TECHNIQUES OF MOLECULAR BIOLOGY:

GENE EXPRESSION

Instructor: Dr. M. A. Srour

Course: Molecular Biology (BIOL 333)

Textbook:
Watson J, et al. (2014). Molecular Biology of the Gene, 7th ed. Chap 7

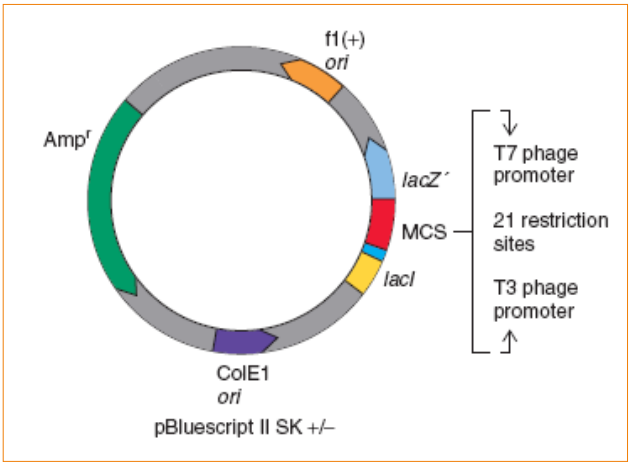
Gene expression

- Why would we want to express a gene?
- To study gene structure & expression
- To make a large quantity of the gene's product, either for investigative purposes or for profit

- If the goal is to use bacteria to produce an eukaryotic gene> use of cDNA works better
- If an eukaryotic cell is used > cDNA usually is preferred
- Applications of gene expression: recombinant protein production (Biotechnology)

Prokaryotic Expression vectors

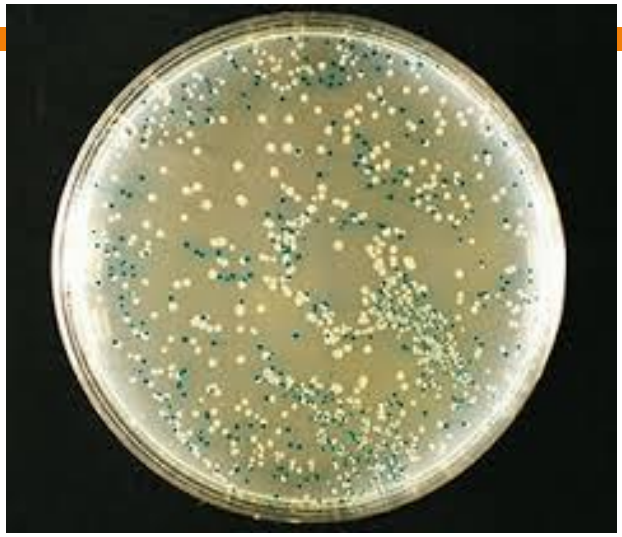
- Ampicillin resistance gene
- Origin of replication (ori)
- Phage f1 origin of replication
- MCS contains 21 unique restriction sites



The pBluescript vector

- MCS is situated between two phage RNA polymerase promoters (T7 and T3)
- MCS is embedded in an *E. coli lacZ´gene (blue), so the* uncut plasmid will produce the β-galactosidase N-terminal fragment when an inducer such as isopropylthiogalactoside (IPTG) is added to counteract the repressor made by the *lacI gene (yellow). Thus, clones* bearing the uncut vector will turn blue when the indicator X-gal is added.
- By contrast, clones bearing recombinant plasmids with inserts in the MCS will have an interrupted *lacZ´gene, so no functional* β-galactosidase is made. Thus, these clones remain white.

