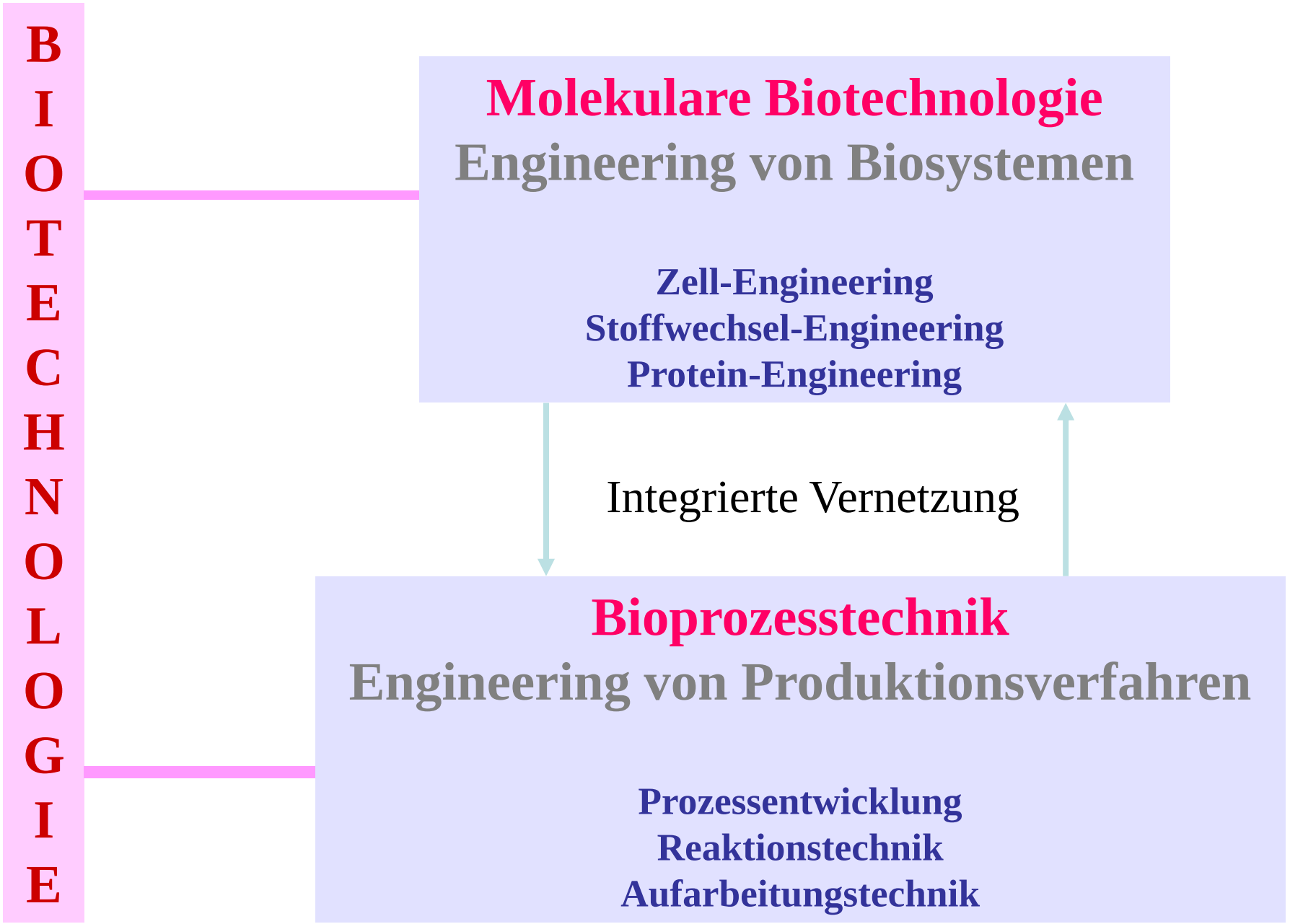

BIOTECHNOLOGIE
Molekulare Biotechnologie
Engineering von Biosystemen
Zell-Engineering
Stoffwechsel-Engineering
Protein-Engineering
Integrierte Vernetzung
Bioprozesstechnik
Engineering von Produktionsverfahren
Prozessentwicklung
Reaktionstechnik
Aufarbeitungstechnik

