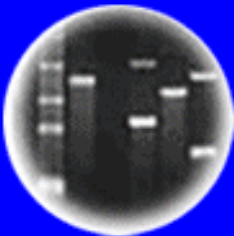


DNA
Genetic Code of Life



Entire Genetic Code
of a Bacteria



DNA Fingerprinting



Cloning: Ethical Issues
and Future Consequences



Plants of Tomorrow

HC70A & PLSS059

Winter 2020

Genetic Engineering in Medicine, Agriculture, and Law

Professors Bob Goldberg & Channapatna
Prakash

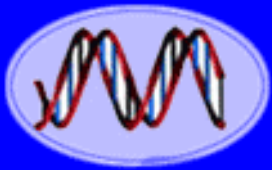
Lecture 1

The Age of DNA: What Is Genetic Engineering-Part One

Please Turn Off Your Cell Phones!!

UCLA

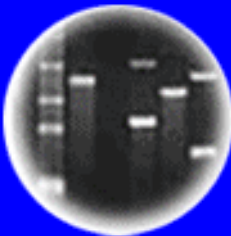
TUSKEGEE
UNIVERSITY



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LECTURE THEMES

1. Genetic Engineering and DNA in the News!
2. What is a *GMO*?
3. What is Genetic Engineering?
4. What Do Genes Look Like - DNA Demonstration
5. How Was Modern Genetic Engineering Invented & What Is the Genetic Engineering Process?
6. Why Use Genetic Engineering?
7. How Has Genetic Engineering Affected Our Lives?
8. How Has Genetic Engineering Created New Ethical and Legal Issues?
9. Genetic Engineering in Medicine, Agriculture, Law, & Society - Some Examples

Just Say
No To
GMO



The Politics of...

GMOs

GMO salmon gets FDA green light to be sold in the US

Congress Passes GMO Food Labeling Bill

FDA, EPA approve 3 types of genetically engineered potatoes

Justices Back Monsanto on Biotech Seed Planting

Human Gene Editing Receives Science Panel's Support

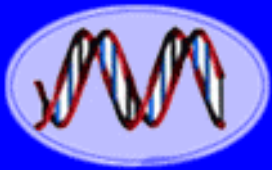
NIH supports call for moratorium on clinical uses of germline gene editing



Genetic Details of Controversial "3-Parent Baby" Revealed

NO ON 37
STOP THE DECEPTIVE
FOOD LABELING SCHEME

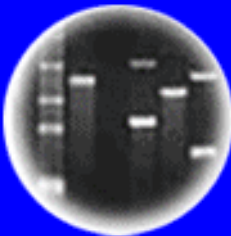




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Genetic Engineering in the News.. Law

Justices, 9-0, Bar Patenting Human Genes

Harvard and M.I.T. Scientists Win Gene-Editing Patent Fight

***Chinese Scientist Who Genetically
Edited Babies Gets 3 Years in Prison***

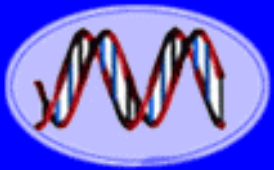
DNA Test Frees Man After 34 Years In Prison

Supreme Court OKs DNA swab of people under arrest

New federal rules limit police searches of family tree DNA databases

Supreme Court Supports Monsanto in Seed-Replication Case

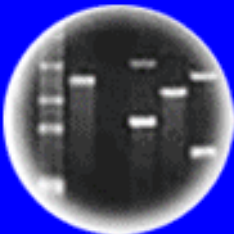
Congress Passes Bill to Bar Bias Based on Genes



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Genetic Engineering in the News.. *Medicine*

In Girl's Last Hope, Altered Immune Cells Beat Leukemia

New gene therapy appears safe, feasible for sickle cell disease

British Lawmakers Approve 'Three-Parent' In-Vitro Fertilization



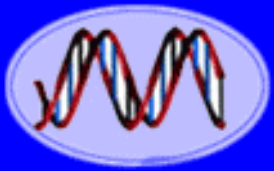
China Quietly Confirms a Third CRISPR-Edited Baby Has Been Born



Genome-edited baby claim provokes international outcry

Gene edits to 'CRISPR babies' might have shortened their life expectancy

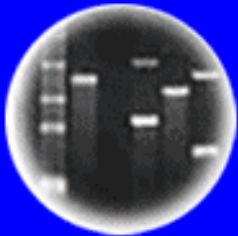
Scientists Talk Privately About Creating a Synthetic Human Genome



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DNA Fingerprinting



Cloning: Ethical Issues
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Genetic Engineering in the News.. *Agriculture*

Genetically Modified Salmon Is Safe To Eat,
FDA Says

**Super-muscly pigs created
by small genetic tweak**

Gene-Altered Apples and Potatoes Are Safe, F.D.A.
Says

GM Wheat Used to Make Bread with Less Gluten

*GM banana shows promise
against deadly fungus strain*

**Scientists hack plant
photosynthesis to boost crop yields
by 40%**

January 3, 2019

And All the GMO Misconceptions!!!!



Diseases caused by GMO food:

Carnosaur virus
Dar-Kosis
Vampiris
Clone-Killing Nanovirus
Black Trump Virus
The Sickness/Imperial bioweapons project 171A/Project: Blackwing
Neurological Degeneration Syndrome, or NDS
Hinamizawa Syndrome
Hapallitis V
Cluckitis
Hot Dog, Fingers

Fb/A Science Enthusiast

TS-19
Rooze
Purity
Maternal Death Syndrome (MDS)
Neurodermatitis
Pale Mare (also known as the Bloody flux)
Stone Sickness
Coolies
Vampiris
T4 Angel Virus
Synaptic/Neuro-Oversimulation Syndrome (SOS/NOS)
Herod's Flu (SHEVA)

Sources: https://en.wikipedia.org/wiki/List_of_fictional_diseases

Don't label GMOs



BAN THEM !!! A.H.

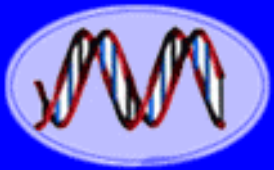


Don't Trust The Feds

organicconsumers.org

On GMOs, Pesticides & Chemicals

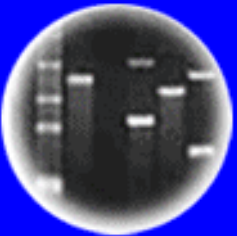




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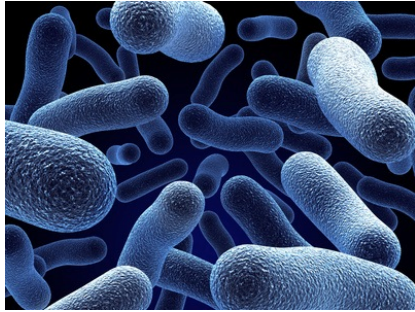


Plants of Tomorrow

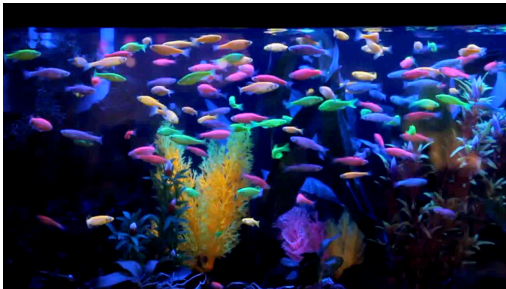
What's a GMO???



So.....What is a GMO?



*A Genetically Engineered Bacteria
Synthesizing
Human Insulin Used as a Drug to
Treat Diabetics?*



*A Genetically Engineered GloFish
Used as a Pet?*



*A Genetically Engineered Pig
With Double Muscles For Leaner
& More Meat?*



*A Genetically Engineered Yeast
That Synthesizes a Plant Protein
Giving the Impossible Burger Its
Red Color?*

So.....What is a GMO?



A Bacteria With a Genome Synthesized in a Laboratory?



A Yeast With Chromosomes Synthesized in a Laboratory?



A Genetically Engineered Bacteria Making Blue Dye For Jeans?



A Genetically Engineered Goat Making a Human Anti-Clotting Drug?

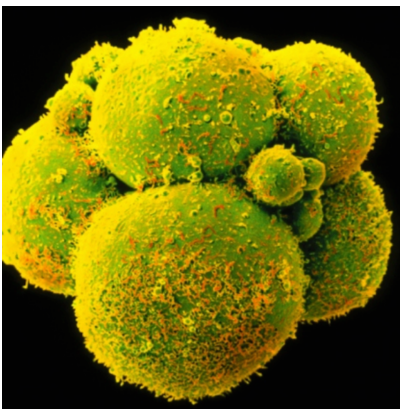
So.....What is a GMO?



A Genetically Engineered Salmon That Grows Faster Than Non-Engineered Salmon & Has Been Approved by the FDA For Human Consumption?



A Genetically Engineered Person With a Gene That They Weren't Born With That "Cured" Their Lethal Genetic Disease?



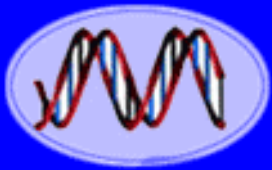
Babies Whose Genomes Were "Edited" to Make Them "Resistant" to the HIV Virus?