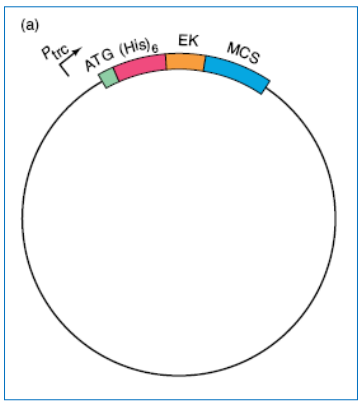
Image source: Wikimedia Commons; Accessed 6/3/15. Author: Stefan Walkowski



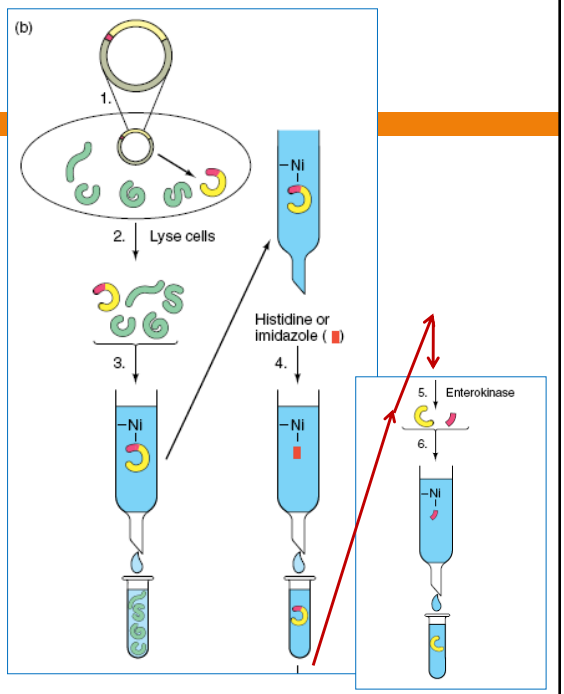
Expression systems

- Produce recombinant proteins, e.g, therapeutic proteins like GH, G-CSF, insulin
- Eukaryotes vs. prokaryotes
- Prokaryotes: lac promoter- induce with IPTG (lactose analog) > inducible promoter
- 6-His tag (epitope Tag) at C- or N-terminus for purification: bind to matrix with chelated nickel and release with low pH

Prokaryotic expression vectors that produce fusion proteins



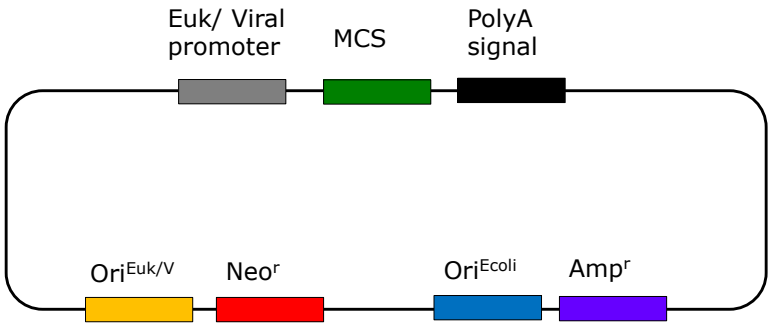
EK: a recognition site for the proteolytic Enzyme enterokinase



Using an oligohistidine (6xHis) expression vector

1. The gene of interest (yellow) is inserted into the vector in frame with the 6xHis (red), > Transform host cells > Cells produce the fusion protein (red and yellow), plus other proteins (green).
2. Lyse the cells, releasing the mixture of proteins.
3. Pour the cell lysate through a nickel affinity chromatography column, which binds the fusion protein but not the other proteins.
4. Release the fusion protein from the column with histidine or with imidazole, a histidine analogue, which competes with 6xHis for binding to the nickel
5. Cleave the fusion protein with Enterokinase (EK)
6. Pass the cleaved protein through the nickel column once more to separate 6xHis from the desired protein