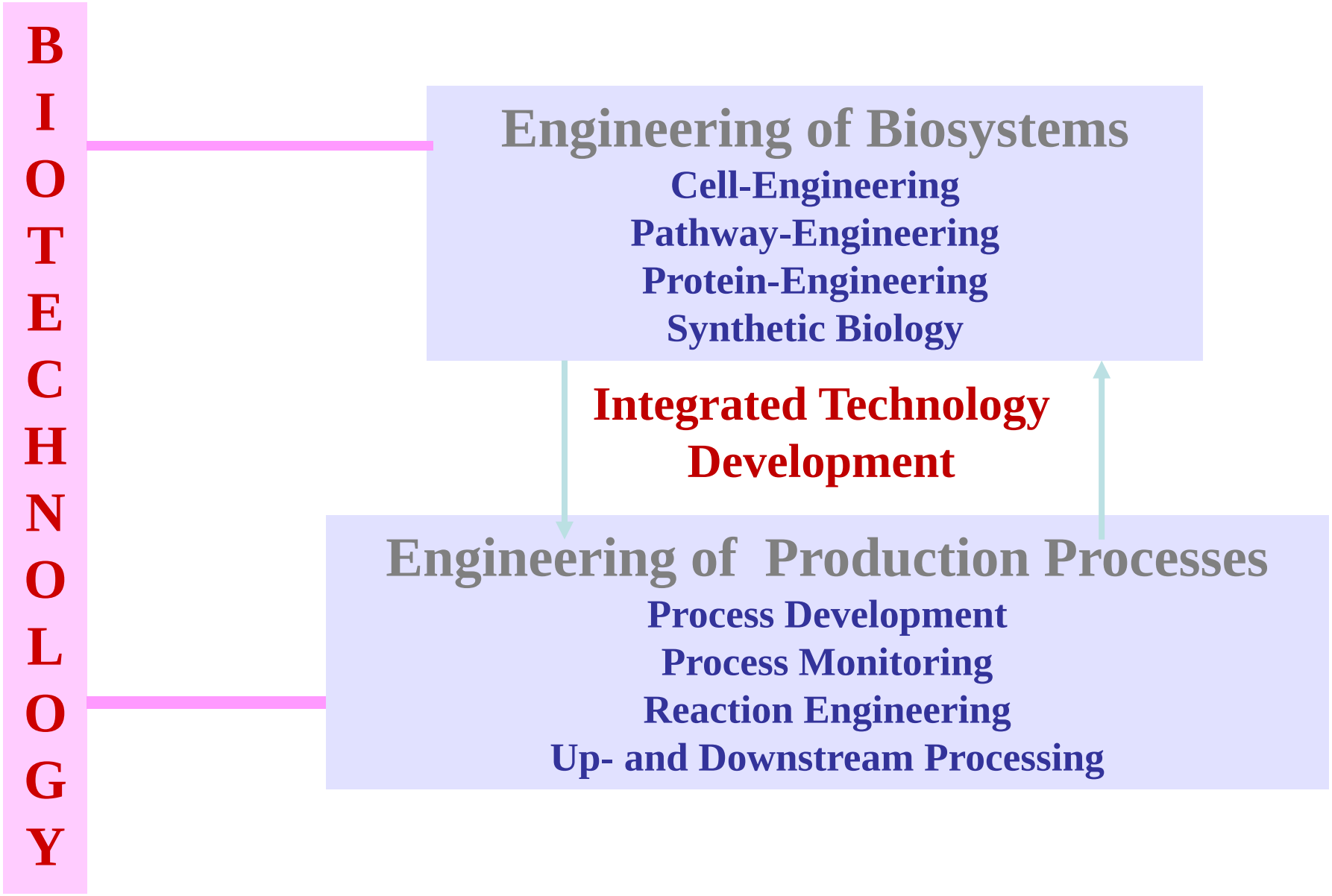