*And.....Crops That Are
Grown For For
Human & Animal
Consumption?*



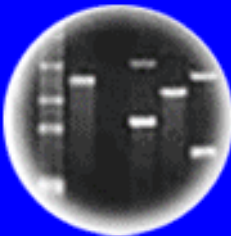
So.....What is a GMO?



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Cloning: Ethical Issues
and Future Consequences



Plants of Tomorrow



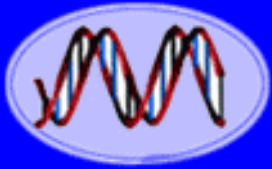
What is Genetic Engineering and a Genetically Modified Organism?

Directed Change of an Organism's Genetic Blueprint or DNA = GMO!!!!!!!



ge·net·ic en·gi·neer·ing
jə'nedik ,enjə'ni(ə)riŋg/
noun
noun: genetic engineering
the deliberate modification of the characteristics of an organism by manipulating its genetic material.

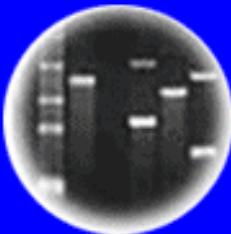




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DNA Fingerprinting



Cloning: Ethical Issues
and Future Consequences



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Genetic Engineering is the TECHNIQUE! That Generates GMOs

1. Classical Breeding By Selective Mating (Thousands of Years)
2. Insertion of a New Gene Into An Organism's Chromosomes (50 Years) - Transgenic Organism
3. Editing Existing Genes Like A "Word Program" (5 Years) - CRISPR Gene Editing

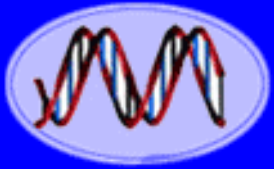
Breeding or DNA Manipulation - They
Are the SAME



&



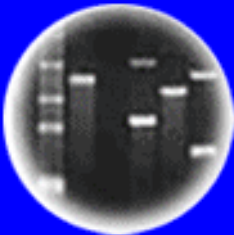
Called *Gene Engineering*
So..... **WHAT IS A GMO???**



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DNA Fingerprinting



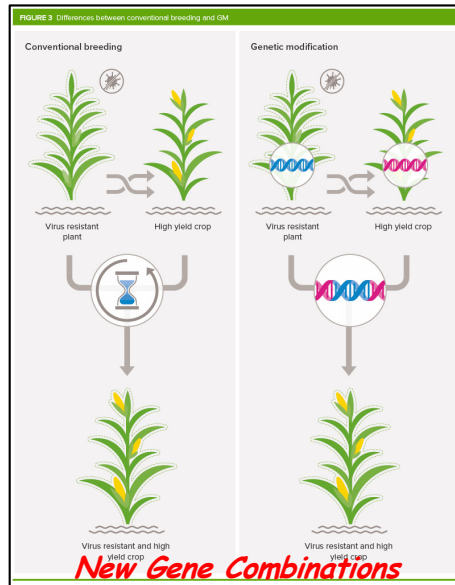
Cloning: Ethical Issues
and Future Consequences



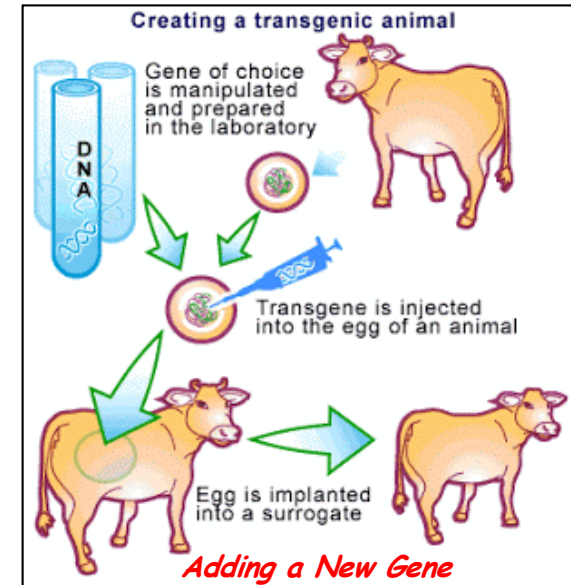
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Three Genetic Engineering Techniques That Generate GMOs!!!

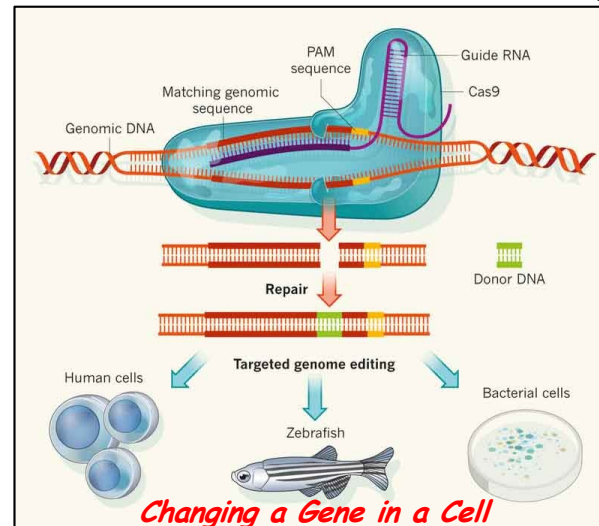
1. Classical Breeding



2. Transgenic Organism



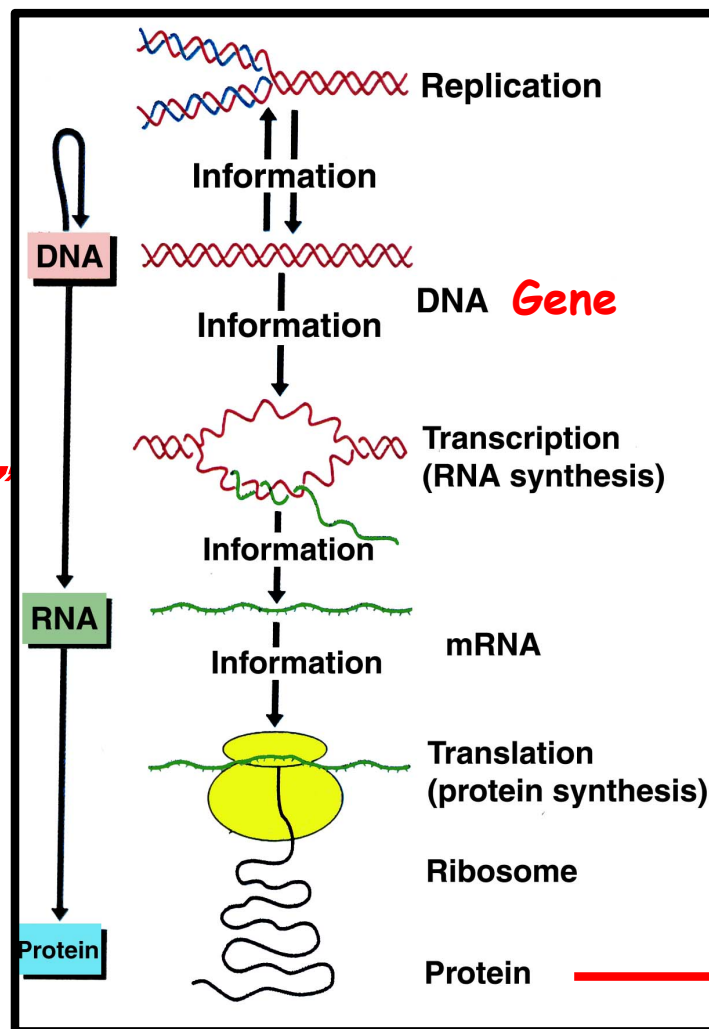
3. CRISPR Gene Editing



Genes & DNA Obey the Same Rules Using *Either* Classical or Modern DNA Engineering Approaches!! **BOTH Produce GMOs!!!!!!**

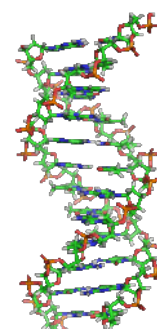
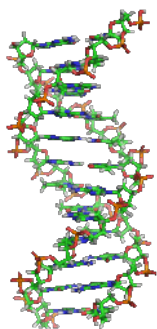
*Can Intervene
in This Process in
Cells*

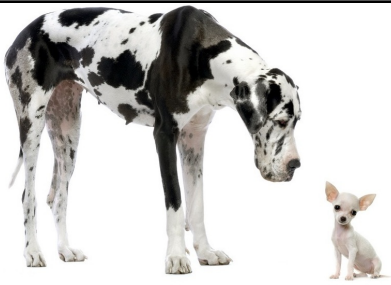
*Genetic Engineering
Is not "Hocus Pocus."
It Uses "Natural"
Cell Processes!!!!*



*All Organisms Use
The SAME Processes
And "RULES" to
Generate Traits!! And
The SAME Molecules
& Chemistry!!*

Coat Color Trait





Important HC70A Theme!

