

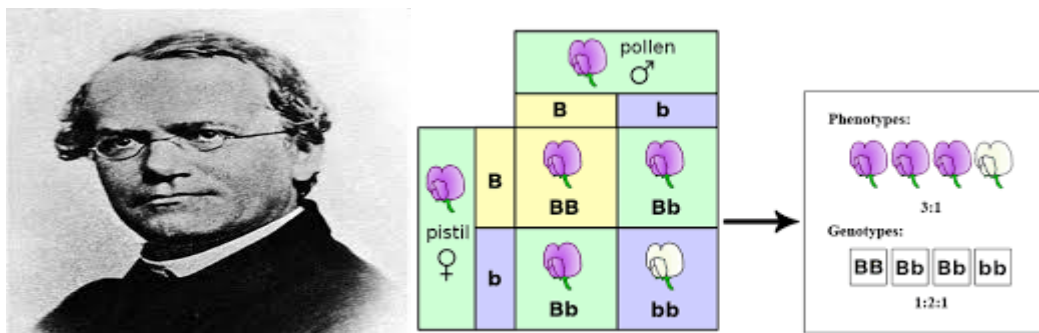
CHAPTER 7: Twentieth Century: Modern Biology

Introduction

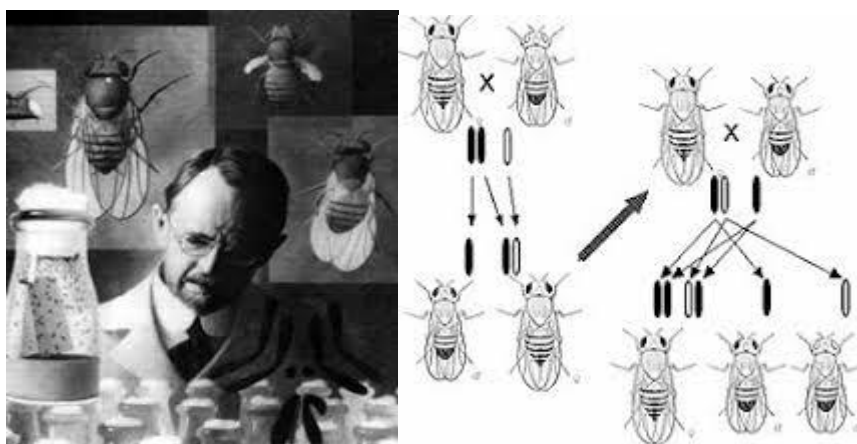
The **20th century** marks the transition of biology into a **modern, experimental, and molecular science**. This period was characterized by extraordinary advances in **genetics, molecular biology, ecology, and medicine**, transforming our understanding of life. Technology such as **microscopy, biochemistry, and molecular genetics** enabled discoveries that shaped today's biology. Among the most revolutionary breakthroughs were the emergence of **gene therapy** and **cloning**, which redefined medicine and biotechnology.

1. Genetics and the Molecular Basis of Life

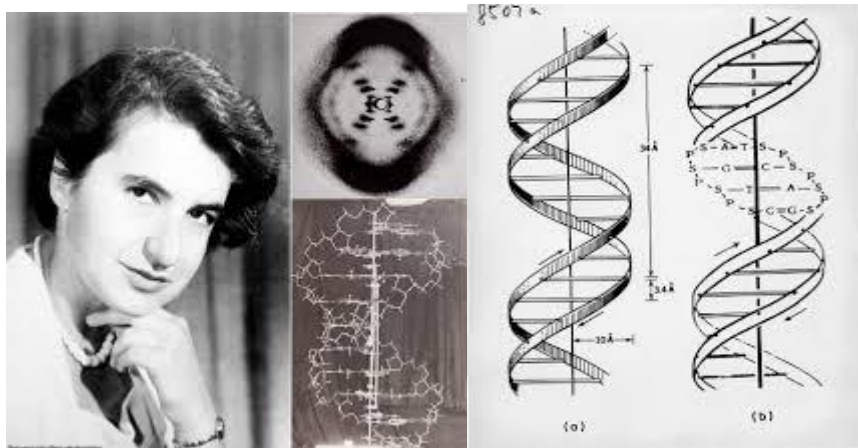
- **1900**: Rediscovery of Mendel's Laws by de Vries, Correns, and Tschermak → foundation of modern genetics.