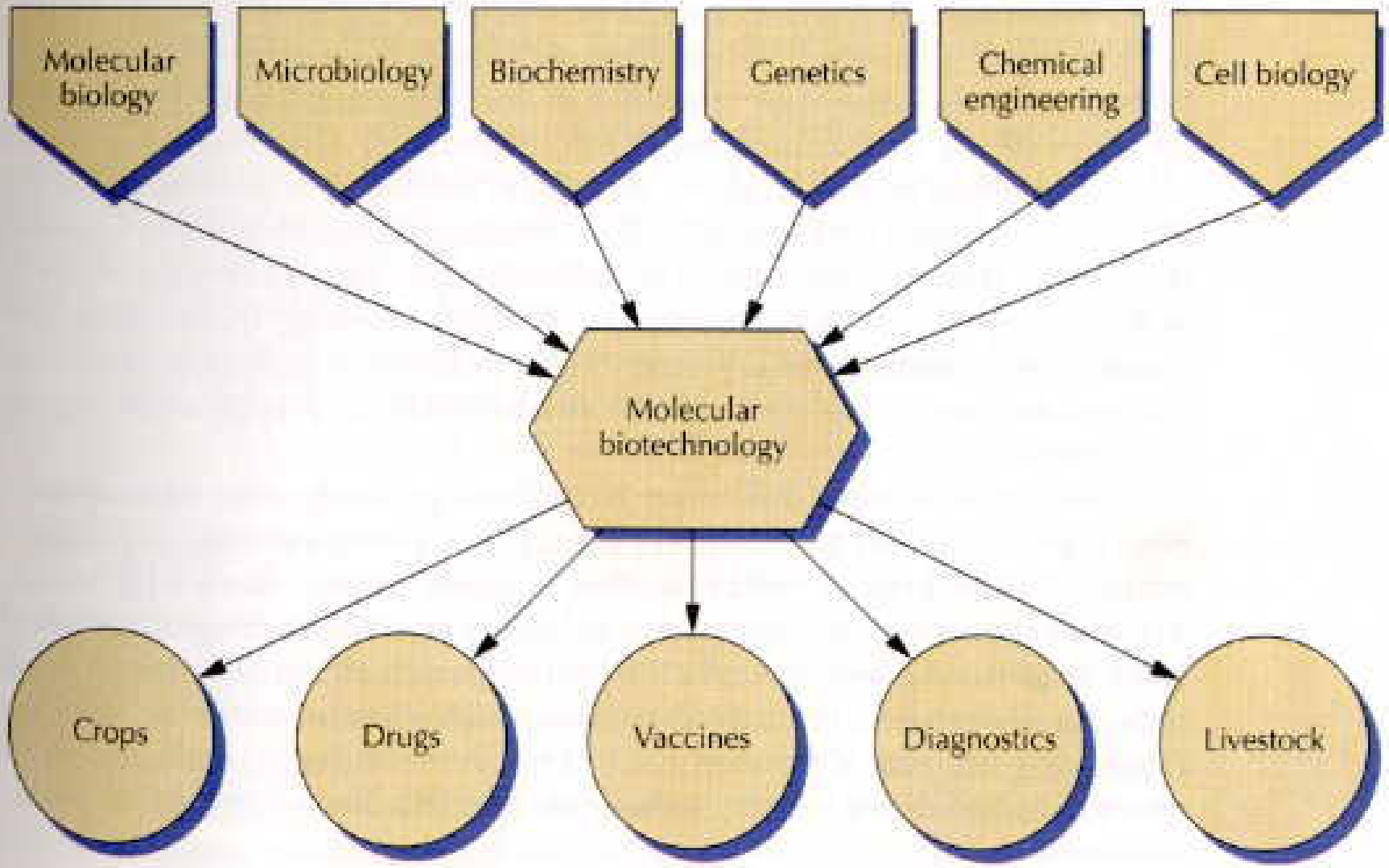

