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DEPARTMENT OF BIOMEDICAL ENGINEERING

VII Semester

OBT357 BIOTECHNOLOGY IN HEALTH CARE

UNIT- 4 OUT PATIENT & IN-PATIENT SERVICES

4.8 Pulmonology

Biotechnology has significantly transformed healthcare, including pulmonology, by enhancing diagnostic, therapeutic, and monitoring capabilities for both outpatient and inpatient services.

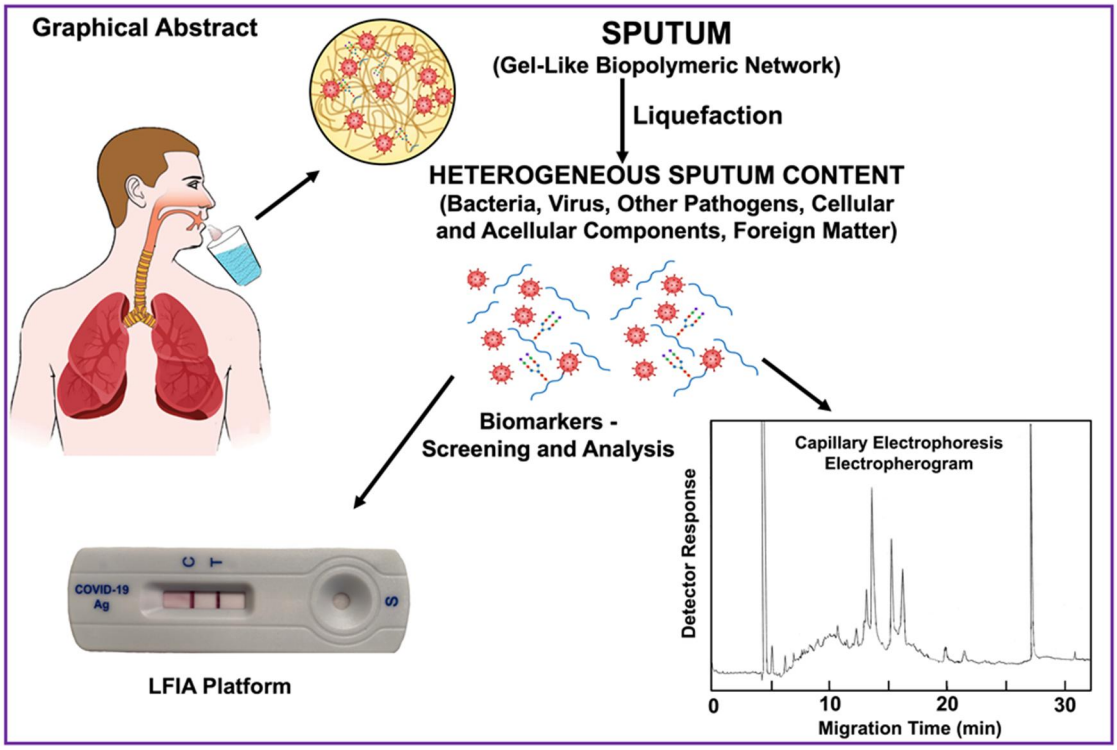
I. Outpatient Services in Pulmonology:

Outpatient services in pulmonology involve non-hospitalized care, typically in clinics or specialized respiratory care centers, for patients with chronic or acute respiratory conditions like asthma, COPD, pulmonary fibrosis, or lung infections. Biotechnology plays a pivotal role in improving diagnostics, treatment, and patient management.

1. Diagnostics and Monitoring:

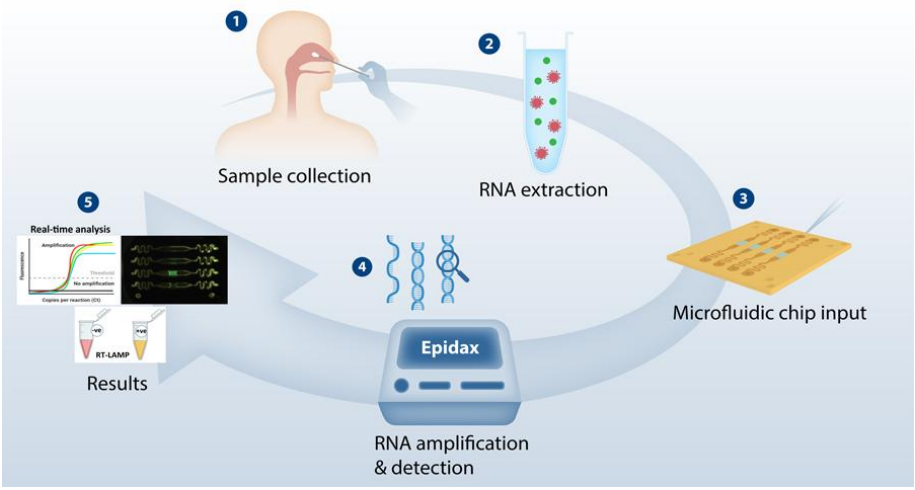
- **Biomarker-Based Diagnostics**: Biotechnology enables the identification of specific biomarkers in blood, sputum, or exhaled breath to diagnose conditions like asthma, COPD, or lung cancer. For instance, fractional exhaled nitric oxide (FeNO) testing, supported by biotech devices, helps assess airway inflammation in asthma patients non-invasively.