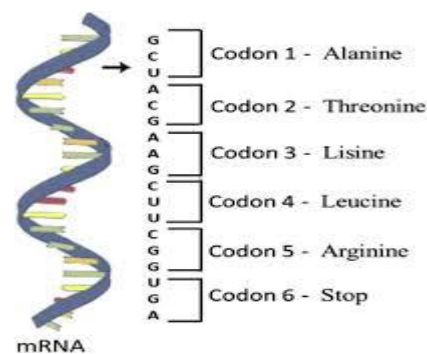
- **1910s**: Thomas Hunt Morgan demonstrated that **genes are located on chromosomes** (*Drosophila* experiments).



- **1953**: Watson & Crick discovered the **DNA double helix**, with Rosalind Franklin's X-ray diffraction data.



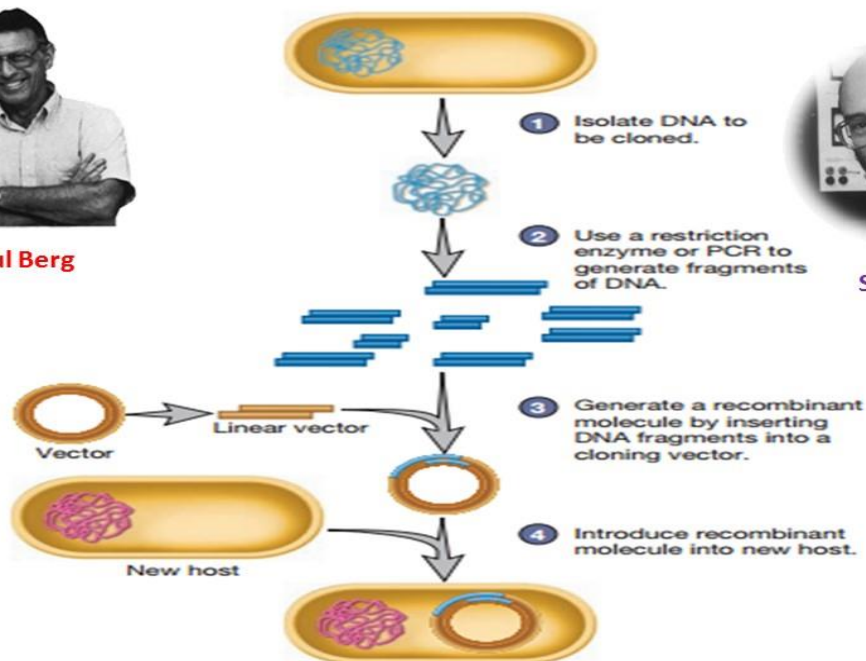
- 1960s: Genetic code deciphered, linking DNA sequences to proteins.



- 1980s: Molecular biology techniques developed → recombinant DNA, cloning, PCR.