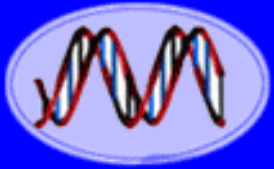


We Live in The Age of Genetic Engineering!

Genetic Engineering Is
Manipulating DNA! ALL GMOs
Have Engineered Genes

*By Classical Breeding
or With DNA in a Test Tube
It's All the Same!!!!*

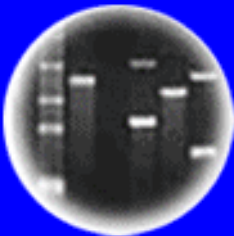




DNA
Genetic Code of Life



Entire Genetic Code
of a Bacteria



DNA Fingerprinting



Cloning: Ethical Issues
and Future Consequences

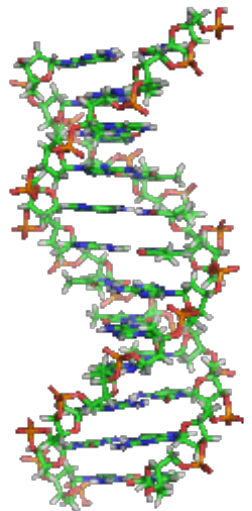
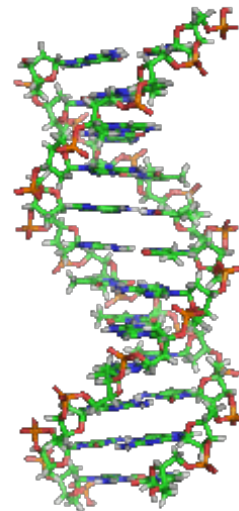
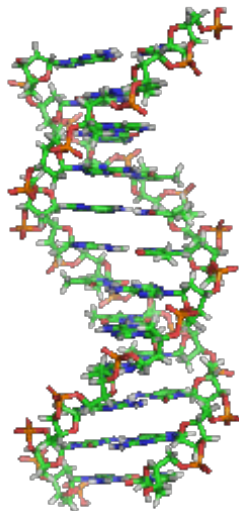


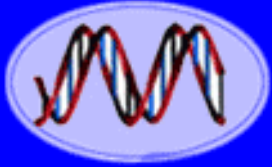
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What Does Your DNA Look Like?

Have You Ever Seen or Touched Your Genes?

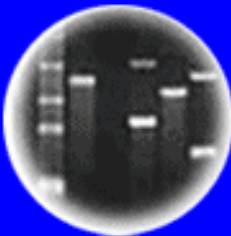




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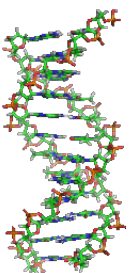
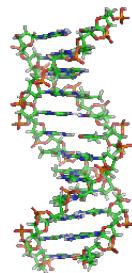


Plants of Tomorrow

How Was Genetic Engineering Using DNA Invented?

&

How Did It Lead To Remarkable Advances In Medicine, Agriculture, & Law?



DNA Genetic Engineering Has Been in the News For 45 Years!!! It's Old Technology!!!!!!

Gene Transplants Seen Helping Farmers and Doctors

By VICTOR K. MCELHENY MAY 20, 1974

1974

Debate on Shifting Genes Nearing a Critical Phase

By BOYCE RENSBERGER MAY 16, 1976

1976

Scientists Report Using Bacteria To Produce the Gene for Insulin; Bacteria Used to Make Insulin Gene

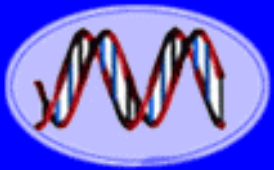
By HAROLD M. SCHMECK Jr. Special to The New York Times ();
May 24, 1977.

1977

Substance Usually Made in Brain Grown in Bacteria

By HAROLD M. SCHMECK JR. NOV. 3, 1977

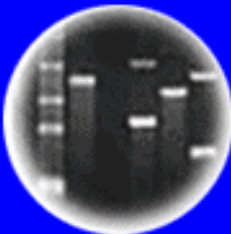
1976



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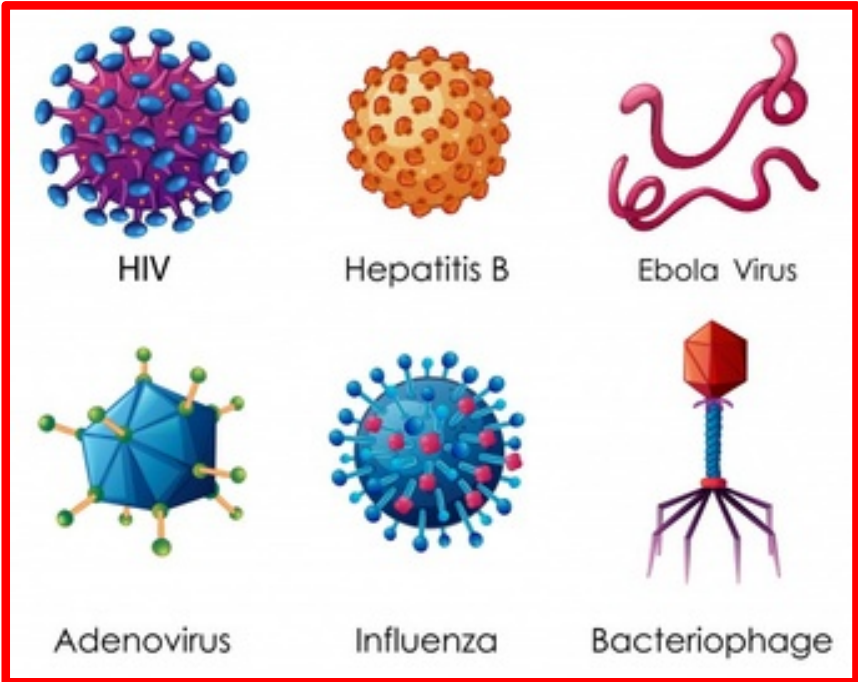


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The Idea That DNA From Different Species Could Be Recombined Started With Viruses ~50 Years Ago!

There is a
Variety of
Viruses That
Engage in
"Warfare"
With Living
Cells of
Diverse
Organisms

A Virus
Consists of a
Protein
Protective
Coat and a
Nucleic Acid
(DNA or
RNA)
Genome That
Contains Its
Genes



HIV

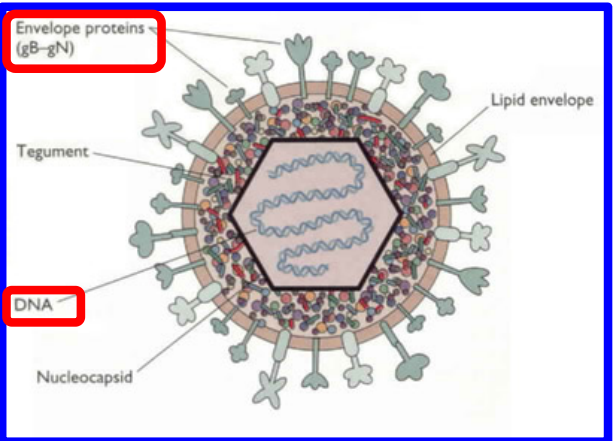
Hepatitis B

Ebola Virus

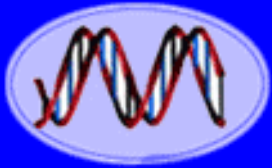
Adenovirus

Influenza

Bacteriophage



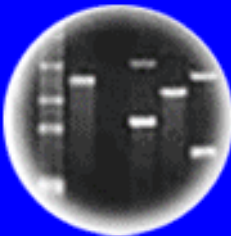
*They Exist
to Exist!!!*



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Plants of Tomorrow

A Hybrid DNA Molecule Was Produced By Combining the DNAs of a Monkey Virus With a Bacteria Virus

1972

Paul Berg (1926-) creates first recombinant DNA molecules

Paul Berg assembled the first DNA molecules that combined genes from different organisms. Results of his experiments, published in 1972, represented crucial steps in the subsequent development of recombinant genetic engineering. By stepwise methods such as he devised, individual genes could be isolated and inserted into mammalian cells or into such rapidly growing organisms as bacteria. The genes themselves could then be studied, and their protein products expressed and even manufactured in quantity.

The prospect of recombinant DNA emerged from a series of advances in biochemistry—most especially, from discoveries of new enzymes. Particularly important were the restriction enzymes that act as "scissors" to cut molecules of DNA at specific points. Similarly, ligases are enzymes that forge covalent bonds. The discovery of DNA ligase provided a kind of chemical soldering that could restore DNA after a foreign gene was spliced into it. These and other enzymes, captured from nature, could be used as tools in genetic engineering.



Paul Berg

In creating hybrid DNA molecules, Berg employed the much-studied SV40 monkey virus and a bacterial virus known as the λ (or lambda) bacteriophage. The SV40 virus has few genes, lacks a protein coat, and is is convenient to work with. The λ bacteriophage normally invades a type of *E. coli*, where it replicates according to the nutritional environment. The DNA of both viruses takes the form of closed loops. Berg's original idea was to open the SV40 DNA, and splice into it genes snipped out of the bacteriophage. The virus could then replicate in cells, as in nature, and the products of the bacteriophage genes could also be expressed.

