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DEPARTMENT OF BIOMEDICAL ENGINEERING

VII Semester

OBT357 BIOTECHNOLOGY IN HEALTH CARE

UNIT- 3 VACCINOLOGY

3.1 History of Vaccinology

- Vaccination has a long history.
- It began in 1796 when the British physician Edward Jenner used variolation to protect people from smallpox.
- Over time, vaccines became more advanced. Today, multivalent vaccines are produced to protect against diseases like pneumonia and human papilloma virus (HPV). These vaccines work against many different strains of the same pathogen found in human communities.

- Vaccinology, the science of developing vaccines to prevent diseases, has a rich history spanning centuries, driven by observation, experimentation, and innovation. Below is a concise yet comprehensive overview of its evolution, focusing on key milestones, figures, and developments.

❒ Early Beginnings: Pre-Modern Vaccination Practices

- **11th Century, China**: The earliest documented form of immunization was variolation, practiced in China as early as the 1000s. This involved exposing healthy individuals to smallpox material (e.g., dried scabs) via inhalation or skin contact to induce a mild infection, conferring immunity. This practice spread across Asia and Africa.
- **15th–17th Century, Global Spread**: Variolation reached the Ottoman Empire and was introduced to Europe and the Americas by the early 18th century. Lady Mary Wortley Montagu, who observed the practice in

Constantinople in 1717, promoted it in England, significantly reducing smallpox mortality.

❒ The Birth of Modern Vaccinology: Edward Jenner and Smallpox

- ❖ **1796, Edward Jenner**: The foundation of modern vaccinology was laid by Edward Jenner, an English physician. Observing that milkmaids exposed to cowpox were immune to smallpox, Jenner inoculated an 8-year-old boy, James Phipps, with cowpox material and later exposed him to smallpox, confirming immunity. This marked the first scientific vaccine.
- ❖ **1800s, Smallpox Vaccination**: Jenner's method spread rapidly. By 1801, smallpox vaccination was adopted in Europe and the Americas. The term "vaccine" (from Latin *vacca*, meaning cow) was coined to describe this process. By the late 19th century, compulsory vaccination laws in some countries reduced smallpox cases significantly.

❒ 19th Century: Scientific Advances and New Vaccines

- ❖ **Louis Pasteur and Attenuation (1880s)**: French scientist Louis Pasteur advanced vaccinology by developing the concept of attenuated (weakened) pathogens. In 1881, he created a vaccine for anthrax by attenuating the *Bacillus anthracis* bacterium. In 1885, Pasteur developed the first rabies vaccine for human use, successfully treating a young boy bitten by a rabid dog. His work established the principle of using weakened or killed microbes to stimulate immunity.
- ❖ **Germ Theory and Immunology**: The acceptance of germ theory in the late 19th century, driven by scientists like Robert Koch and Joseph Lister, provided a scientific basis for vaccinology. Understanding that specific microbes caused diseases allowed targeted vaccine development.

❒ Early 20th Century: Expanding the Vaccine Arsenal

- ❖ **1900s–1920s, Bacterial Vaccines**: Vaccines for diseases like diphtheria (toxoid vaccine, 1923), tetanus (1924), and tuberculosis (BCG vaccine, 1921) emerged. These were based on inactivated toxins or attenuated bacteria, building on Pasteur's principles.

- **Viral Vaccines**: The development of techniques to grow viruses in the laboratory (e.g., in chicken eggs) enabled vaccines for viral diseases. The 1930s saw the introduction of the yellow fever vaccine by Max Theiler (1937), for which he later won a Nobel Prize.

❒ **Mid-20th Century: The Golden Age of Vaccines**

- **Polio Vaccines (1950s–1960s)**: Polio, a devastating disease, spurred major vaccine efforts. In 1955, Jonas Salk introduced the inactivated polio vaccine (IPV), which used killed poliovirus. Albert Sabin followed with the oral polio vaccine (OPV) in 1961, using a live attenuated virus. Mass vaccination campaigns led to polio's near-eradication by the late 20th century.
- **Measles, Mumps, and Rubella (MMR)**: John Enders and colleagues developed the measles vaccine in 1963, followed by mumps (1967) and rubella (1969) vaccines. These were combined into the MMR vaccine in 1971, drastically reducing the incidence of these childhood diseases.
- **Global Immunization Efforts**: The World Health Organization (WHO), founded in 1948, began coordinating global vaccination campaigns. The Expanded Programme on Immunization (EPI), launched in 1974, aimed to vaccinate children worldwide against six major diseases: diphtheria, tetanus, pertussis, measles, polio, and tuberculosis.