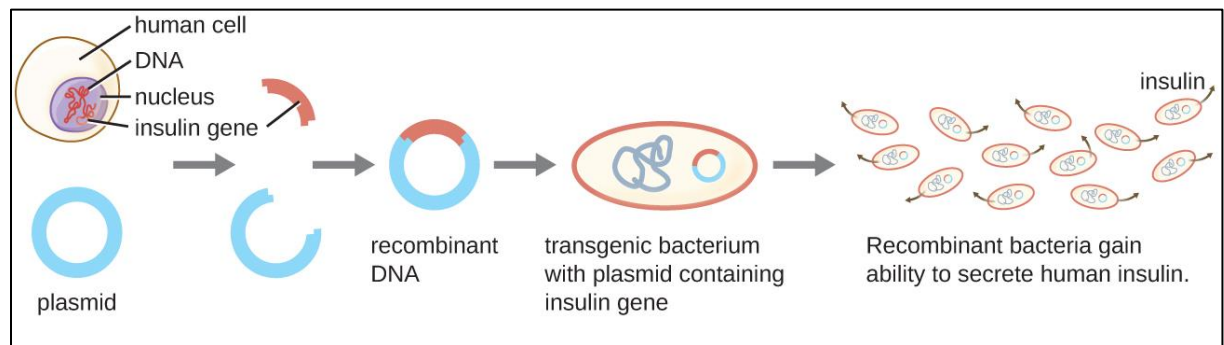


Paul Berg



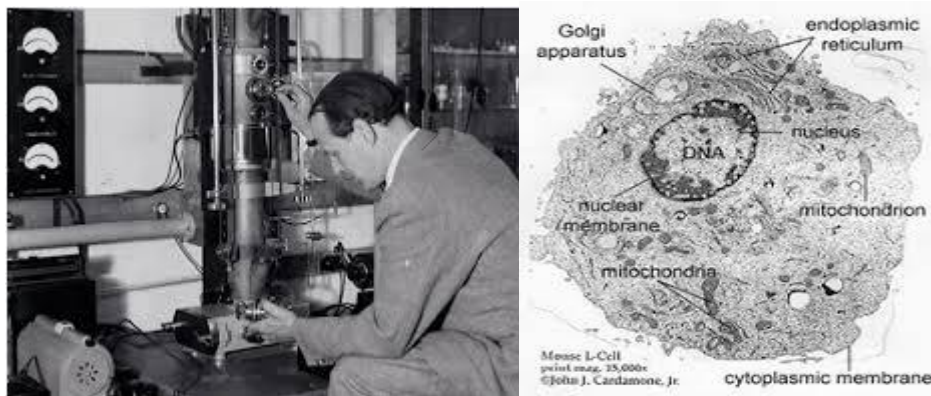
Stanley Cohen

Figure: Steps in cloning a gene

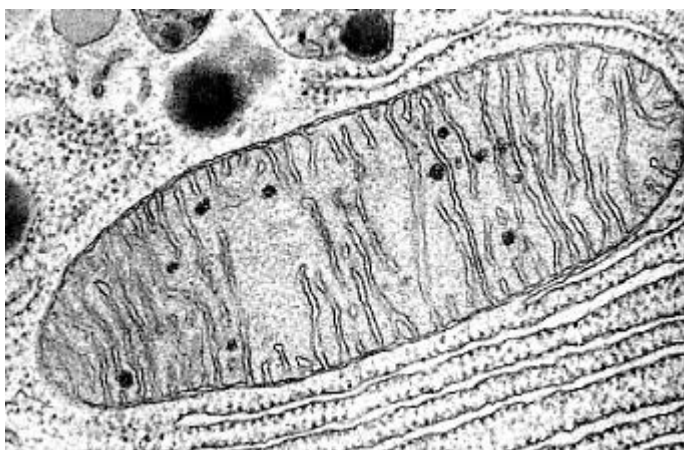


2. Cell Biology and Biochemistry

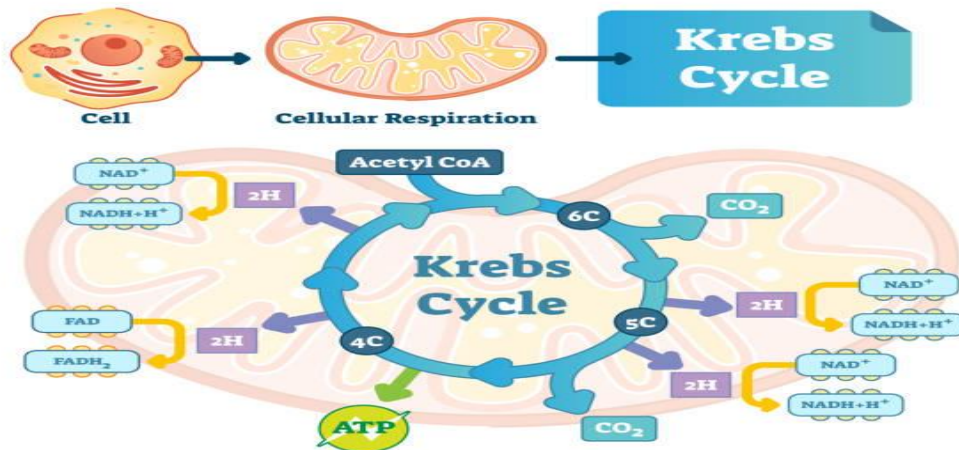
- 1930s: Electron microscope invented → revealed **ultrastructure of cells**.