BIOTECHNOLOGY
Engineering of Biosystems
Cell-Engineering
Pathway-Engineering
Protein-Engineering
Synthetic Biology
Integrated Technology Development
Engineering of Production Processes
Process Development
Process Monitoring
Reaction Engineering
Up- and Downstream Processing

Figure 1.2 Many scientific disciplines contribute to molecular biotechnology, which generates a wide range of commercial products.



Molekulare Biotechnologie

Industrielle Biotechnologie - Biokatalyse

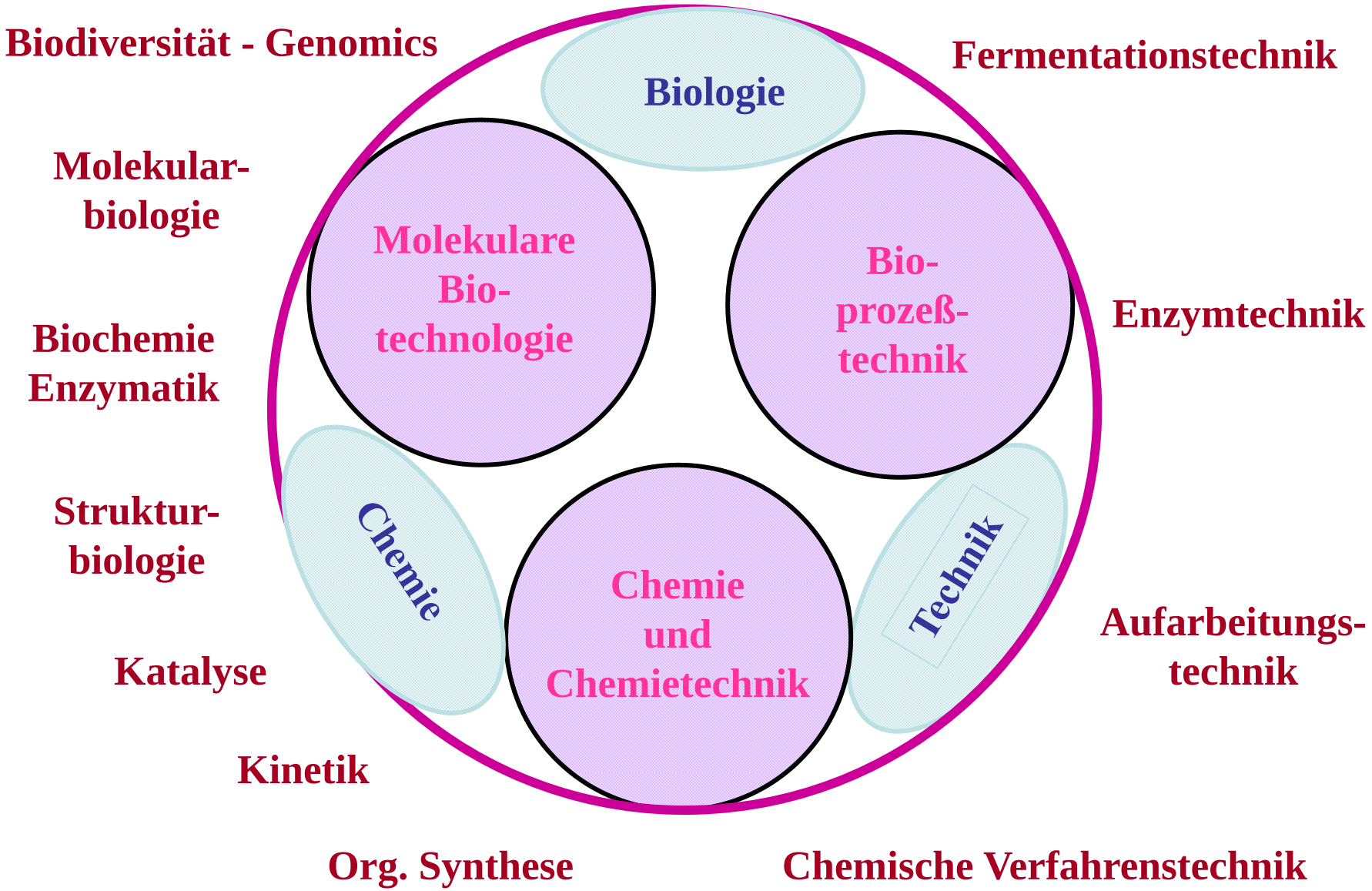


Table 1.1 Historical development of molecular biotechnology

Date	Event
1917	Karl Ereky coined the term *biotechnology*
1943	Penicillin produced on an industrial scale
1944	Avery, MacLeod, and McCarty demonstrated that DNA is the genetic material
1953	Watson and Crick determined the structure of DNA
1961	Journal *Biotechnology and Bioengineering* established
1961–1966	Entire genetic code deciphered
1970	First restriction endonuclease isolated
1972	Khorana and coworkers synthesized an entire tRNA gene
1973	Boyer and Cohen established recombinant DNA technology
1975	Kohler and Milstein described the production of monoclonal antibodies
1976	First guidelines for the conduct of recombinant DNA research issued
1976	Techniques developed to determine the sequence of DNA
1978	Genentech produced human insulin in *E. coli*
1980	U.S. Supreme Court ruled in the case of *Diamond v. Chakrabarty* that genetically manipulated microorganisms can be patented
1981	First commercial automated DNA synthesizers sold
1981	First monoclonal antibody-based diagnostic kit approved for use in the United States
1982	First animal vaccine produced by recombinant DNA technology approved for use in Europe
1983	Engineered Ti plasmids used to transform plants
1988	U.S. patent granted for a genetically engineered mouse susceptible to cancer
1988	Polymerase chain reaction (PCR) method published
1990	Approval granted in the United States for a trial of human somatic cell gene therapy
1990	Human Genome Project officially initiated
1994–1995	Detailed genetic and physical maps of human chromosomes published
1996	First recombinant protein, erythropoietin, exceeds 1 billion dollars (U.S.) in annual sales
1996	Complete DNA sequence of all the chromosomes of a eukaryotic organism, the yeast *Saccharomyces cerevisiae*, determined
1997	Nuclear cloning of a mammal, a sheep, with a differentiated cell nucleus