Eukaryotic Expression vectors

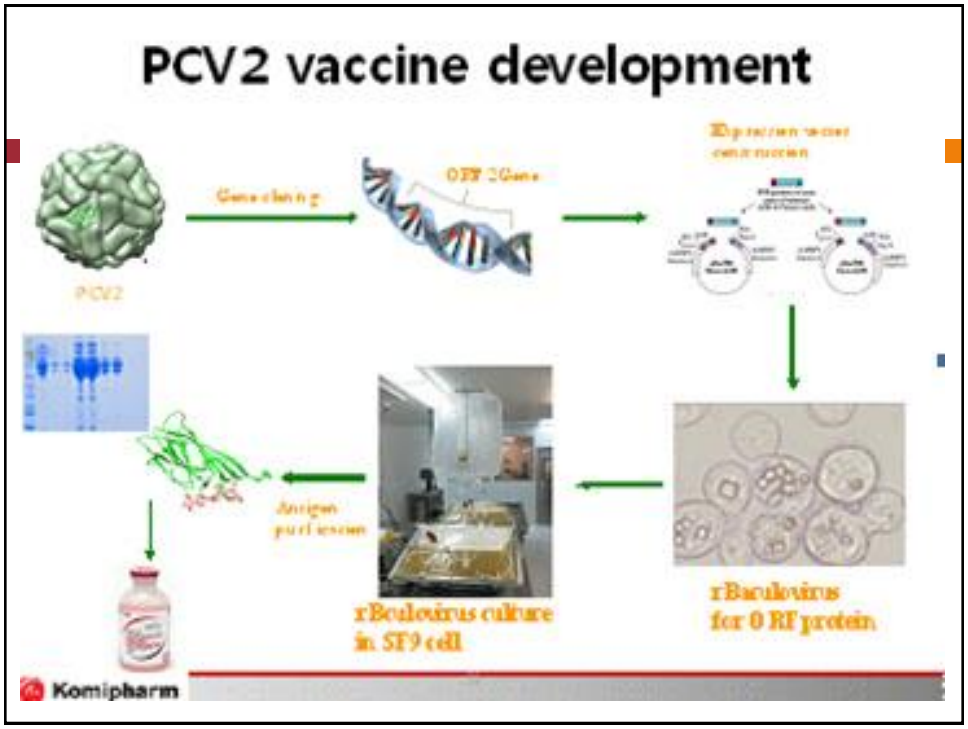


Basic elements of an Eukaryotic Expression vector

- **Euk/Viral promoter:** eukaryotic or viral promoter, inserted upstream of MCS, e.g HCMV promoter
- **MCS:** multiple cloning site, used to insert the gene or cDNA of interest
- **PolyA signal:** termination signal for transcription
- **Ori euk/Viral:** eukaryotic or viral ori, allows the plasmid to replicate inside eukaryotic cells ((Optional))
- **NeoR:** neomycine resistance gene, allows selection of plasmid inside eukaryotic cells
- **Ori E. coli & AmpR:** allows replication of plasmid inside E coli cells and selection, respectively

Production of eukaryotic proteins

- Advantages of eukaryotic systems over prokaryotic systems:
- Eukaryotic proteins made in eukaryotic cells tend to be properly folded & not aggregated into insoluble inclusion bodies
- Eukaryotic proteins made in eukaryotic cells are modified in a eukaryotic manner


PCV2 vaccine development
PCV2
rBaculovirus culture in SF9 cell
rBaculovirus for ORF protein
Komipharm


ADVATE
Baxter

Production of recombinant proteins

- Obtain cDNA
- Insert cDNA into plasmid/ expression vector
- Transfect/transform plasmid into appropriate host cells
- Downstream processing

Production of Eukaryotic proteins in ***E. coli*** from plasmid vectors containing **lac promoter**.