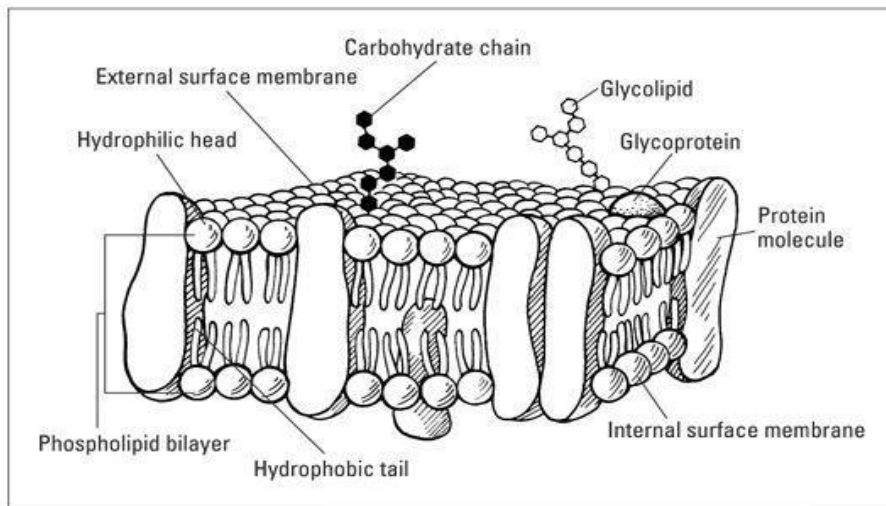
- Discovery of organelle functions: **mitochondria (respiration)**, **chloroplasts (photosynthesis)**.



- 1937: Krebs cycle described; ATP identified as the **universal energy molecule**.



- 1972: Fluid mosaic model proposed for **cell membranes**.



3. Evolution and Ecology

- 1930s–1940s: Modern Synthesis integrated **Darwin's evolution with Mendelian genetics** (Dobzhansky, Mayr, Simpson).

The Modern Synthesis

1930s ~ 1940s

Also called the "Synthesis of Evolution and Genetics"

The synthesis of population genetics
(role of mutation, selection, genetic drift)
paleontology, systematics

Darwin and Mendel Reconciled



- **Population genetics** became central to evolutionary theory.
- **Ecology** emerged as a discipline: **ecosystems, biodiversity, conservation biology**.

4. Physiology and Medicine

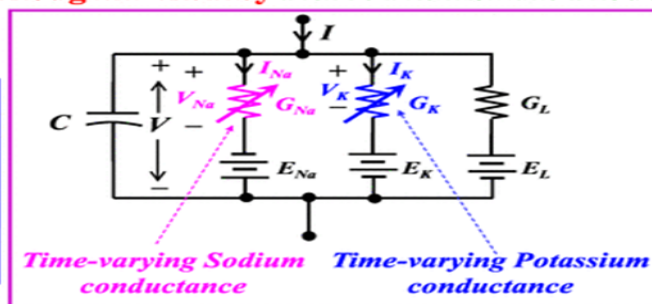
- 1952: Hodgkin & Huxley explained **nerve impulse mechanism**.

1961 Nobel Prize in Physiology

Hodgkin- Huxley Nerve Membrane Model



Sir A. L. Hodgkin



Time-varying Sodium conductance Time-varying Potassium conductance



Sir A. F. Huxley

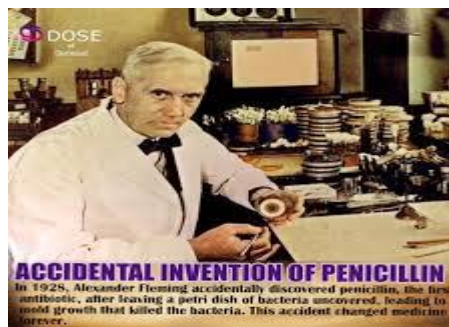
From

A. L. Hodgkin and A. F. Huxley

A Quantitative Description of Membrane Current and its Application to Conduction and Excitation in Nerve.

Journal of Physiology, Vol. 117, pp.500-544, 1952

- Advances in **endocrinology** (hormones, metabolic regulation).
- 1928: Discovery of penicillin (Fleming); widespread use in the 1940s.