Recent Years

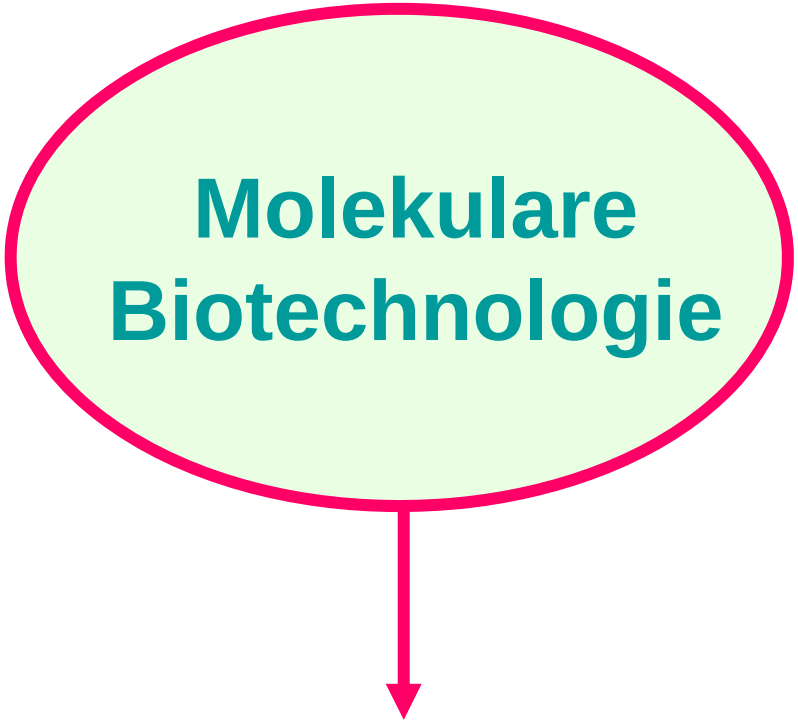
Recombinant Antibodies

High Throughput Sequencing

„Omics“

Systems Bio/techno/logy

Synthetic Bio(techno)logy



Gezieltes Engineering von Biosystemen

Ingenieurmäßige Planung
Exakte Ausführung nach Konstruktionsplänen

Engineering von Biosystemen

Selection of natural variants

natural diversity

Mutation - random genetic Changes

randomly induced mutagenesis

Induced evolution

Kreuzungen – genetische Rekombination

Sexual crosses

Induced cell fusion

parasexual systems (conjugation, transduction, transformation)

(Gezielte) Gene manipulationen – Recombinant DNA

in vitro Recombination of DNA

in vitro site-specific mutagenesis

„designed evolution“

directed evolution

Systems Biotechnology

Integrated understanding / modeling / ratio-based construction of biosystems/cells