In Berg's cut-and-splice method he created, in the DNA of both viruses, what came to be known as "sticky ends." Restriction enzymes were first used to open the circular units of DNA of phage and virus. In separate operations, types of terminal transferase (another enzyme) were used to add complementary DNA bases (adenine and thymine) to the ends of the molecules. When both kinds of DNA were incubated together, the ends would anneal naturally. Addition of DNA ligase would seal the plasmid. In succeeding with a series of enzymatic reactions, Berg wrote that his methods "are general and offer an approach for covalently joining any two DNA molecules together."

Potential dangers of recombinant genetic engineering emerged even before Berg published his landmark paper. Although the SV40 virus was thought to be innocuous in humans, the prospect of an altered form of the virus spreading through such a common bacterial agent as *E. coli* caused Berg to defer part of his research program. He did not insert the recombinant virus into bacterial cells as he originally planned. (With bacterial and animal genes, Herbert Boyer and Stanley Cohen took this step shortly.) A professor at Stanford University, in 1974 Berg published a widely discussed letter on the potential dangers of recombinant DNA research. Subsequently, a moratorium on research in 1975 provided time for regulations to be devised and put into effect in 1976.

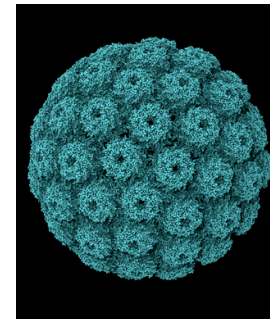
In 1980 Paul Berg shared the Nobel Prize in Chemistry with Walter Gilbert and Frederick Sanger, for "his fundamental studies of the biochemistry of nucleic acids, with particular regard to recombinant DNA."

Proc. Nat. Acad. Sci. USA
Vol. 69, No. 10, pp. 2004-2006, October 1972

Biochemical Method for Inserting New Genetic Information into DNA of Simian Virus 40: Circular SV40 DNA Molecules Containing Lambda Phage Genes and the Galactose Operon of *Escherichia coli*
(molecular hybrids/DNA joining/viral transformation/genetic transfer)

DAVID A. JACKSON*, ROBERT H. SYMONS†, AND PAUL BERG

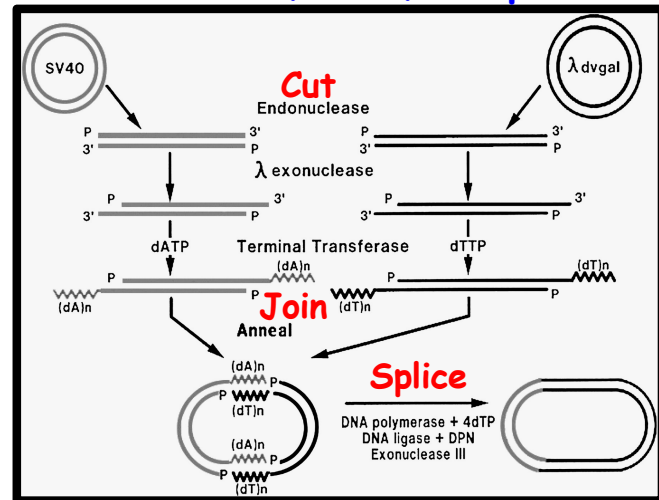
Simian Virus 40



λ Bacteriophage

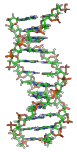
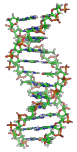


"Cut, Join, & Splice"

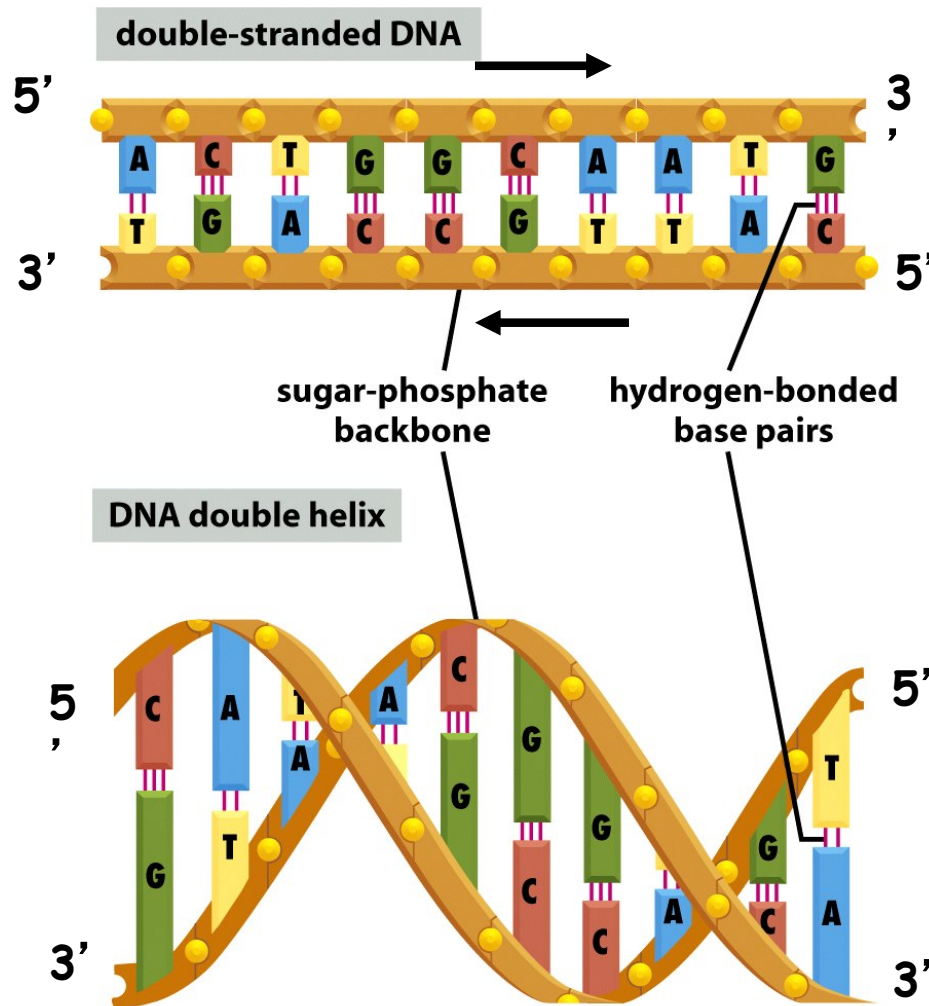


In Test Tube Only!

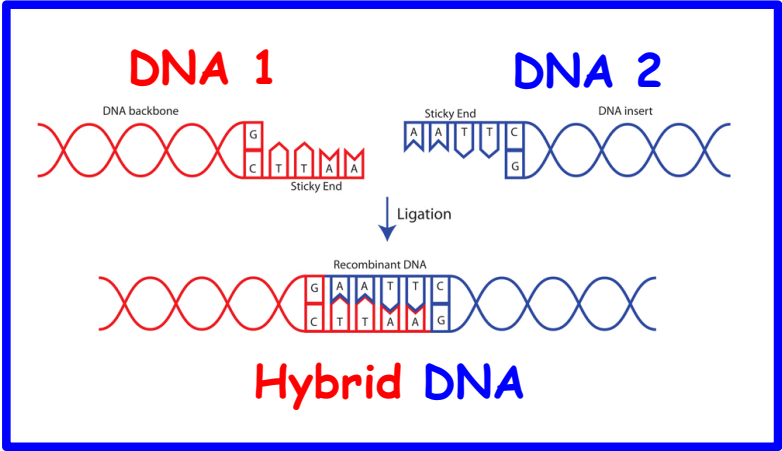




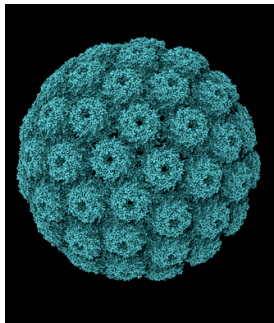
Major HC70A Concept - Complementary Bases of the DNA Double Helix Allows Two DNAs to be Spliced (Joined) Together & Form a Hybrid



Complementary Strands
A=T and G=C (Four Bases)



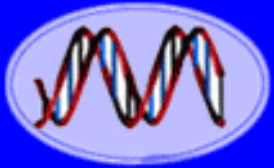
Simian Virus 40



λ Bacteriophage



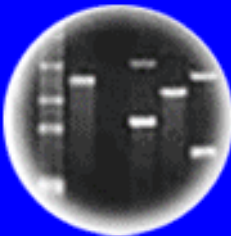
Major Genetic Engineering Concept!!



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of a Bacteria



DNA Fingerprinting

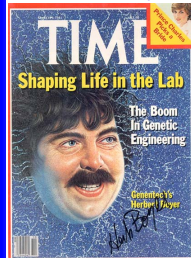


Cloning: Ethical Issues
and Future Consequences



Plants of Tomorrow

Herb Boyer



Modern Genetic Engineering of Living Cells Was Invented a Year Later & Caused a Revolution in Biology - 47 Years Ago!