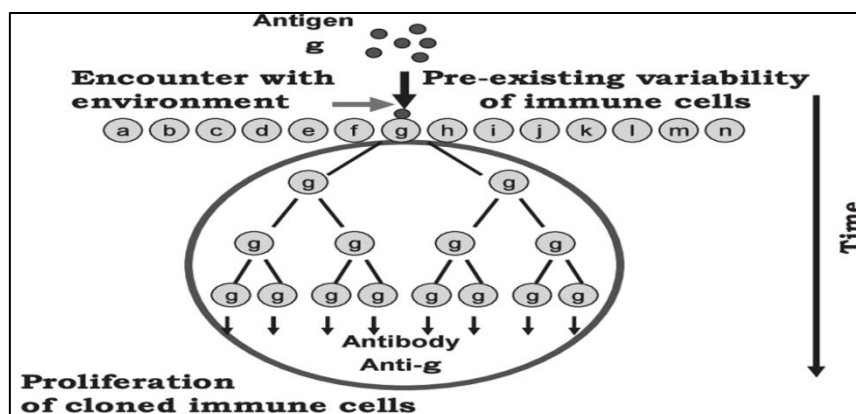
ACCIDENTAL INVENTION OF PENICILLIN

In 1928, Alexander Fleming accidentally discovered penicillin, the first antibiotic, after leaving a petri dish of bacteria uncovered, leading to mold growth that killed the bacteria. This accident changed medicine forever.

- Development of **vaccines**: polio (Salk, Sabin), recombinant vaccines.

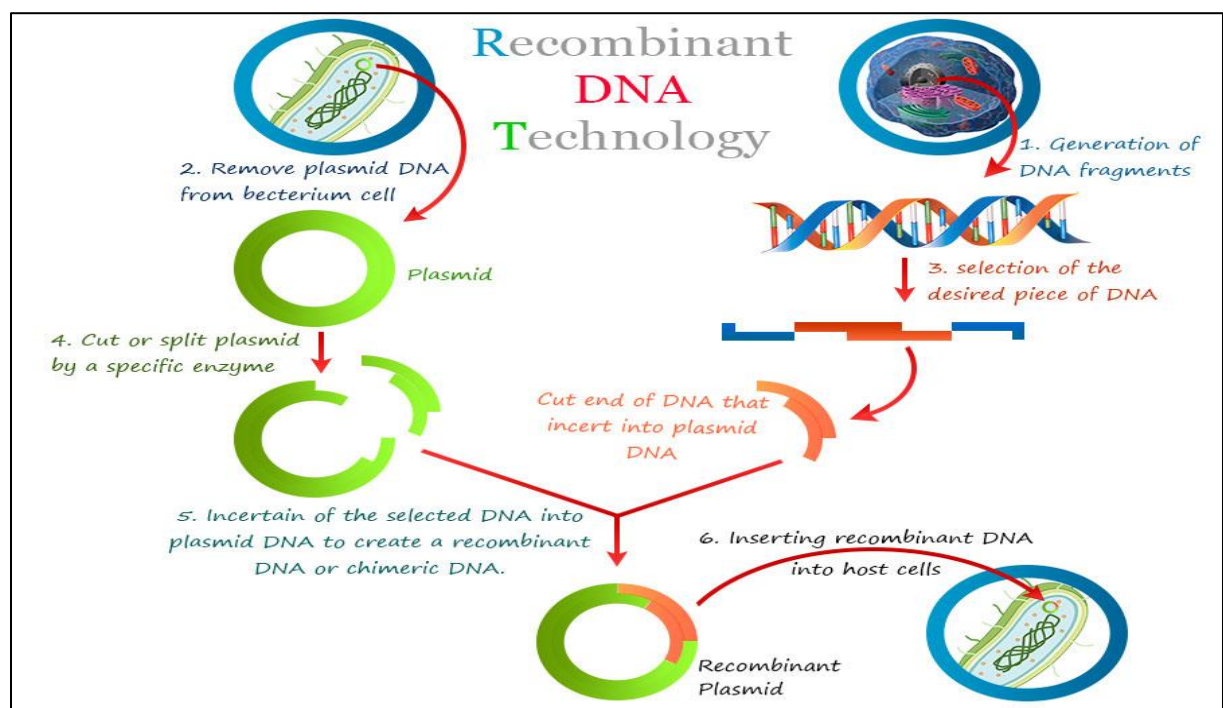


- 1950s**: Clonal selection theory in immunology (Burnet).