Designed biosystems

Synthetic Biology

De novo design and construction of complex biosystems/cells

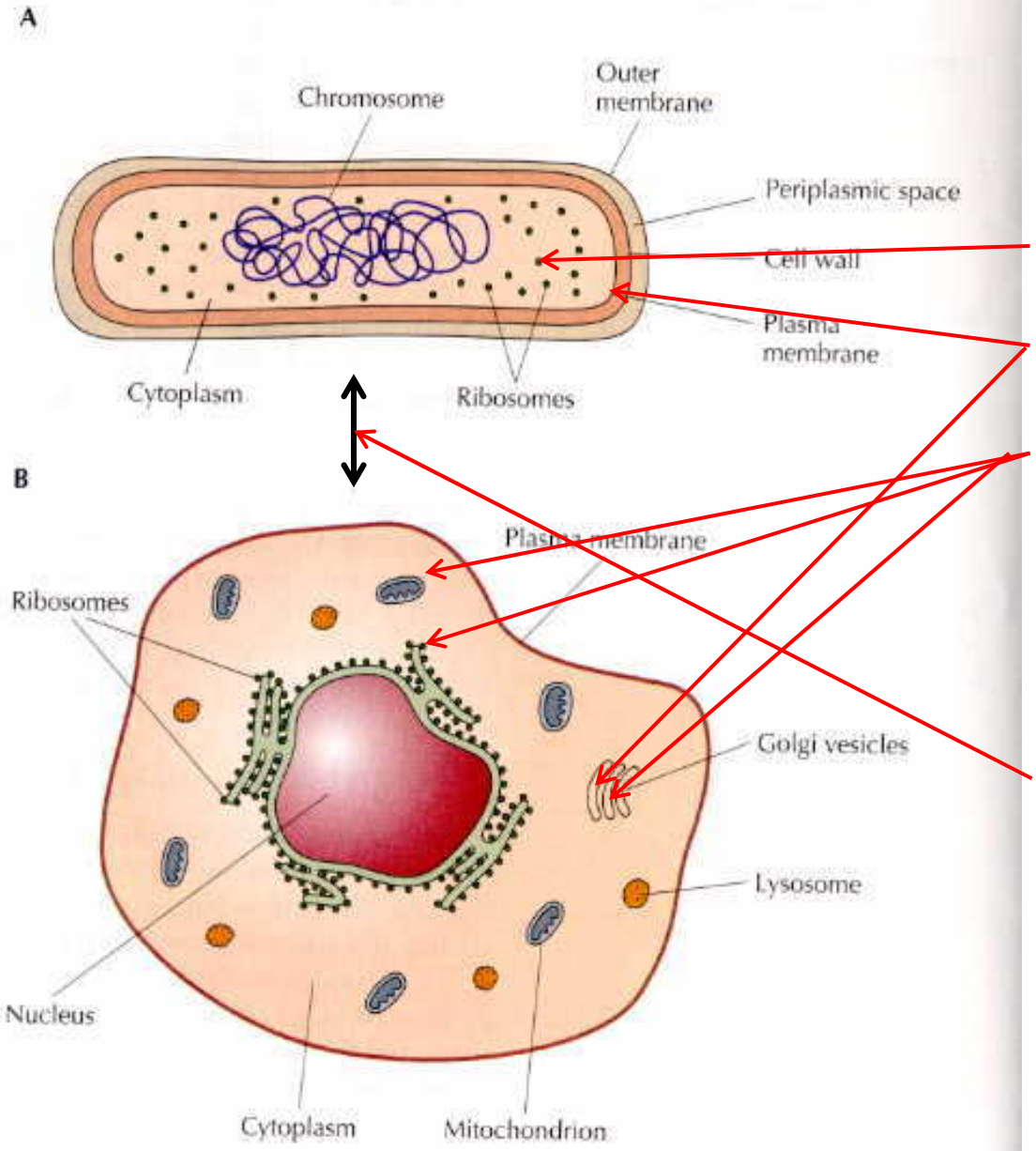
Engineering of Proteins

Enzymes
Funktional Proteins – Biopharmazeuticals

Improvement of the Traits of Enzymes and Proteins by Rational Design or Directed Evolution

Stability (T., pH, Solvents …)
Activity (v_{max} , K_m …)
Substrate specificity (
Selectivity (Enantioselectivity, position specificity ..)
Affinity
…. etc.

Figure 2.1 Schematic representations of a prokaryotic bacterium **(A)** and a eukaryotic animal cell **(B)**.



Important Cell Functions

Metabolism

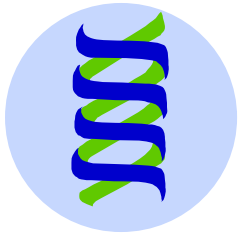
Transport

Specialised Compartments
- Protein clusters
- Membranes
- Organelles
- Cytosceleton