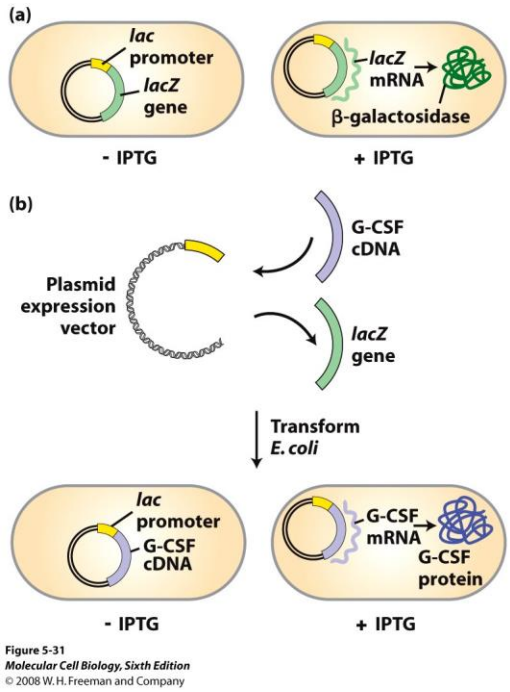


Figure 5-31
Molecular Cell Biology, Sixth Edition

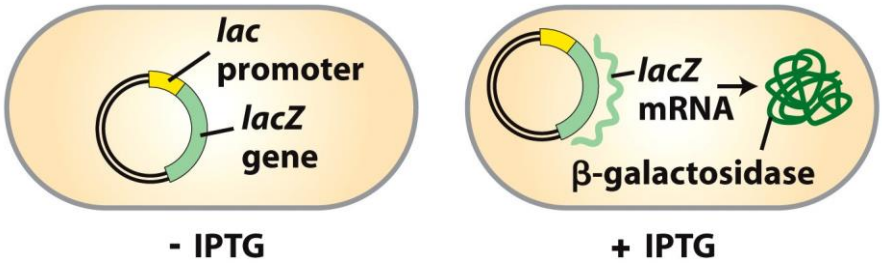


Figure 5-31a
Molecular Cell Biology, Sixth Edition

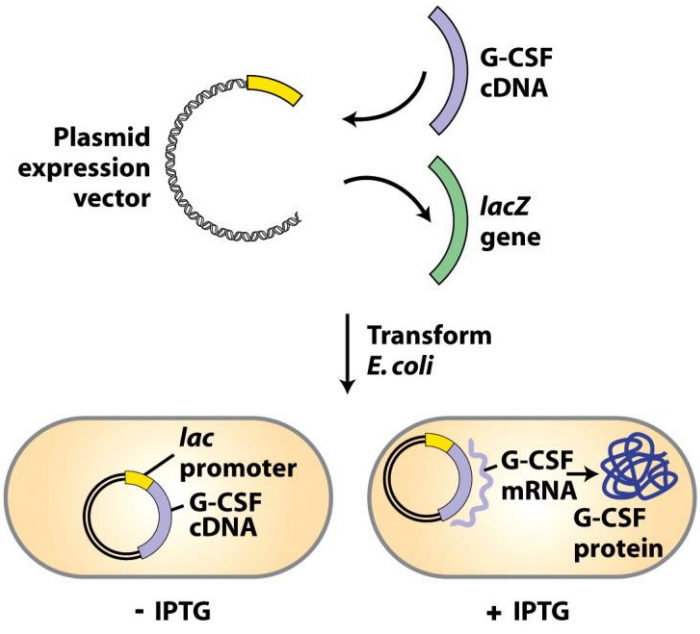
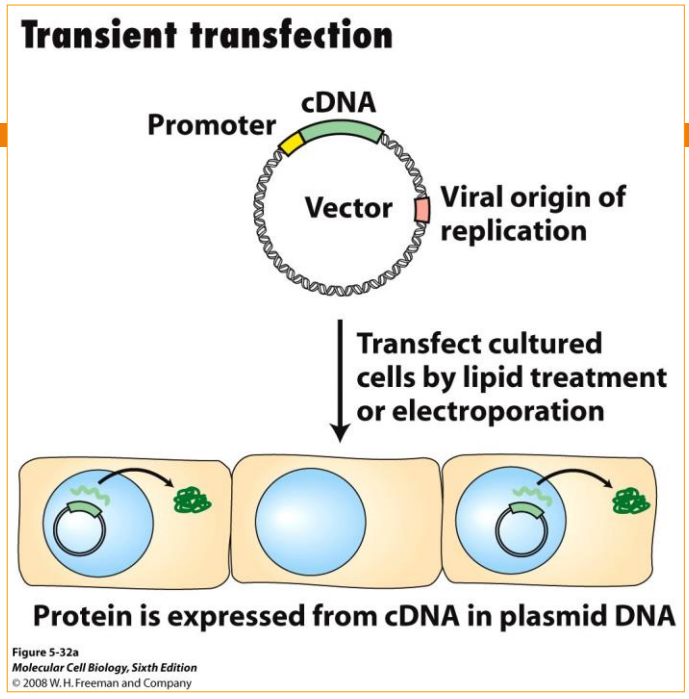
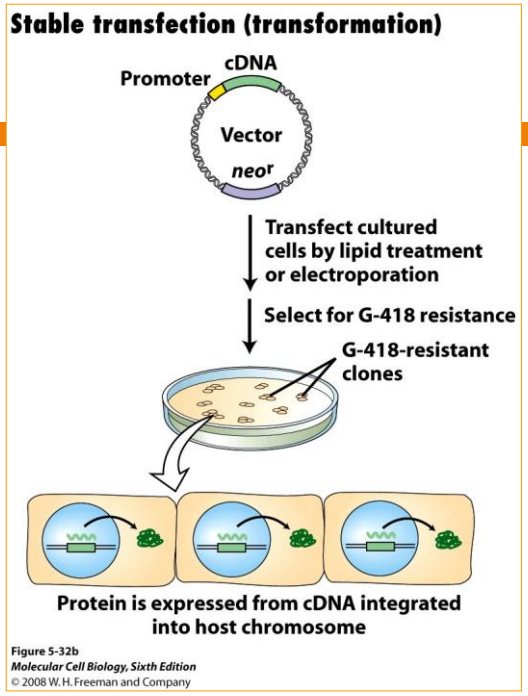