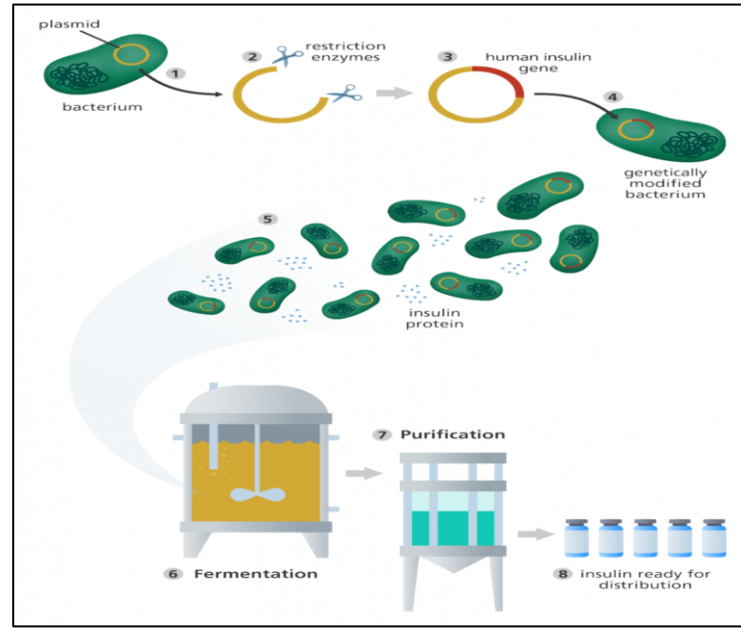


5. Biotechnology and Genomics

- 1970s**: Recombinant DNA technology → beginning of **genetic engineering**.



- 1982: Production of insulin by **genetically modified bacteria**.

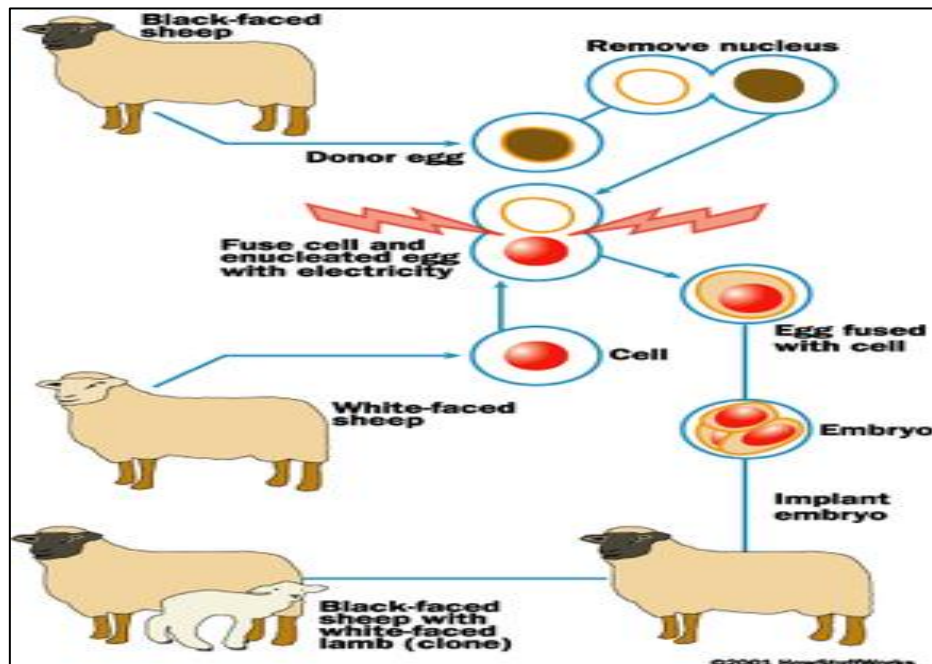


- 1990–2003: Human Genome Project → sequencing of the entire **human genome**.

مشروع الجينوم البشري → هو مشروع علمي دولي هدفه تسلسل ورسم خريطة لجميع الجينات في الجينوم البشري (حوالي 3 مليارات قاعدة من الـ DNA) وقد وفر هذا المشروع خريطة كاملة للحمض النووي للإنسان، مما ساعد العلماء على فهم الأمراض الوراثية والتطور والبيولوجيا البشرية بشكل أعمق.