Proc. Nat. Acad. Sci. USA
Vol. 70, No. 11, pp. 3240-3244

November 1973

This is the 47th Anniversary of Genetic Engineering's Origins

Construction of Biologically Functional Bacterial Plasmids *In Vitro*

(R factor/restriction enzyme/transformation/endonuclease/antibiotic resistance)

STANLEY N. COHEN*, ANNIE C. Y. CHANG*, HERBERT W. BOYER†, AND ROBERT B. HELLING†

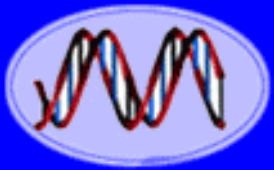
* Department of Medicine, Stanford University School of Medicine, Stanford, California 94305; and † Department of Microbiology, University of California at San Francisco, San Francisco, Calif. 94122

Communicated by Norman Davidson, July 18, 1973

It is Not a New Technology..... To Those of Us Who Have Done This Our Entire Careers, It is an OLD technology!!

Stanley Cohen

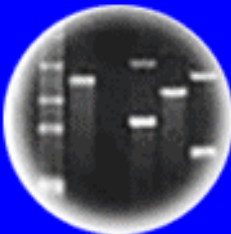




DNA
Genetic Code of Life



Entire Genetic Code
of a Bacteria



DNA Fingerprinting



Cloning: Ethical Issues
and Future Consequences

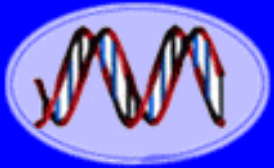


Plants of Tomorrow

Modern Genetic Engineering Was Invented in 1973 With An Unexpected “Eureka” Moment Dealing With Two Unrelated Areas of Study Related To Bacterial Defense Systems:

1. The Mechanism of Bacterial Antibiotic Resistance To Fight Off “Predators”
2. How Novel Enzymes Protect Bacteria From Destruction By Viruses “Cut” DNA Into Pieces

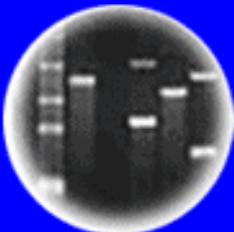




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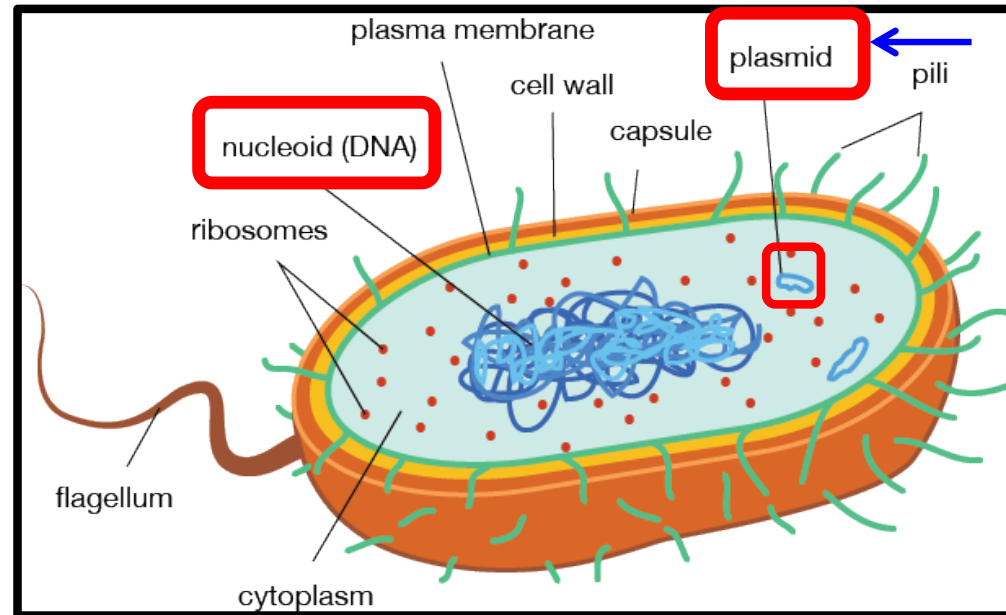


Cloning: Ethical Issues
and Future Consequences



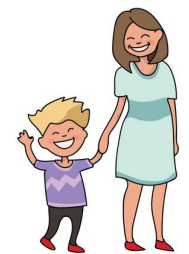
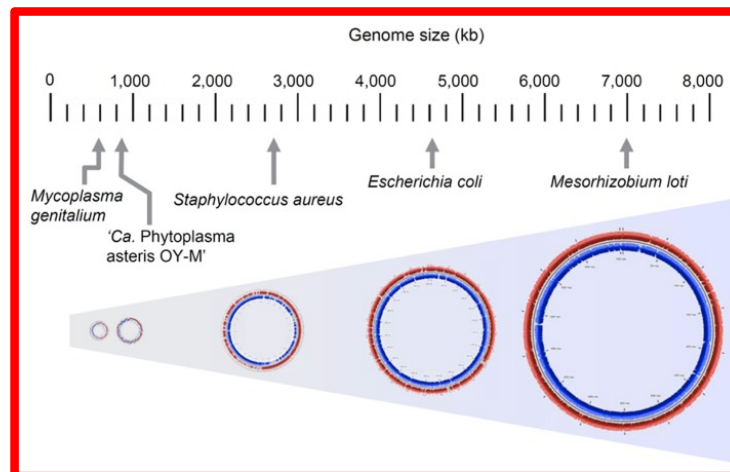
Plants of Tomorrow

A Typical Bacterial Cell

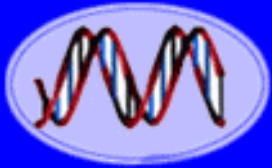


1. Replicates/Divides
2. Produces Energy
3. Responds to Stimuli
4. Communicates

Bacterial Chromosomes Are Circular & Contain 500 to 7500 Genes



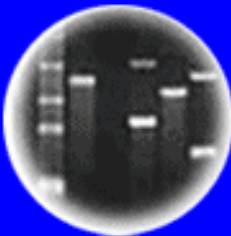
Humans Have
Linear Chromosomes
With 25,000 Genes



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DNA Fingerprinting



Cloning: Ethical Issues
and Future Consequences



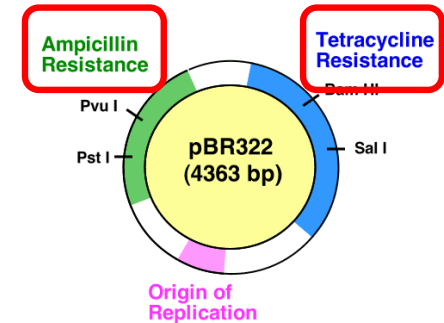
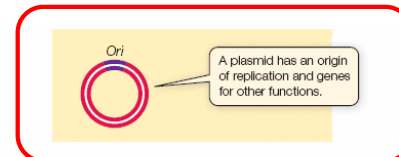
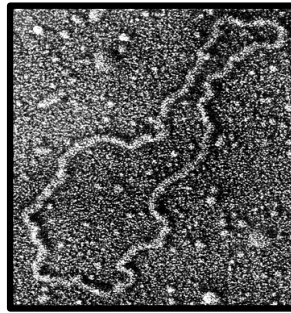
Plants of Tomorrow

Bacteria Also Contain Plasmids - Circular Self-Replicating DNA Molecules - That Carry Antibiotic Resistance Genes



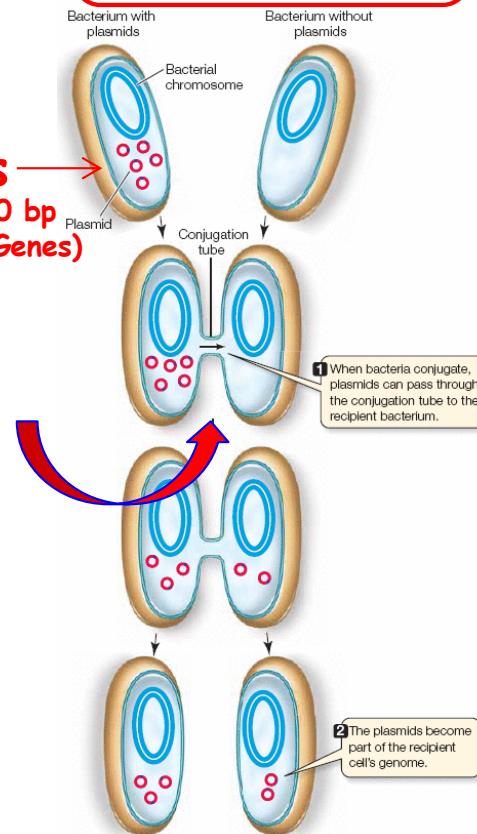
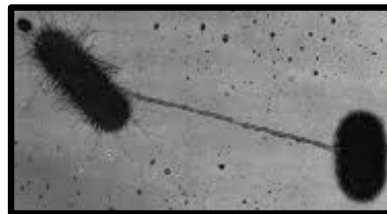
Stanley Cohen