Communication

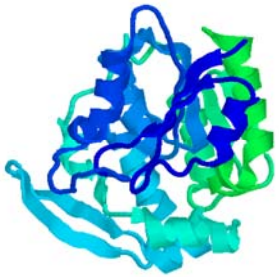
ORGANISMS

GENOME

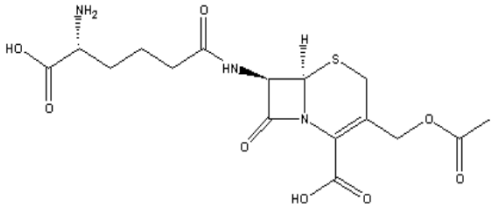


TRANSCRIPTOME

PROTEOME

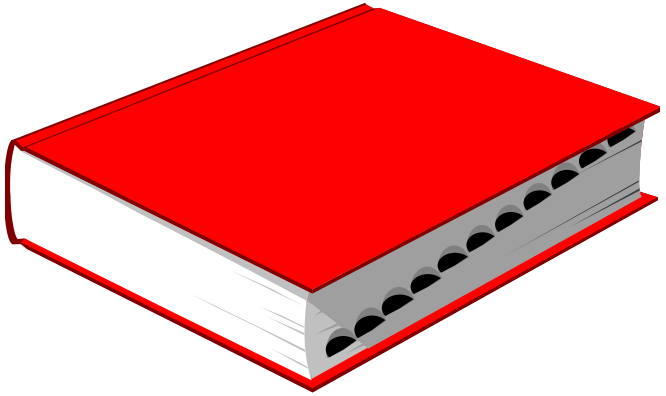


METABOLOME



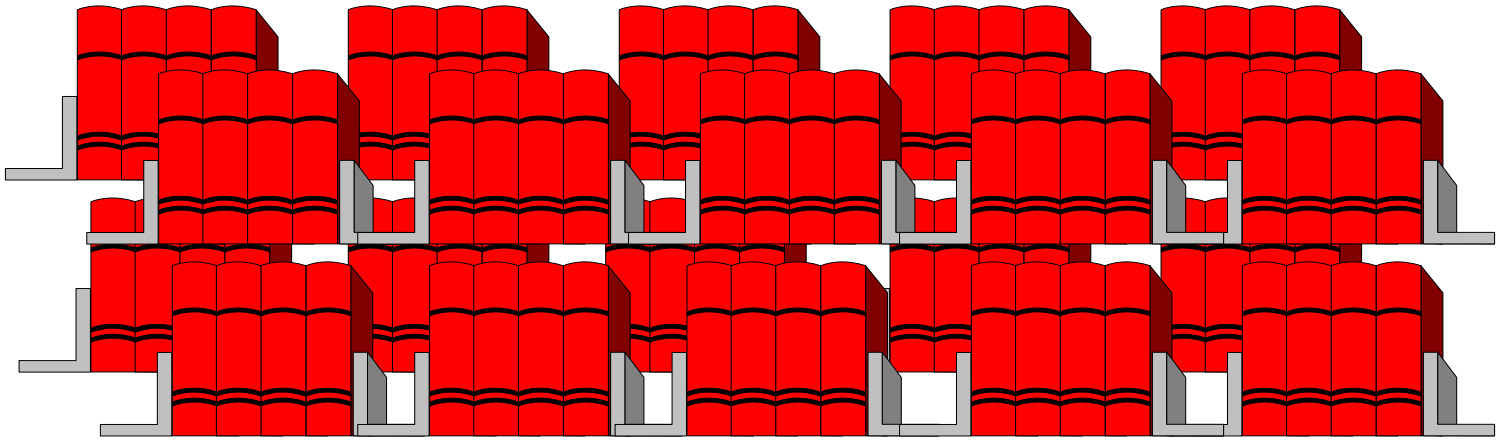
Gene: Menge an Information

1 Gen: 1 Seite mit 2000 Buchstaben



Bakterium. 1 Buch mit 2300 Seiten ($4{,}6 \times 10^6$ Nukleotide)

Mensch: 1 Bibliothek mit 717 Bänden zu 2300 Seiten ($3{,}3 \times 10^9$ Nukleotide)



Recombinant DNA Technology (Cloning)

Construct proper Vectors

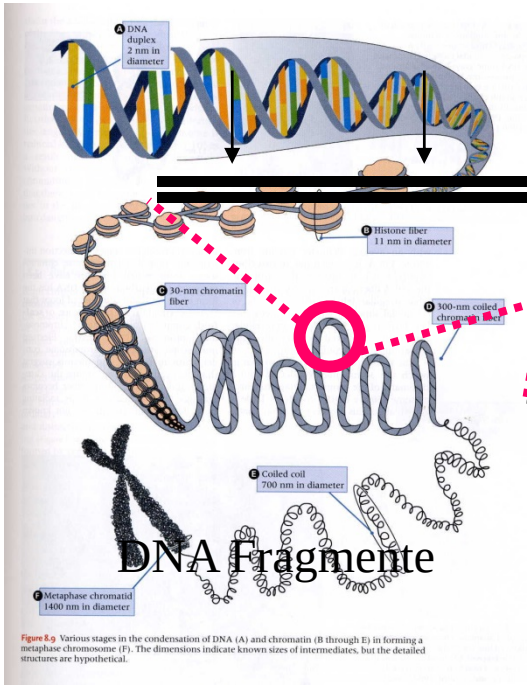


Figure 8.9 Various stages in the condensation of DNA (A) and chromatin (B through E) in forming a metaphase chromosome (F). The dimensions indicate known sizes of intermediates, but the detailed structures are hypothetical.