- 1996: Birth of **Dolly the sheep** through cloning.

ولادة النعجة دوللي عن طريق الاستنساخ → كانت دوللي أول حيوان ثديي يتم استنساخه من خلية جسدية بالغة باستخدام تقنية تُعرف باسم نقل نواة الخلية الجسدية، وقد أثبتت ولادتها أنه من الممكن إنشاء نسخة وراثية مطابقة لحيوان بالغ.



6. Gene Therapy

Definition: A technique that involves introducing, removing, or altering **genetic material (DNA/RNA)** in cells to treat disease.

Key Milestones:

- **1972:** Friedmann & Roblin propose gene therapy.

فريدمان وروبليين يقترحان العلاج الجيني → في هذا العام، اقترح العالمان فريدمان وروبليين فكرة العلاج الجيني، وهي استخدام الجينات لعلاج الأمراض الوراثية عن طريق استبدال أو إصلاح الجينات المعيبة في خلايا الإنسان.

- **1990:** First clinical success (Ashanti DeSilva, ADA-SCID).

أول نجاح سريري (أشانتى دي سيلفا، ADA-SCID) → في هذا العام تم أول تطبيق ناجح للعلاج الجيني على الطفلة أشانتى دي سيلفا التي كانت تعاني من نقص إنزيم ADA المسبب لمرض نقص المناعة الشديد (SCID)، حيث تم إدخال نسخة سليمة من الجين إلى خلاياها، مما حسن جهازها المناعي بشكل واضح.

- Use of **viral vectors** (retroviruses, adenoviruses).

استخدام النواقل الفيروسية (الفيروسات القهقرية، الفيروسات الغدية) → في العلاج الجيني تُستخدم الفيروسات كنواقل لنقل الجينات السليمة إلى خلايا المريض.

- **الفيروسات القهقرية (Retroviruses):** تُدمج مادتها الوراثية في DNA الخلية المستهدفة.
- **الفيروسات الغدية (Adenoviruses):** تُدخل الجين إلى الخلية دون الاندماج في DNA، مما يجعل تأثيرها مؤقتًا.
- Applications:
 - Genetic diseases (**hemophilia, cystic fibrosis, muscular dystrophy**)
 - **Cancer therapy** (tumor-suppressor genes)
 - **CAR-T immunotherapy**

7. Cloning

Definition: The production of **genetically identical copies** of DNA, cells, or whole organisms.

Types:

1. **Gene cloning** → copying DNA fragments (basis of recombinant DNA).
2. **Therapeutic cloning** → stem cells for regenerative medicine.
3. **Reproductive cloning** → creating a whole organism.

Key Milestones:

- **1970s:** Recombinant DNA technology.
- **1996: Dolly the sheep**, first mammal cloned from an adult cell.
- Later cloning of cows, pigs, cats, dogs, and monkeys.
- **Therapeutic cloning:** stem cells for **Parkinson's, diabetes, spinal cord injuries**.

8. Ethical Considerations

- **Gene therapy:** Risks of unintended mutations, enhancement misuse.
- **Cloning:** Controversial—**reproductive cloning in humans banned** in most countries, while **therapeutic cloning** is partly accepted.
- Growth of **bioethics** to regulate advances.

Table 1. Key Discoveries in 20th-Century Biology

Field	Key Achievements
Genetics	Mendel rediscovery, DNA structure (1953), genetic code, recombinant DNA
Cell Biology	Electron microscopy, organelle functions, membrane models
Biochemistry	Krebs cycle, ATP, enzyme kinetics
Evolution	Modern synthesis of evolution and genetics
Medicine	Antibiotics, vaccines, immunology advances
Biotechnology	Genetic engineering, Human Genome Project, cloning
Gene Therapy	ADA-SCID trial (1990), CAR-T immunotherapy
Cloning	Recombinant DNA, Dolly the sheep (1996), therapeutic cloning

Summary

The **20th century** transformed biology into a **molecular and genetic science**. From the rediscovery of Mendel's laws to the sequencing of the human genome, biology became interconnected with **chemistry, physics, and technology**. **Gene therapy** and **cloning** stand out as revolutionary innovations: one offering hope for curing diseases at their root, the other showing the possibility of replicating life. Together, these achievements shaped the **21st century as the age of genomics, biotechnology, and bioethics**.