogen peroxide 过氧化氢熏蒸	Compared with formaldehyde fumigation, chlorine dioxide fumigation and hydrogen peroxide fumigation have more advantages in terms of safety, environmental protection, controllability of the fumigation process, and speed. 与甲醛熏蒸相比，二氧化氯熏蒸和过氧化氢熏蒸在安全性、环境保护、熏蒸过程的可控性和速度等方面都更有优势。 Hydrogen peroxide is irritating to the eyes, mucous membranes, or skin. If accidental contact occurs, rinse immediately with plenty of water and seek medical attention promptly. 过氧化氢对眼、黏膜或皮肤有刺激性，若不慎接触，应使用大量水冲洗并及时就医。
Chlorine dioxide 二氧化氯熏蒸	Chlorine dioxide is moderately corrosive to carbon steel and aluminum, and mildly corrosive to copper and stainless steel. After metal items are disinfected with chlorine dioxide, they should be promptly rinsed thoroughly with water and then dried. 二氧化氯对碳钢、铝有中度腐蚀性，对铜、不锈钢有轻度腐蚀性。金属制品经二氧化氯消毒后，应及时用符合要求的水冲洗干净并干燥。
Formaldehyde 甲醛熏蒸	Fumigation with formaldehyde was conventional practice for HEPA filter disinfection, including BSCs. 使用甲醛进行熏蒸是HEPA高效过滤器消毒的传统做法，包括生物安全柜的消毒。 Formaldehyde was classified as human carcinogen since 2004. 2004年起，甲醛被列为人类致癌物。 Formaldehyde fumigation should be substituted with alternatives. 甲醛熏蒸消毒应被其他更安全的方案取代。 

Decontamination -- Sterilization
清除污染的方式 —— 灭菌

- Sterilization is used when a complete elimination of any biological agent, including spores and prions
  当需要完全消除任何生物因子(包括孢子和朊病毒)时，必须使用灭菌法。

- Sterilization can be achieved using several decontamination methods such as autoclaving, certain chemical disinfectants and gaseous disinfection combined with a strict SOP, and irradiation.
  灭菌可以通过高压灭菌、某些化学消毒剂、气体消毒、辐照等几种方法结合严格的标准操作规程（SOP）来实现。

- To monitor the effectiveness of the sterilization process, biological indicators are used.
  为了监测灭菌过程的有效性，需要生物指示剂。

Overview of concentrations required for activity of chemical sterilants 化学灭菌剂达到活性需要的浓度一览	
Chemical sterilants 化学灭菌剂名称	Recommended Dilution Ratio or Concentration for Activity 具有活性应有的稀释比例或浓度
Ethylene oxide 环氧乙烷	400 ~ 1200mg/L
Formaldehyde 甲醛	6% ~ 8%
Glutaraldehyde 戊二醛	Variable 可变
Hydrogen peroxide 过氧化氢	6% ~ 30%
Peracetic acid 过氧乙酸	Variable 可变
Chlorine dioxide 二氧化氯	Variable 可变

Autoclaving
高压灭菌

- Autoclaving, when used correctly, is the most effective and reliable means to sterilize laboratory materials and decontaminate waste materials by destroying or inactivating biological agents.
高压灭菌可以通过破坏或灭活生物因子为实验室材料和废弃物消毒，在正确使用时是最有效和最可靠的消毒手段。

- Autoclaving uses high temperatures (for example, 121°C, 134 °C) applied as moist heat (steam) under pressure to destroy microorganisms.
高压灭菌通过压力下的湿热（蒸汽）高温（如121°C，134°C）破坏微生物。