Electron Micrograph



Plasmids
2,000 to 150,000 bp
(One to Several Genes)

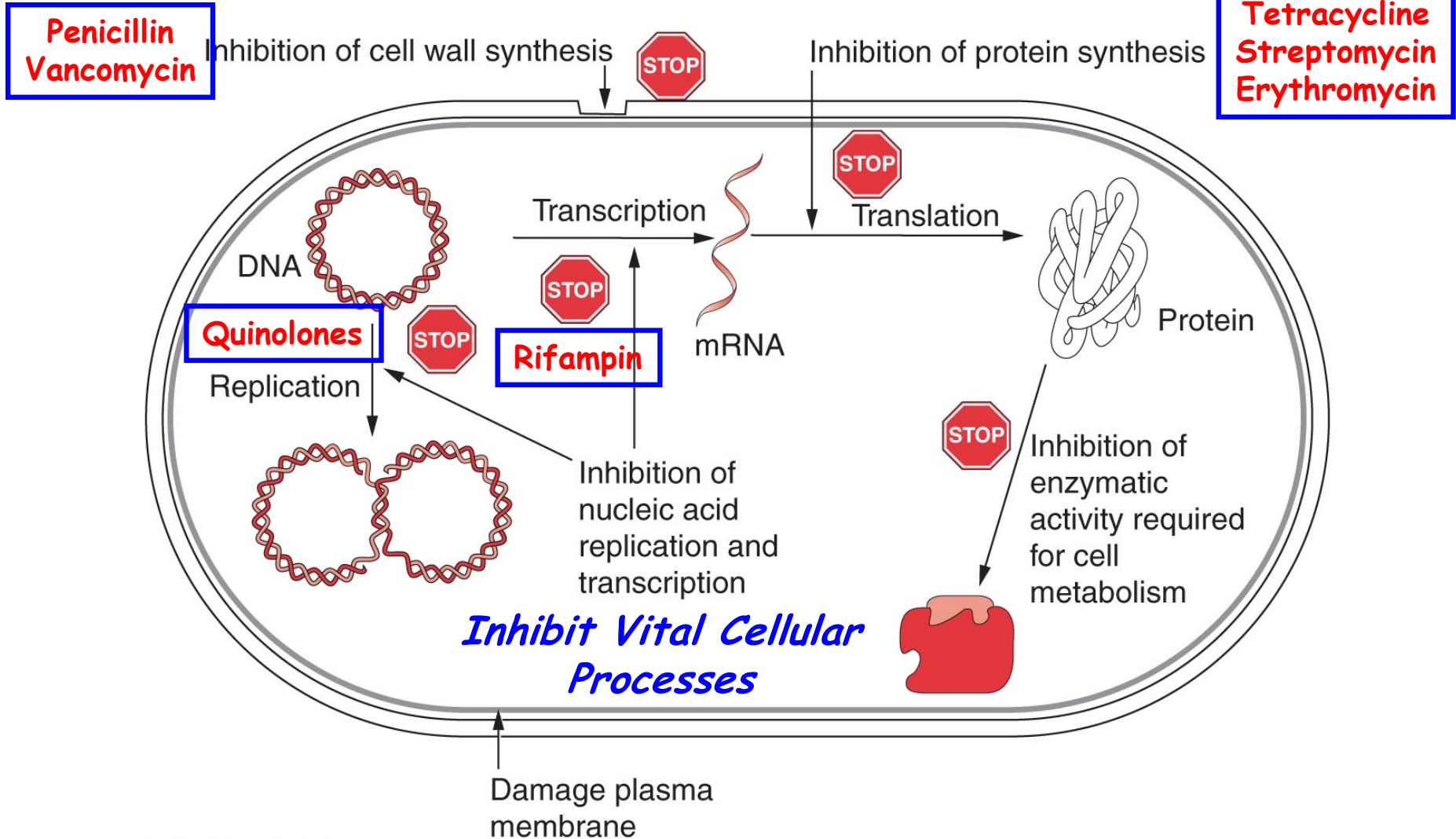
Bacteria Mating



**Small Plasmids
Move From Cell
to Cell
Spreading
Antibiotic
Resistance
Genes in
Bacterial
Populations!
A Major Public
Health Crisis!**

**Plasmids Defend Bacteria Against Antibiotics!
(The "Workhorses" or Vectors for Genetic Engineering)**

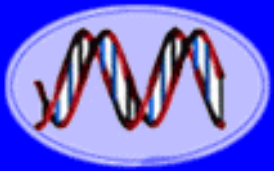
Microorganisms Produce Antibiotics To Protect Themselves Against Predators (Cellular "Warfare") - How Do Antibiotics Kill Bacterial Cells?



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Plasmid Antibiotic Resistance Genes Allow Bacteria to "Fight Off" the Effects of Antibiotics & Select For Genetically Engineered Organisms!

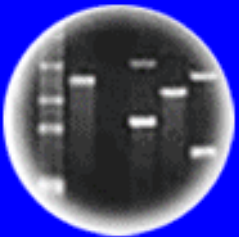
Plasmid Properties Making Them Ideal For Genetic Engineering



DNA
Genetic Code of Life



Entire Genetic Code
of a Bacteria



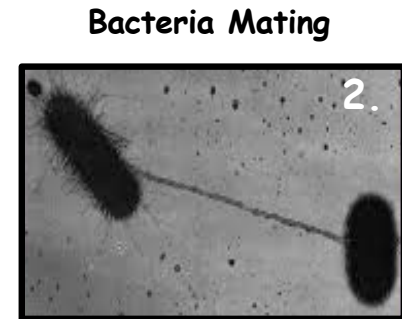
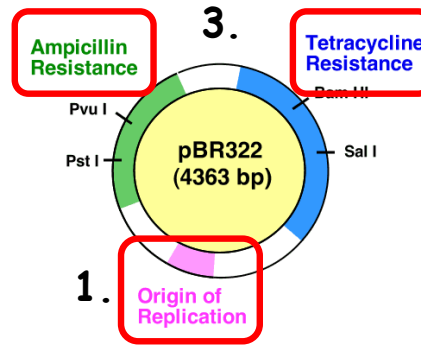
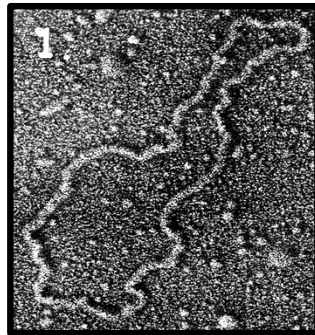
DNA Fingerprinting



Cloning: Ethical Issues
and Future Consequences

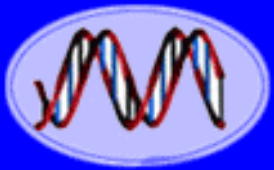


Plants of Tomorrow



1. Small DNA Molecule That Can Replicate Into Many Copies
2. Easy to Isolate & Put Back In Cells
3. Have Antibiotic Resistance Genes - *Can Select Bacteria With a Plasmid*
4. Easy To Manipulate & Modify With Foreign Genes

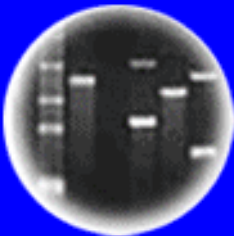
Ideal Vehicles For Isolating, Replicating, & Engineering "Foreign" Genes