Fractional exhaled nitric oxide (FeNO) testing



Human Sputum Proteomics: Advancing Non-Invasive Diagnosis of Respiratory Diseases

- **<u>Molecular Diagnostics</u>**: PCR-based tests and next-generation sequencing (NGS) detect genetic mutations or pathogens (e.g., Mycobacterium tuberculosis) in outpatient settings, enabling rapid diagnosis of infections like tuberculosis or respiratory viral infections.



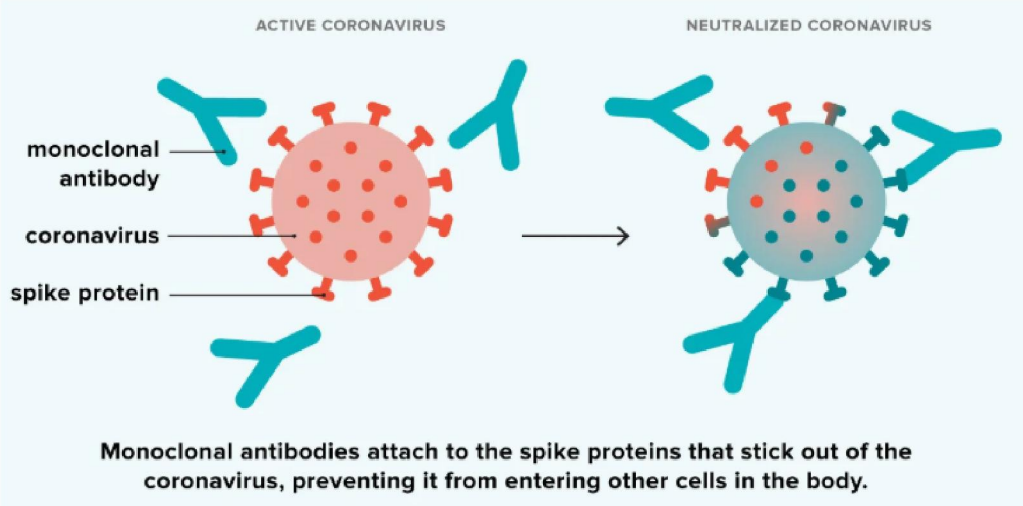
PCR system for onsite rapid diagnosis of COVID'19

❖ **Wearable and Remote Monitoring Devices**: Biotech-driven wearables, such as smart inhalers with sensors, track medication adherence and lung function (e.g., peak expiratory flow). These devices sync with mobile apps, allowing pulmonologists to monitor patients remotely and adjust treatment plans.