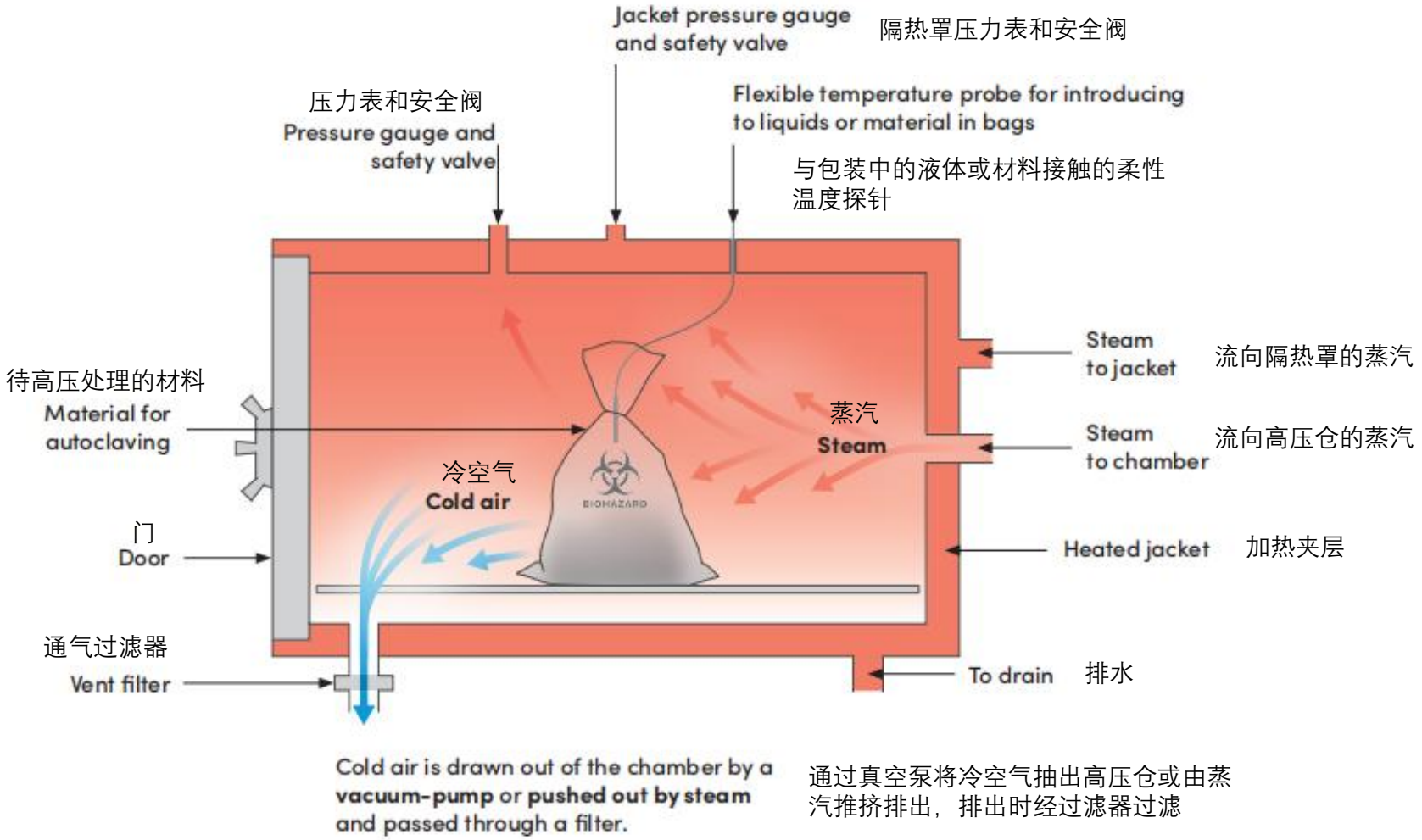
- The holding time, temperature and pressure used for the autoclave cycle help determine the efficiency of inactivation. Autoclaves must therefore be equipped with systems to check these parameters. A written log should be maintained to record, for each cycle performed, the time, date, operator name, and type and approximate amount of waste that was treated.
高压灭菌器循环的保持时间、温度和压力可以决定灭活的效率。因此，高压灭菌器必须配备检查这些参数的系统。保存每个操作周期的日期、时间、操作者姓名、处理的废弃物的类型和大致数量的记录。

- Since air is an efficient insulator, it is essential that air is effectively removed from the chamber in order to ensure temperatures are not affected.
由于空气是一种高效的绝缘体，因此必须有效地去除灭菌室内的空气，以确保灭菌器内部温度不受影响。

Autoclaving
高压灭菌

- The main component of an autoclave is a pressure vessel (or sterilization chamber), which can be sealed tightly by a lid or a door. An arrangement of pipes and valves allows steam to be introduced and removed.
高压灭菌器的主要部件是灭菌室，可用阀盖或门密封。管道和阀门的排布可控制蒸汽进出。