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DNA Fingerprinting



Cloning: Ethical Issues
and Future Consequences



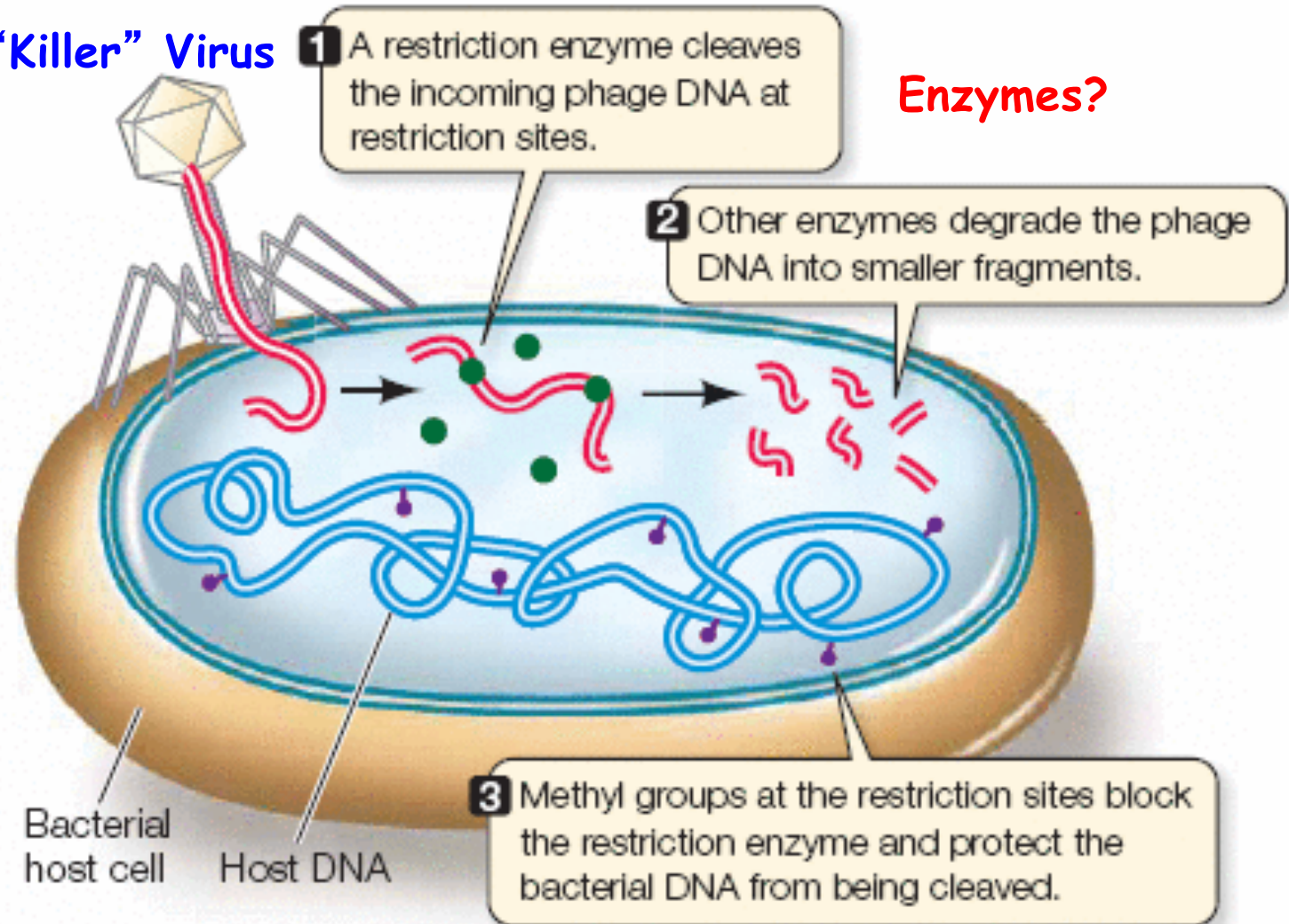
Plants of Tomorrow

Restriction Enzymes Are Proteins in Bacteria That "Cut" DNA Into Pieces



Herb Boyer

"Killer" Virus

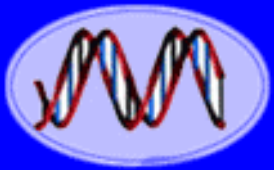
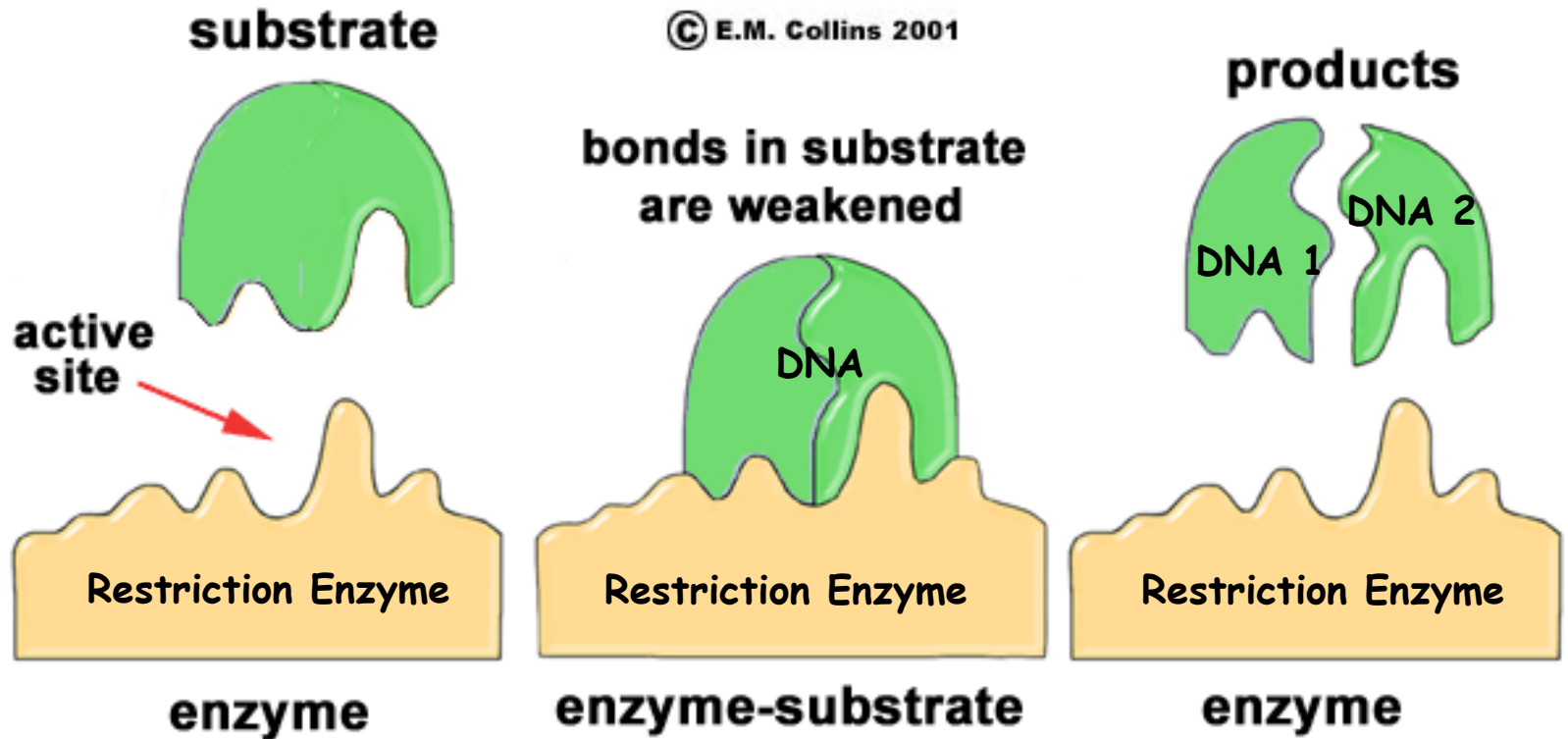


Enzymes?

Restriction Enzymes Protect Bacteria From "Killer" Viruses!

Enzymes Are Proteins That Catalyze or Facilitate Chemical Reactions

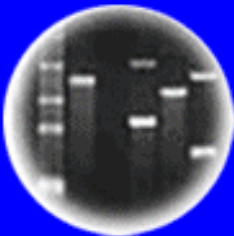
© E.M. Collins 2001



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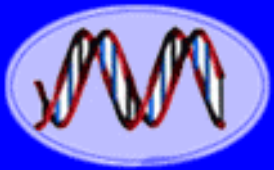
DNA Fingerprinting



Cloning: Ethical Issues
and Future Consequences



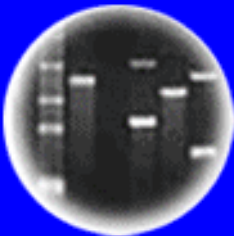
Plants of Tomorrow



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DNA Fingerprinting

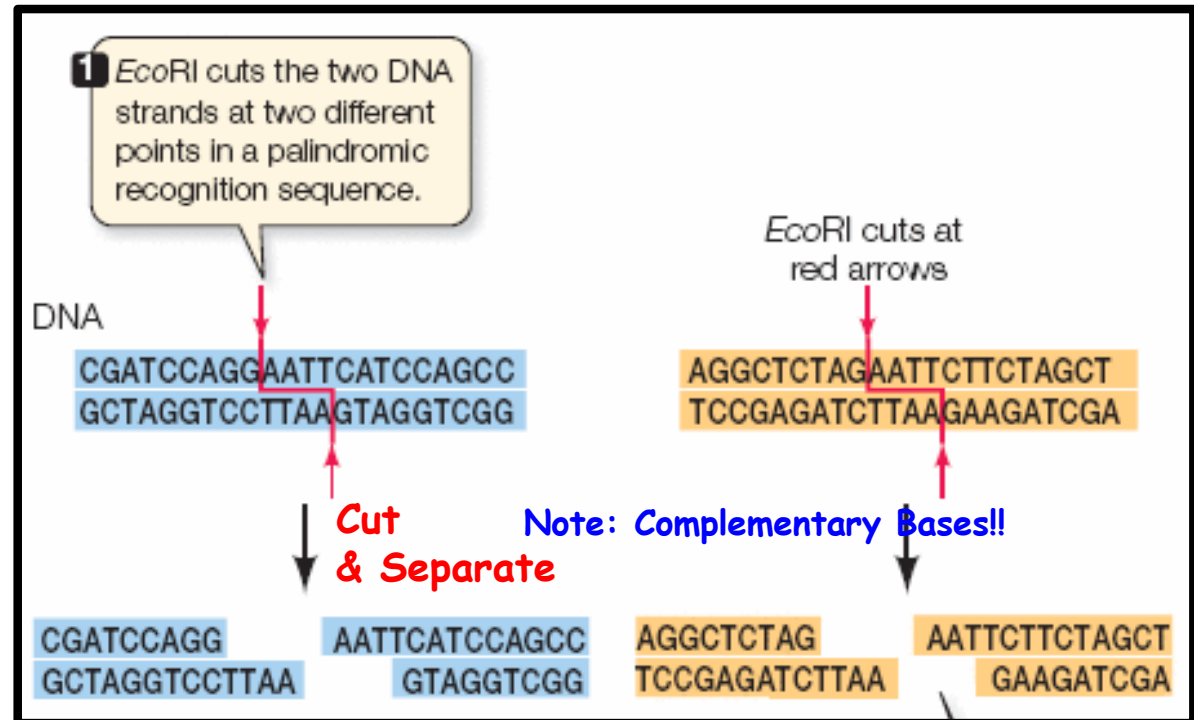


Cloning: Ethical Issues
and Future Consequences

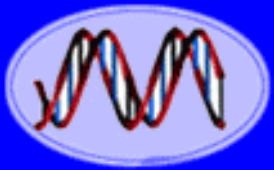


Plants of Tomorrow

Restriction Enzymes Are Proteins That “Cut” DNA Into Pieces At Specific Sequences