Late 20th Century: Technological Advances

- **Recombinant DNA Technology**: In the 1980s, the hepatitis B vaccine became the first to use recombinant DNA technology, producing viral proteins in yeast cells rather than using live or killed pathogens. This approach improved safety and scalability.
- **Conjugate Vaccines**: The 1990s saw the development of conjugate vaccines, such as those for *Haemophilus influenzae* type b (Hib) and *Streptococcus pneumoniae*. These vaccines linked bacterial polysaccharides to proteins, enhancing immune responses in young children.

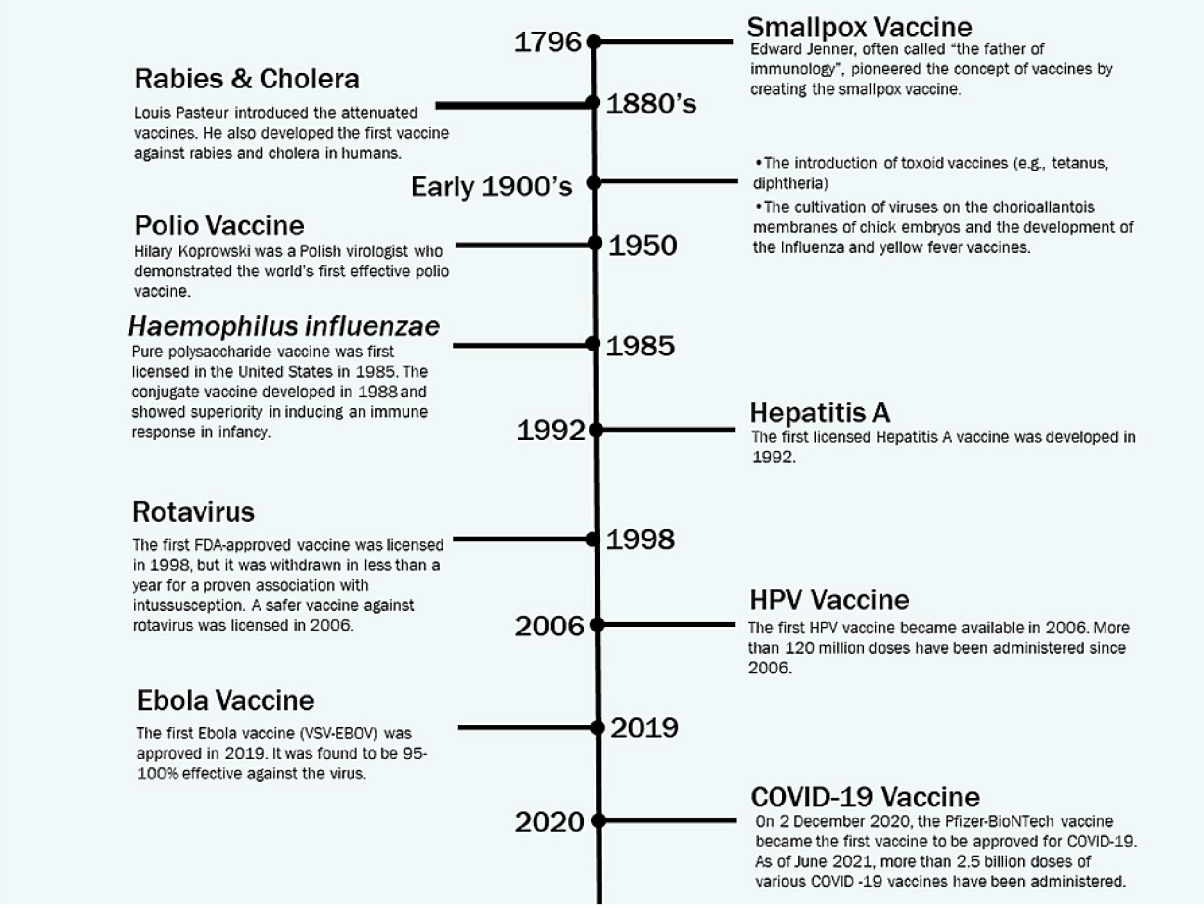
- **Eradication of Smallpox (1980)**: The WHO declared smallpox eradicated in 1980, the first and only human disease eliminated through vaccination. This success underscored the power of global immunization campaigns.