- In simple devices, the lower part of the vessel is filled with water, which can then be evaporated by an electric heater.
在简单的设备中，容器下部充满了水，可以通过电加热器产生蒸汽。



Autoclaving
高压灭菌

- **Safety precautions must be taken when using steam autoclaves:**
  使用高压灭菌器前必须了解的安全事项：

  - Operation and maintenance of autoclaves must be assigned to trained, competent individuals.
    高压灭菌器的操作和维护必须交给经过培训且取得相应资质的人员。

  - Operating instructions for the autoclave must be available. Sterilization programmes with application area (for example, solids, liquids) and the parameters to be maintained (temperature, pressure, time) must be defined.
    高压灭菌器的操作说明应随时可供查阅。必须确定灭菌方案，包括待灭菌样品的类型（例如固体、液体）和需保持的参数（温度、压力、时间）。

  - A loading plan (with information on the contents, number, volume and mass of the sterilized product) should also be available. Large and bulky material, large animal carcasses, sealed heat-resistant containers and other waste that impedes the transfer of heat must be avoided.
    灭菌器的设备信息应随时可供查阅（包括需要灭菌的产品的内容、数量、体积和质量信息）。必须避免大而笨重的材料、大型动物尸体、密封的耐热容器和其他阻碍热量传递的废弃物。

Autoclaving
高压灭菌

◆ **Safety precautions must be taken when using steam autoclaves: (Continue)**
使用高压灭菌器前必须了解的安全事项：（接上一页）

- A preventive maintenance programme must be developed, including regular visual inspection of the chamber, door seals, gauges and controls. This should be conducted by qualified personnel.
应制定预防性维护计划，包括定期对灭菌室、门密封件、仪表和控制器进行目视检查。这些工作应由有相应资质的人员完成。

- A reliable steam source must be used to provide appropriately saturated steam, uncontaminated by water droplets or chemicals which inhibit the function of the autoclave, or may damage the pipes or chamber of the autoclave.
必须使用可靠的蒸汽源提供适宜的饱和蒸汽，无水滴或化学物质污染，它们会妨碍高压灭菌器功能，还可能损坏高压灭菌器的管道或仓室。

- Waste or materials placed in the autoclave must be in containers that readily allow removal of air and permit good heat penetration.
放置在高压灭菌器中的废弃物或材料必须装在易于去除空气和热渗透性良好的容器中。

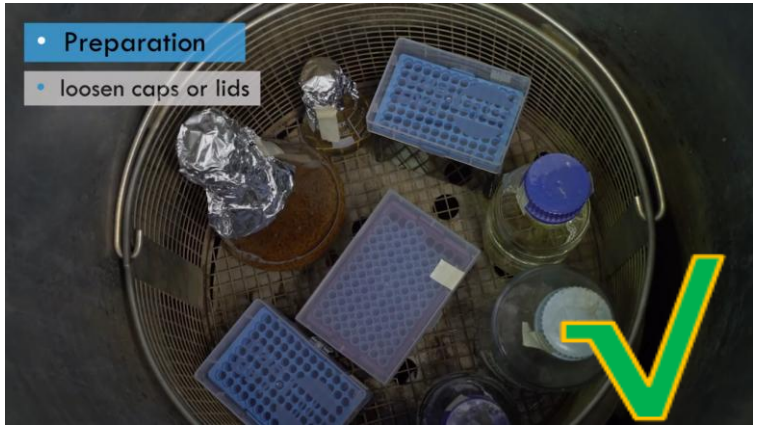
Autoclaving
高压灭菌

◆ **Safety precautions must be taken when using steam autoclaves: (Continue)**
使用高压灭菌器前必须了解的安全事项：（接上一页）

- The chamber of the autoclave must be loosely packed so that steam can penetrate evenly.
高压灭菌器的灭菌室必须松散装载，以使蒸汽能够均匀渗透。

- Hazardous chemical waste (for example, bleach), mercury or radioactive waste must not be treated in an autoclave.
有害化学废弃物（例如漂白剂）、汞或放射性废弃物不得放在高压灭菌器中处理。