Figure 5-31b
Molecular Cell Biology, Sixth Edition

Transfection of animal cells

- Method: Calcium phosphate; liposomes; electroporation; or by direct physical methods like microinjection using fine glass pippettes or firing metallic microparticles coated with DNA using "gene gun".
- Transient transfection: short-term expression from strong promoter, plasmid lost during cell division
- Stable transfection: vector integrates into host chromosome; cells selected using selectable markers like neo^r (neomycin phosphotransferase; select with Geneticin or G-418)



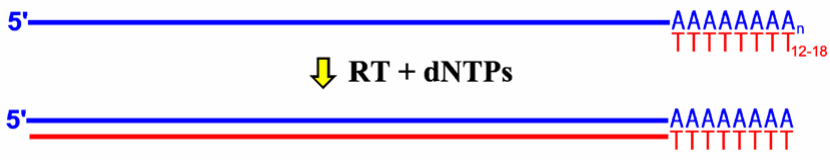


Genomic & cDNA libraries

- **Genomic library**: a collection of DNA molecules each cloned into a vector molecule (e.g, λ-clones) representing all DNA sequences in the genome of an organism
- **cDAN library**: a collection of cDNA molecules each cloned into a vector molecule (e.g, λ-cDNA clones) representing all the mRNAs expressed in a cell type (tissue-type specific)
- **cDNA:** DNA molecule copied from an mRNA by reverse transcription

Preparation of cDNA

- Preparation of mRNA (or total RNA) from target tissue
- Synthesis of DNA-RNA hybrid (first strand) using
  - Reverse transcriptase (RNA dependent DNA Polymerase)
  - Oligo-dT primer or random priming (hexamers) or gene-specific primers
  - RNAse inhibitor
- Synthesis of second DNA strand & amplification by conventional PCR using a pair of gene-specific primers



- Genomic DNA library:
- http://www.sumanasinc.com/webcontent/animations/content/dnalibrary.html
- cDNA library:
- https://www.youtube.com/watch?v=qMcdzn6tLPE