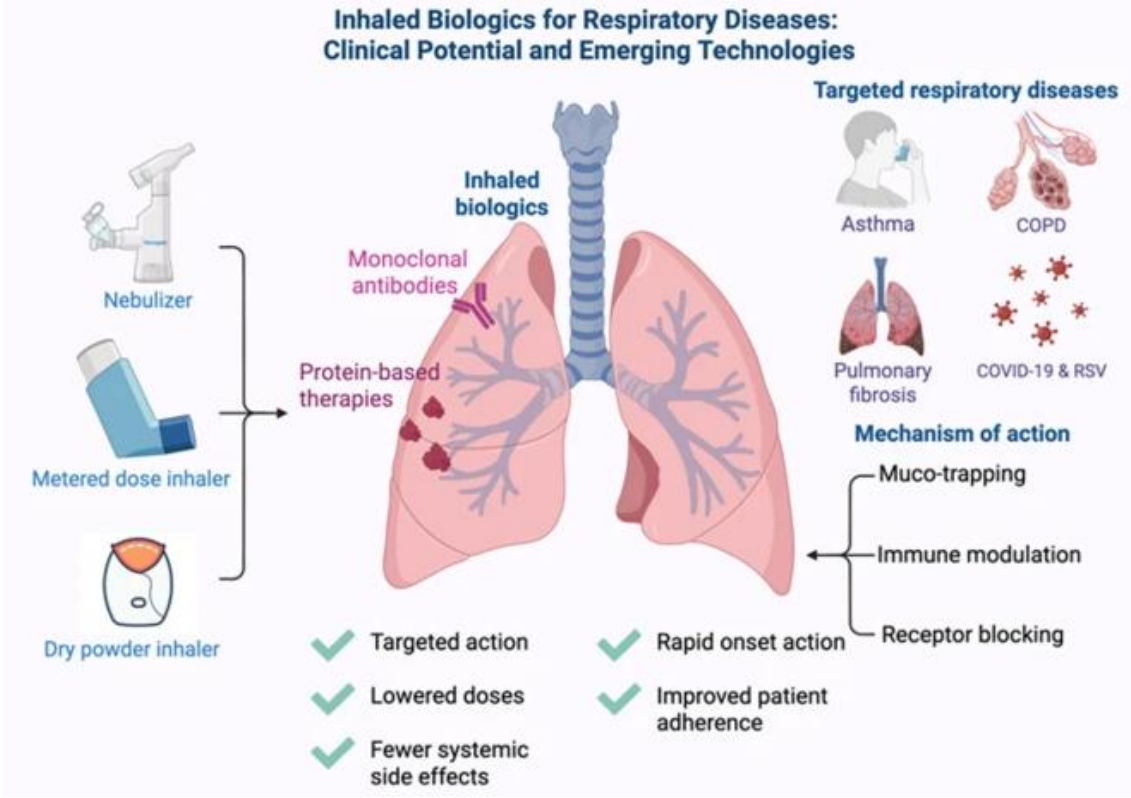
Smart inhalers

2. Therapeutics:

❖ **Biologics for Respiratory Diseases:** Monoclonal antibodies, such as omalizumab (for severe asthma) or mepolizumab (for eosinophilic asthma), target specific inflammatory pathways. These biologics are administered in outpatient clinics, reducing exacerbations and improving quality of life.



❖ **Inhalable Biotherapeutics:** Advances in aerosolized drug delivery systems, such as nanoparticle-based inhalers, enhance targeted drug delivery to the lungs for conditions like cystic fibrosis or COPD.



Delivery Devices:

- **Nebulizer** – converts liquid medicine into a fine mist.
- **Metered Dose Inhaler (MDI)** – delivers a fixed dose of drug as an aerosol.
- **Dry Powder Inhaler (DPI)** – patient inhales powdered drug directly into lungs.

Types of Inhaled Biologics:

- **Monoclonal Antibodies** – e.g., for asthma or viral infections.
- **Protein-Based Therapies** – enzymes, peptides, or hormones delivered via inhalation.

Targeted Respiratory Diseases

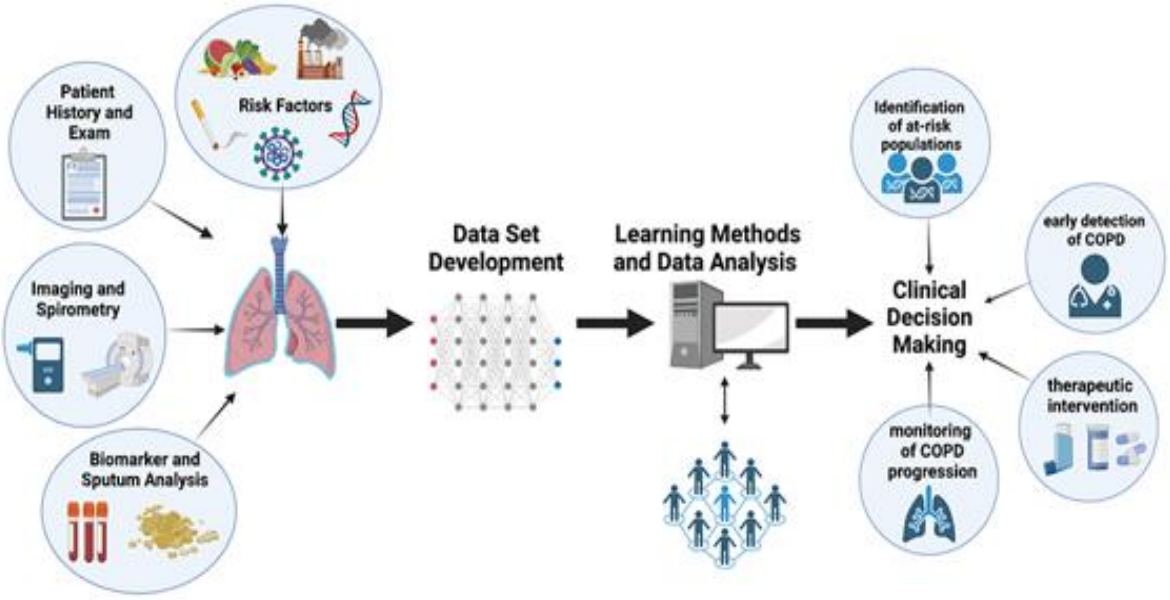
- **Asthma**
- **Chronic Obstructive Pulmonary Disease (COPD)**
- **Pulmonary Fibrosis**
- **Viral Infections** – COVID-19, Respiratory Syncytial Virus (RSV).