- Operators must wear suitable thermally protective gloves, protective clothing and eye protection when opening the autoclave, even when the temperature has fallen to levels appropriate for opening the chamber.
操作人员在打开高压灭菌器时，即使灭菌器温度已降至适合打开灭菌室门的水平，也必须穿戴合适的热防护手套、防护服和眼部防护装置。



Autoclaving
高压灭菌

- **Safety precautions must be taken when using steam autoclaves: (Continue)**
  使用高压灭菌器前必须了解的安全事项：（接上一页）

  - Care should be taken to ensure that the relief valves and drains of autoclaves do not become blocked by paper, plastic or other materials included in the waste or materials for decontamination.
    应小心确保高压灭菌器的安全阀和排水管不会被废弃物中的纸张、塑料及其他材料、或是用来去除污染的材料堵塞。

  - For the decontamination of volatile hazardous material (for example, spores of pathogens) the air relief of the autoclave must be equipped with an appropriate filter.
    为了清除不稳定的危害物质（例如病原微生物的孢子）的污染，高压灭菌器内的空气排放时必须配备合适的过滤器。

It is essential that the material is packed in an air- and vapour-permeable way to allow complete removal of the air. Air pockets trapped inside the goods prevent proper steam contact, lead to cold spots and may prevent complete inactivation of biological agents.

材料必须以空气和蒸汽都能渗透的方式包装，以便完全去除空气。滞留在物品内的空气袋（残余空气）会阻止物品与蒸汽接触，导致出现冷点，妨碍生物因子的完全灭活。

Sterilization Performance Check
灭菌效果监测

- Biological and chemical Indicators are routinely used to check and/or monitor the effectiveness of decontamination processes (cleaning, disinfection or sterilization).
  生物和化学指示剂通常用于监测清除污染过程(清洁、消毒或灭菌)的有效性。

◆ Biological indicators
生物指示剂

Biological indicators consist of a standardized population of microorganisms.
生物指示剂由标准化微生物群组成。

Non-pathogenic bacterial endospores are commonly used as test organisms as they are highly resistant to sterilization processes and easy to detect when cultured.
非致病性细菌内生孢子通常用作测试生物，因为它们对灭菌过程具有高度抵抗力，并且在培养时易于检测。

If the spores are not decontaminated by the sterilization process, they will germinate and grow and eventually release dipicolinic acid that can be detected by a pH indicator dye present in the growth medium.
如果孢子未被灭菌过程清除污染，它们将萌发并生长，最终释放出二吡啶甲酸，可通过生长培养基中pH指示染料检测到。

Sterilization Performance Check
灭菌效果监测

Sterilization processes and appropriate biological indicators 灭菌程序及其适用的生物指示剂	
Sterilization processe 灭菌程序	Biological indicators 对应的生物指示剂
Formaldehyde 甲醛	Geobacillus stearothermophilus 嗜热脂肪芽孢杆菌
Hydrogen peroxide 过氧化氢	Geobacillus stearothermophilus 嗜热脂肪芽孢杆菌
Moist heat 湿热灭菌	Geobacillus stearothermophilus 嗜热脂肪芽孢杆菌
Dry heat 干热灭菌	Bacillus atrophaeus, B. subtilis 萎缩芽孢杆菌，枯草芽孢杆菌
Ionizing radiation 电离辐射灭菌	B. pumilus 短小芽孢杆菌

Sterilization Performance Check
灭菌效果监测

◆ **Biological indicators -- Geobacillus stearothermophilus**
生物指示剂——嗜热脂肪芽孢杆菌

- Used for monitoring the effectiveness of hydrogen peroxide, formaldehyde, autoclave sterilization.
用于监测过氧化氢、甲醛和高压蒸汽灭菌的效果。

- Placed together with the waste during sterilization.
灭菌过程中，将嗜热脂肪芽孢杆菌生物指示剂与废弃物放在一起。

- Incubated at 55 °C–60 °C for 24 hours
灭菌结束，将其至于在55℃–60℃环境下培养24小时。

- A color change from purple to yellow indicates bacterial growth.
如果指示剂颜色由紫色变为黄色表明细菌生长，灭菌效果不合格。

Sterilization Performance Check
灭菌效果监测

- **Chemical indicators**
  化学指示剂

Chemical indicators check for specific direct parameters that are essential for disinfection or sterilization.
化学指示剂用于检查消毒或灭菌所需的特定参数。