Synthesis of cDNA

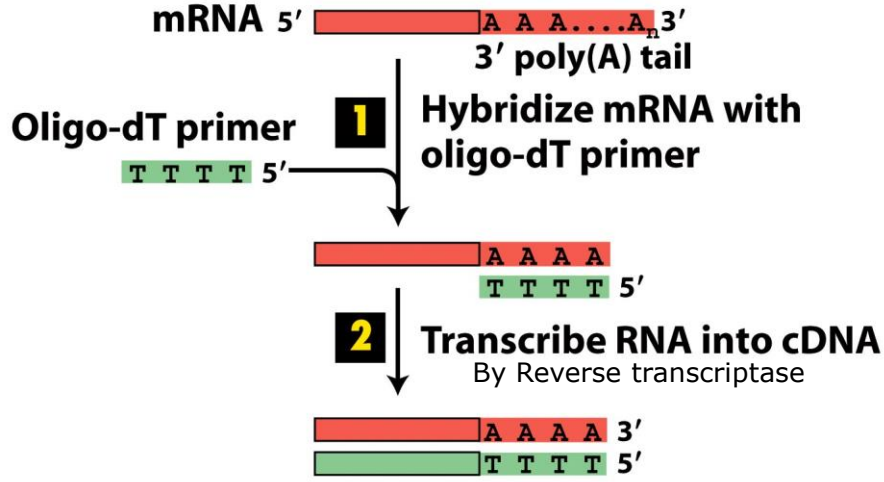
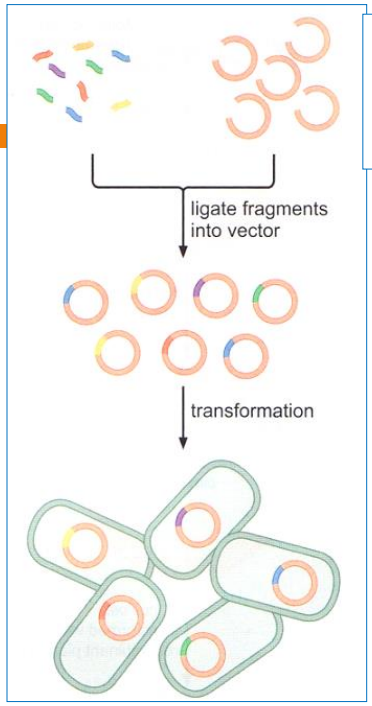


Figure 5-15 part 1
Molecular Cell Biology, Sixth Edition

Applications of cDNA

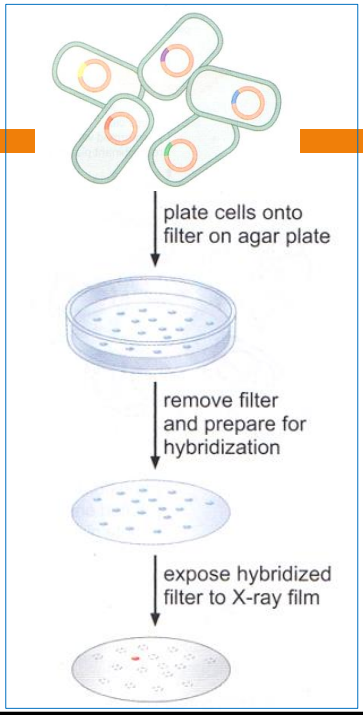
- cDNA can be used for:
  - Cloning
  - DNA sequencing
  - Generation of cDNA library
  - Analysis of gene expression