Mechanisms of Action:

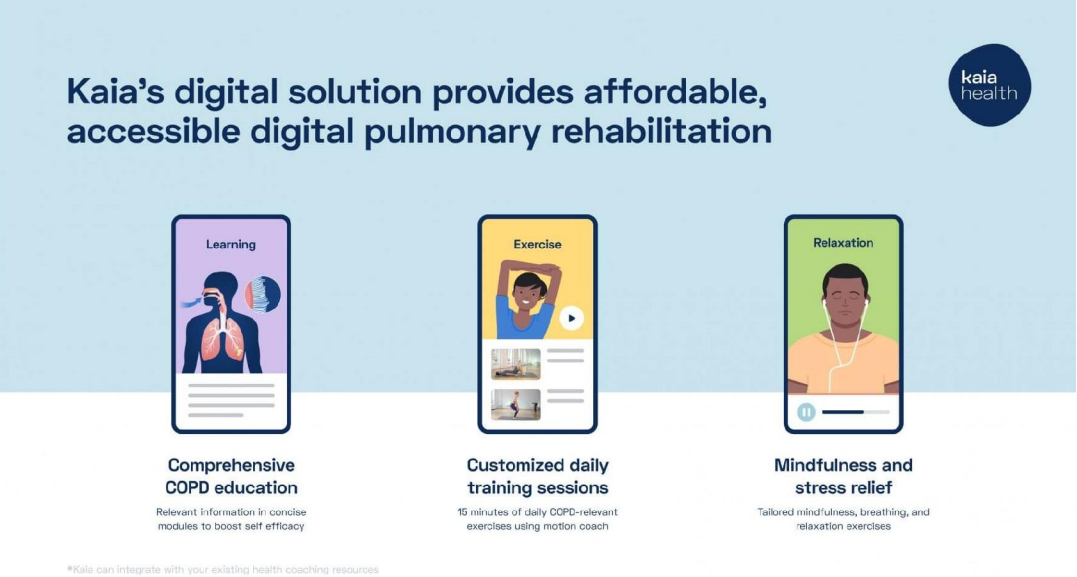
1. **Muco-trapping** – helps clear mucus buildup in lungs.
2. **Immune Modulation** – regulates overactive immune responses.
3. **Receptor Blocking** – prevents viruses, allergens, or inflammatory mediators from binding.

❖ **Personalized Medicine:** Genetic profiling in outpatient settings helps tailor treatments, such as identifying EGFR mutations in lung cancer patients to guide targeted therapies like osimertinib. **Epidermal Growth Factor Receptor (EGFR)** is a **protein receptor** found on the surface of many cells. The receptor is activated when specific growth factors (like epidermal growth factor, EGF) bind to it.

3. **Patient Management:**
   ❖ **Telemedicine and AI Integration:** Biotech tools combined with AI analyze patient data (e.g., spirometry results or imaging) to provide real-time insights for outpatient consultations. Telemedicine platforms facilitate follow-ups, reducing the need for in-person visits.



- **Pulmonary Rehabilitation Apps:** Biotech-supported apps provide guided breathing exercises and education for patients with chronic lung conditions, improving self-management in outpatient care.