These parameters include verification that a minimum concentration of a disinfectant has been used or that a specific condition has been reached in the autoclave.
这些参数包括验证消毒剂是否达到最低使用浓度或高压蒸汽灭菌器中是否达到特定条件。

Chemical indicators also check for indirect variables that are important to the efficacy of the process; for example, the Bowie-Dick (BD) test that confirms the correct removal of air in pre-vacuum autoclaves.
化学指示剂还能用于监测影响消毒过程有效性重要的间接变量；例如，确认预真空高压蒸汽灭菌器中空气能否正常排出的BD测试。

BD试纸初始状态

BD测试通过

BD测试不合格

HKUST(GZ) Laboratory Biosafety Requirements
香港科技大学（广州）实验室生物安全要求

- **Laboratory biosafety risk assessment and risk control**
  实验室生物安全风险评估和风险控制

When experimental activities involve pathogenic biological agents, the relevant experiment/project must undergo a risk assessment.
当实验活动涉及致病性生物因子时，应对该实验项目进行风险评估。

When any of the following situations occur, a re-assessment of the risk for an experiment project that has already undergone risk assessment shall be carried out:
当涉及以下情况时，需对已经过风险评估的实验项目重新开展风险评估:

1. Changes in experimental activities, such as modifications to facilities, equipment, scope of activities, operating procedures, etc., related to the experiment.
   实验活动发生改变的情况，如实验活动相关的设施、设备、活动范围、操作方法等发生变动。
2. Changes in relevant policies, regulations, or standards.
   相关政策、法规、标准变动的情况。
3. Occurrence of incidents or accidents related to the experiment project involving the pathogenic microorganism.
   发生与该病原微生物实验项目相关的事件、事故的情况。
4. Changes in the biological characteristics of the pathogen involved in the experiment project or in the prevention and control strategies.
   实验项目涉及的病原体生物学特性或防控策略发生改变的情况。

HKUST(GZ) Laboratory Biosafety Requirements
香港科技大学（广州）实验室生物安全要求

- **Laboratory biosafety risk assessment and risk control (Continue)**
  实验室生物安全风险评估和风险控制（接上一页）

  Regular reviews of the risk assessment reports for experimental activities should be conducted, and the review cycle shall be determined based on the nature of the experimental activities and the characteristics of the risks involved.
  应定期开展实验活动风险评估报告的复审工作，复审周期根据实验活动和风险特征而定。

  The process of hazard identification, risk assessment and risk control applies not only to the routine operation of laboratories and facilities/equipment, but also to periods when laboratories and facilities/equipment are being cleaned, maintained or shut down.
  危险识别、风险评估和风险控制的过程不仅适用于实验室、设施设备的常规运行，而且适用于对实验室、设施设备进行清洁、维护或关停期间。

  In the risk assessment of an experiment project, consider not only the risks from the lab's own activities, but also those from external personnel actions and from using externally supplied items or services.
  实验项目风险评估过程中，除考虑实验室自身活动的风险外，还应考虑非本实验室的外部人员活动、使用外部提供物品或服务带来的风险。

HKUST(GZ) Laboratory Biosafety Requirements
香港科技大学（广州）实验室生物安全要求

- **Laboratory biosafety risk assessment and risk control (Continue)**
  实验室生物安全风险评估和风险控制（接上一页）

  The data underlying the risk assessment, as well as the proposed risk control measures and safety operating procedures, should be based on guidelines and standards issued by national authorities and international or industry recognized authoritative organizations.
  风险评估所依据的数据及拟采取的风险控制措施、安全操作规程等应以国家主管部门和国际权威组织或行业权威机构发布的指南、标准等为依据。

  Any new technology should be fully validated before being put into use.
  任何新技术在使用前应经过充分验证。

  All risk assessment reports for experiments involving pathogenic microorganisms shall be properly retained.
  所有病原微生物实验活动的风险评估报告应妥善保存。

HKUST(GZ) Laboratory Biosafety Requirements
香港科技大学（广州）实验室生物安全要求

- **Personnel management requirements for biological laboratories**
  生物实验室人员管理要求