Construction of a Genomic DNA library

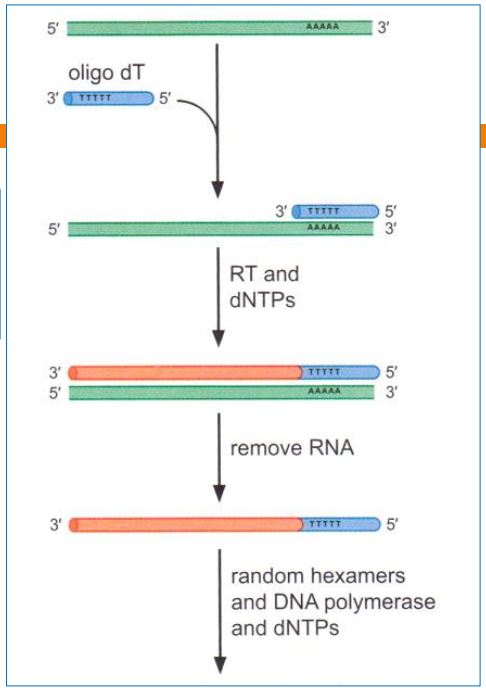


Partial digestion of genomic DNA, & digestion of vector by same RE

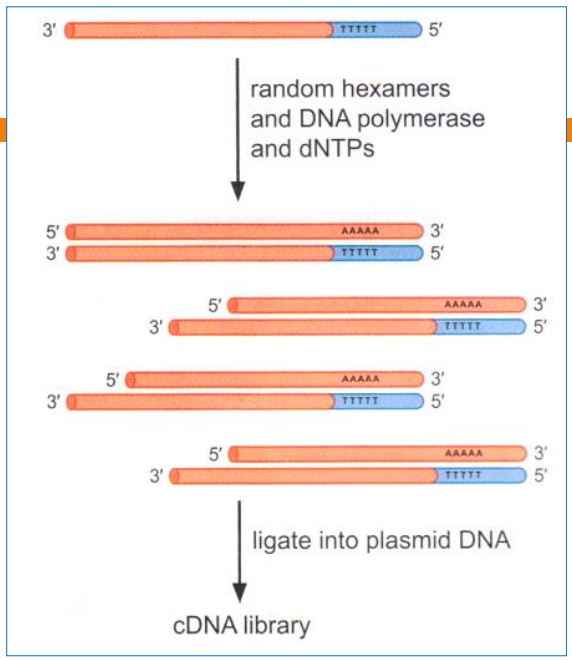
Construction of a Genomic DNA library



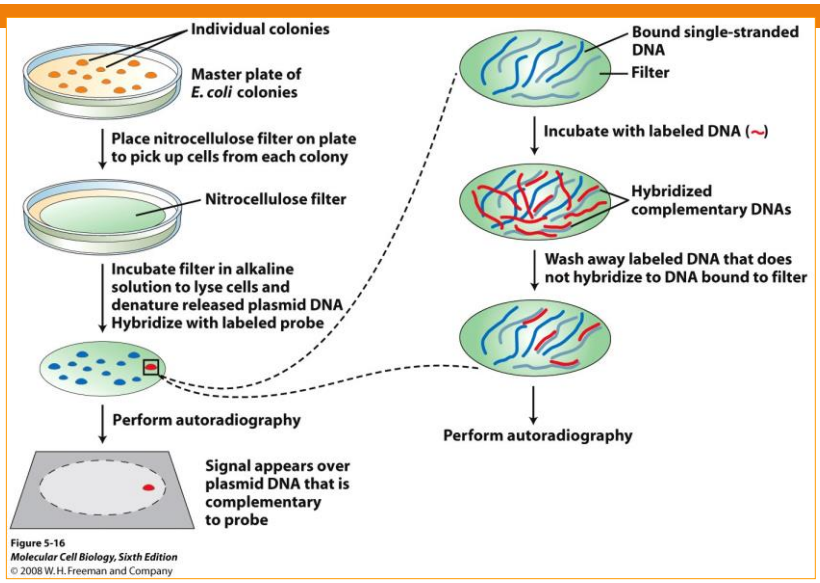
Construction of a cDNA library



Construction of a cDNA library



Screening of a cDNA library by ***Hybridization*** to a labeled oligonucleotide **probe**



From protein to DNA; or from DNA to protein?

- Synthesis of a probe based on aa sequence

6 6 1 2 1 3 2 4 1 6
Arg-Leu-Met-Glu-Trp-Ile-Cys-Pro-Met-Leu

How many different 17-mers are needed?

5aa+first 2 bases of 6th aa,

Met-Glu-Trp-Ile-Cys (15 nts)> 1X2X1X3X2=12 probes;

Plus first 2 bases of Pro (CC; CCU/A/C/G)