Creating defined Gene Elements – DNA Fragments

DNA Fragmente

Vector DNA

ori

Selection marker

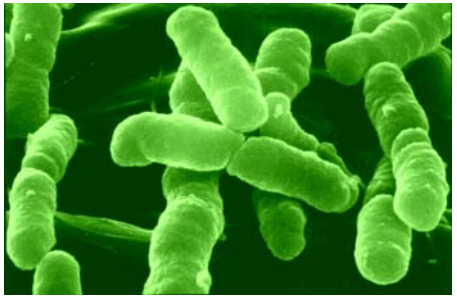
Combine Fragments with Vector

cut Vector DNA

ori

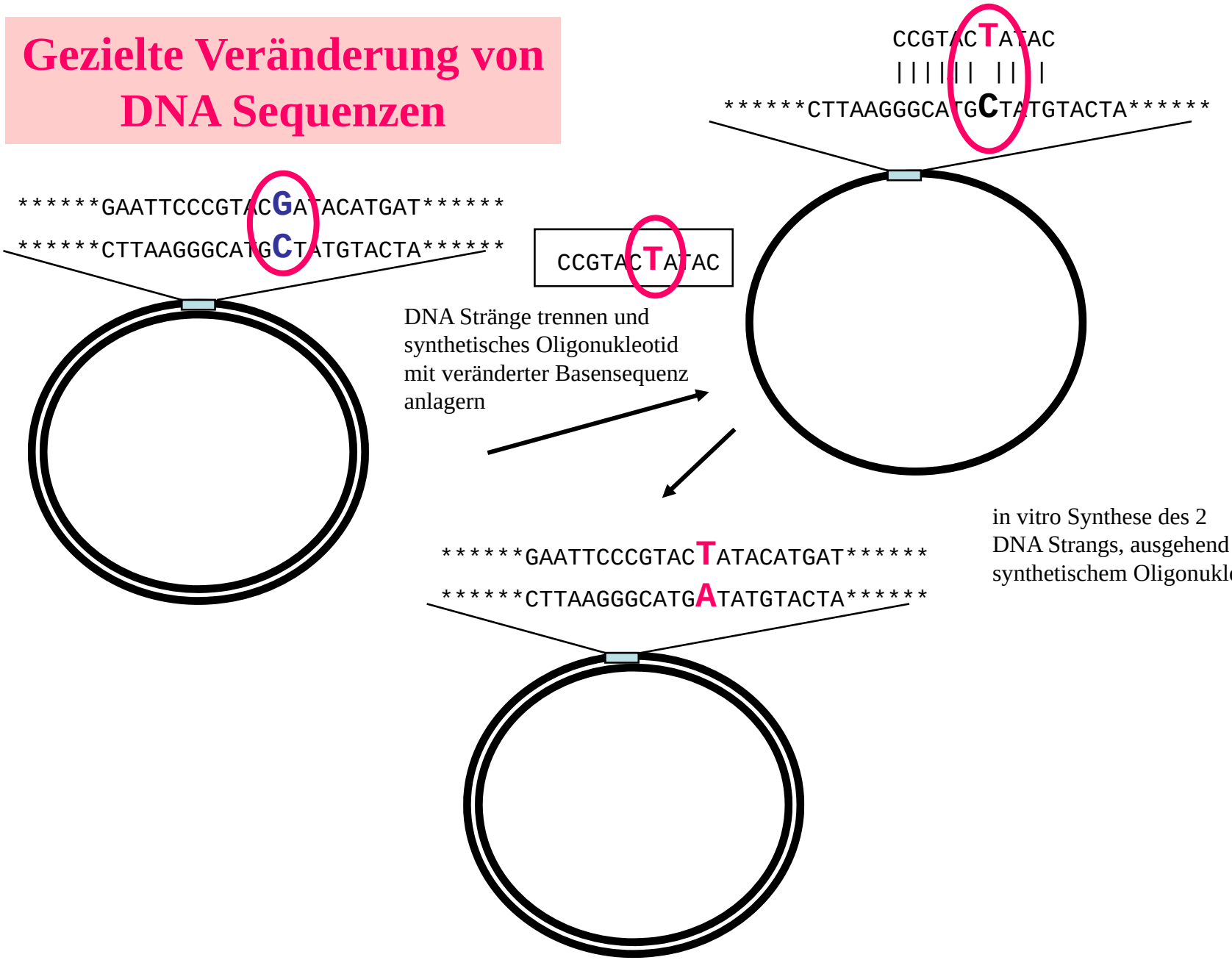
Selection marker

Transfer in Living Cells



recombinant DNA Molecule

ori

Amp^r

Gezielte Veränderung von DNA Sequenzen