  The laboratory should establish a personnel access and assessment system; all personnel involved in experimental activities must undergo access training, and the access requirements shall refer to the *HKUST(GZ) Laboratory Safety Orientation Management*.
  实验室应建立人员准入及考核制度，所有与实验活动相关的人员均应经过准入培训，准入要求参照《香港科技大学（广州）安全准入暂行办法》。

  The laboratory should ensure that relevant personnel fully recognize and understand the risks associated with the pathogenic microorganism experiments they are conducting. If necessary, they should sign an informed consent form acknowledging the risks of the pathogenic microorganism experimental activities.
  实验室应保证相关人员充分认识和理解所从事病原微生物实验活动的风险，必要时，应签署病原微生物实验活动风险知情同意书。

  All risk assessment reports for experiments involving pathogenic microorganisms shall be properly retained.
  The laboratory should establish personnel records for those involved in pathogenic microorganism experimental projects within the laboratory, and regularly assess the ability of laboratory personnel to undertake corresponding work tasks.
  实验室应建立本实验室参与病原微生物实验项目人员的档案，定期评估实验室人员承担相应工作任务的能力。

HKUST(GZ) Laboratory Biosafety Requirements
香港科技大学（广州）实验室生物安全要求

- **Personnel management requirements for biological laboratories**
  生物实验室人员管理要求

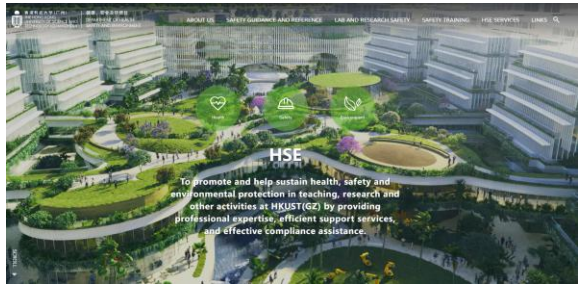
  When personnel involved in pathogenic microorganism experimental projects exhibit clinical symptoms or signs of infection related to their experimental activities, the relevant individuals should report the situation in accordance with the HKUST(GZ) Reporting and Investigation of Laboratory Safety Incidents Management. The laboratory should immediately activate its emergency response plan. Personnel showing symptoms should seek medical attention at a healthcare facility and inform the attending hospital of the type and hazard level of the pathogenic microorganisms they have been exposed to.
  参与病原微生物实验项目的人员出现与其实验活动相关的感染临床症状或者体征时，相关人员应根据《香港科技大学（广州）实验室安全事故报告与调查暂行处理办法》报告，实验室应立即启动本实验室应急预案。出现症状的人员应前往医疗机构就诊，并向就诊医院告知其所接触病原微生物的种类和危害程度。

  If personnel from external organizations come to the laboratory to conduct experimental activities, or if the laboratory hires temporary staff for such work, the laboratory must ensure that they are competent to perform the tasks assigned to them, and that they understand and comply with the requirements of the laboratory's management system.
  如有外单位人员到实验室开展实验活动或实验室聘用临时工作人员进行实验活动的情况，实验室需确保其有能力胜任所承担的工作，了解并遵守实验室管理体系的要求。

HKUST(GZ) Laboratory Biosafety Requirements
香港科技大学（广州）实验室生物安全要求

◆ **For More Information...**
如果您想了解更多学校实验室生物安全管理要求和指引：

- LHSD Safety Procedures webpage:
  LHSD 安全管理制度:
  https://lhsd.hkust-gz.edu.cn/safety-guidance/safety-procedures/



- HKUST(GZ) Safety Manual (Chapter 9, Biological Safety):
  香港科技大学（广州）安全手册（第九章，生物安全）:
  https://lhsd.hkust-gz.edu.cn/posts/476/%e7%ac%ac%e4%b9%9d%e7%ab%a0-%e7%94%9f%e7%89%a9%e5%ae%89%e5%85%a8/

- HKUST(GZ) Emergency Procedures:
  香港科技大学（广州）应急程序:
  https://lhsd.hkust-gz.edu.cn/safety-guidance/emergency-procedures/

- HKUST(GZ) Safety Guidelines:
  香港科技大学（广州）安全指引:
  https://lhsd.hkust-gz.edu.cn/safety-guidance/safety-guidelines/

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