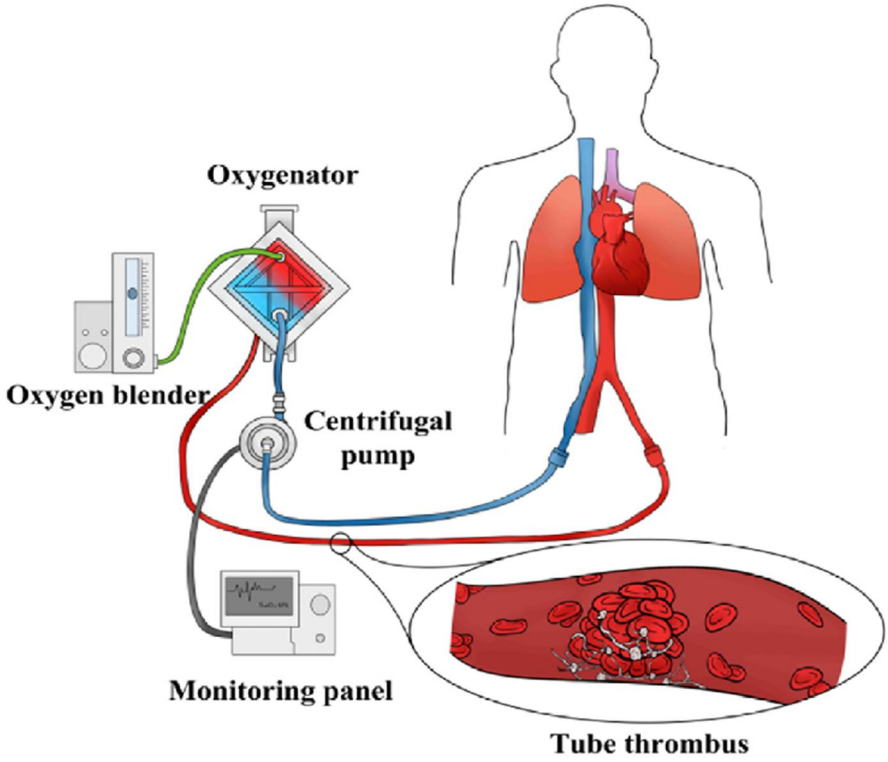


II. Inpatient Services in Pulmonology:

Inpatient services in pulmonology cater to patients requiring hospitalization for severe respiratory conditions, such as acute respiratory distress syndrome (ARDS), severe pneumonia, lung cancer, or exacerbations of chronic diseases. Biotechnology enhances critical care, surgical interventions, and recovery.

1. **Diagnostics and Monitoring:**
   - **Advanced Imaging and AI:** Biotech-driven imaging technologies, like high-resolution CT scans with AI-based analysis, improve the detection of lung abnormalities (e.g., nodules, fibrosis) in hospitalized patients. These tools aid in rapid diagnosis and treatment planning.
   - **Point-of-Care Testing:** Portable biotech devices, such as blood gas analyzers or rapid antigen tests, enable real-time assessment of respiratory failure or infections in ICU settings.
   - **Genomic Sequencing for Infections:** In cases of severe or drug-resistant infections (e.g., multidrug-resistant TB), NGS identifies pathogen resistance profiles, guiding precise antibiotic therapy.

2. **Therapeutics:**
   - ❖ **Biologics in Critical Care:** Monoclonal antibodies, like tocilizumab, are used in inpatient settings for severe inflammatory conditions, such as COVID-19-related cytokine storms affecting the lungs.
   - ❖ **Gene and Cell Therapies:** Emerging biotech therapies, such as CRISPR-based gene editing or stem cell therapies, are being explored for conditions like cystic fibrosis or pulmonary fibrosis in clinical trials, often administered in specialized inpatient units.
   - ❖ **Extracorporeal Membrane Oxygenation (ECMO):** Biotech advancements in ECMO technology provide life-saving respiratory support for patients with severe ARDS, bridging them to recovery or transplant. **Extracorporeal Membrane Oxygenation (ECMO)** is an advanced life-support technique used in patients with severe respiratory or cardiac failure unresponsive to conventional treatments. It works by draining deoxygenated blood from the body, pumping it through a **centrifugal pump** to an **oxygenator** (artificial lung) where carbon dioxide is removed and oxygen is added, and then returning oxygen-rich blood back to the patient.



3. Surgical and Interventional Support:

- **Lung Transplantation:** Biotechnology improves transplant outcomes through better tissue matching (using HLA typing) and immunosuppressive biologics to prevent rejection. Inpatient care post-transplant relies on biotech tools for monitoring graft function.
- **Minimally Invasive Procedures:** Biotech-enabled bronchoscopy tools, such as endobronchial ultrasound (EBUS), allow precise biopsies or stent placements in hospitalized patients with lung tumors or airway obstructions.
- **Tissue Engineering:** Research into bioengineered lung tissue or scaffolds for airway reconstruction is advancing, with potential inpatient applications for severe lung damage.

4. Ventilation and Support Systems:

- **Smart Ventilators:** Biotech-integrated ventilators with real-time monitoring and AI algorithms optimize ventilation settings for patients with respiratory failure, improving outcomes in ICUs.
- **Oxygen Delivery Systems:** Advanced biotech oxygen concentrators and high-flow nasal cannula systems enhance oxygen therapy efficiency for inpatients.

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