21st Century: Modern Vaccinology:

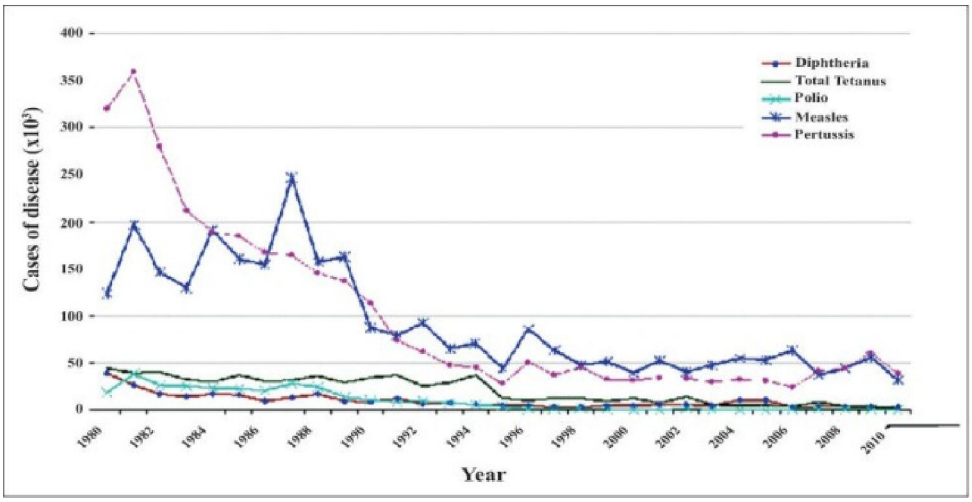
- **Human Papillomavirus (HPV) and Rotavirus Vaccines**: In 2006, vaccines for HPV (linked to cervical cancer) and rotavirus (a major cause of childhood diarrhea) were introduced, showcasing advances in targeting non-infectious diseases and complex pathogens.
- **mRNA Vaccines**: The 21st century marked a revolution with mRNA vaccines. Research on mRNA technology, pioneered by scientists like Katalin Karikó and Drew Weissman, enabled rapid development of COVID-19 vaccines (e.g., Pfizer-BioNTech and Moderna) in 2020. These vaccines use mRNA to instruct cells to produce viral proteins, triggering immunity without using the pathogen itself.
- **Global Challenges and Innovations**: Vaccines for diseases like Ebola (2019) and malaria (RTS,S, 2021) addressed complex pathogens in resource-limited settings. Meanwhile, therapeutic vaccines for cancer and chronic diseases are under development, expanding vaccinology's scope.

Important Themes and Trends

- **Technological Evolution**: From variolation to mRNA, vaccinology has progressed through better understanding of immunology, pathogen biology, and biotechnology.
- **Global Impact**: Vaccines have saved millions of lives, with smallpox eradication and polio's near-elimination as standout achievements. The WHO estimates vaccines prevent 6 million deaths annually.
- **Challenges**: Vaccine hesitancy, driven by misinformation, and access disparities in low-income countries remain hurdles. Emerging pathogens (e.g., SARS-CoV-2, Zika) require rapid vaccine development.
- **Future Directions**: Advances in synthetic biology, AI-driven vaccine design, and personalized vaccines promise to accelerate development. Universal vaccines (e.g., for influenza or coronaviruses) are a major research focus.



Vaccine Development Throughout History



Reported cases of major vaccine preventable diseases in India (1980-2010).

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