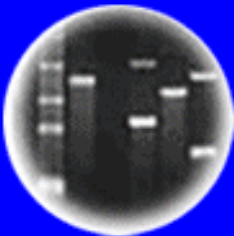
The “Scissors” For Genetic Engineering



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DNA Fingerprinting

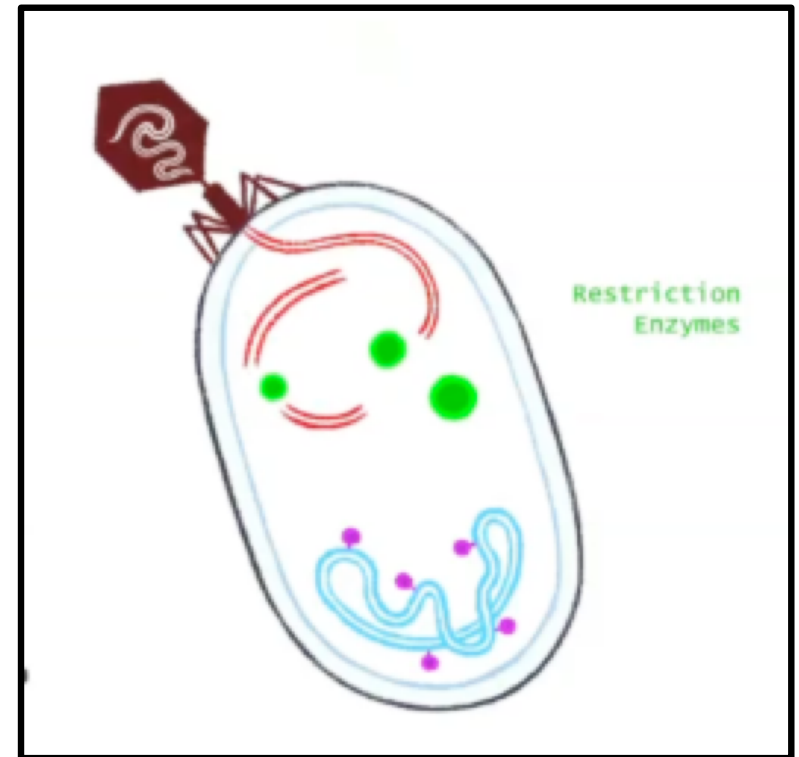
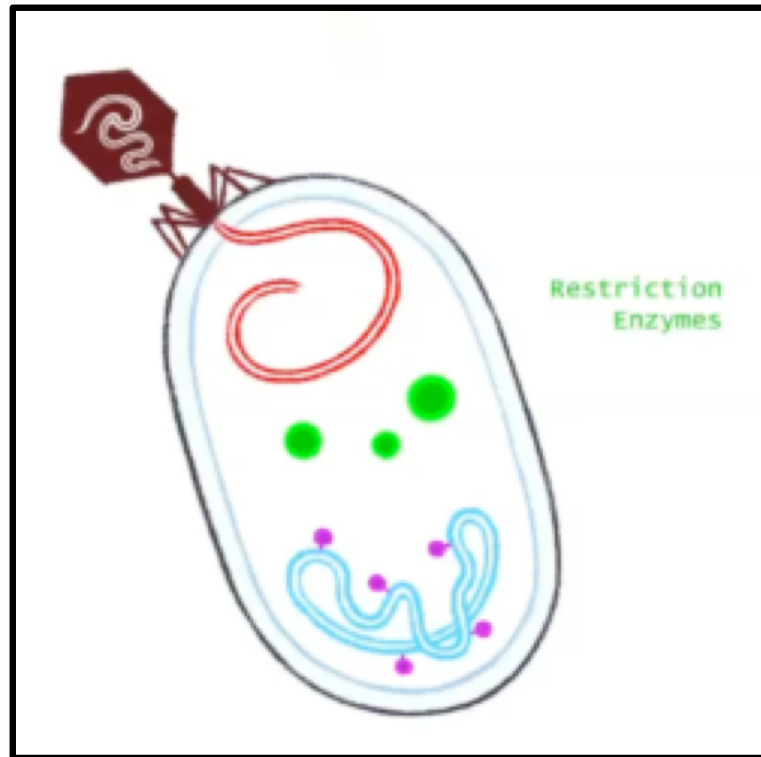


Cloning: Ethical Issues
and Future Consequences

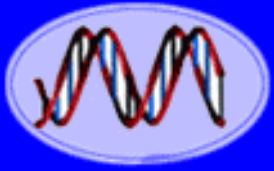


Plants of Tomorrow

Herb Boyer's Restriction Enzymes Digesting DNA



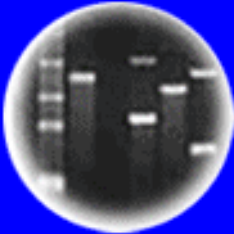
**Restriction Enzymes Protect
Bacteria From "Killer"
Viruses!**



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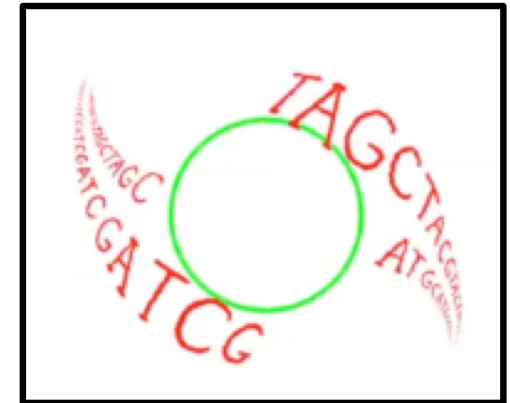
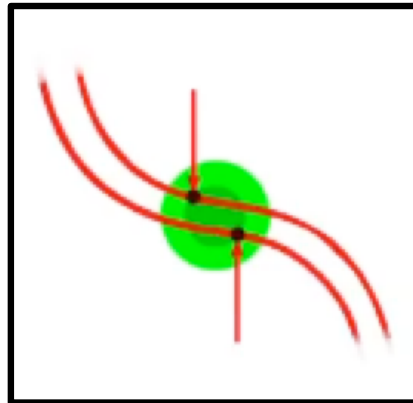
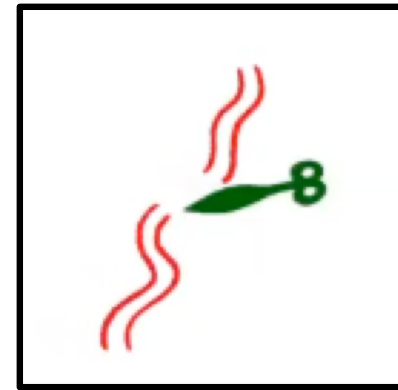
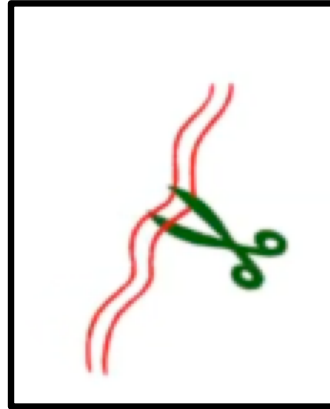


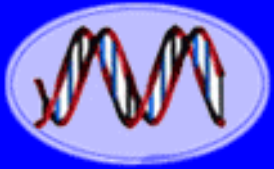
Cloning: Ethical Issues
and Future Consequences



Plants of Tomorrow

Restriction Enzymes Digest DNA At Specific DNA Sequences That Produce "Sticky Ends" That Can Be Used to Join ANY Two DNA Molecules

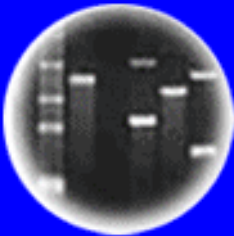




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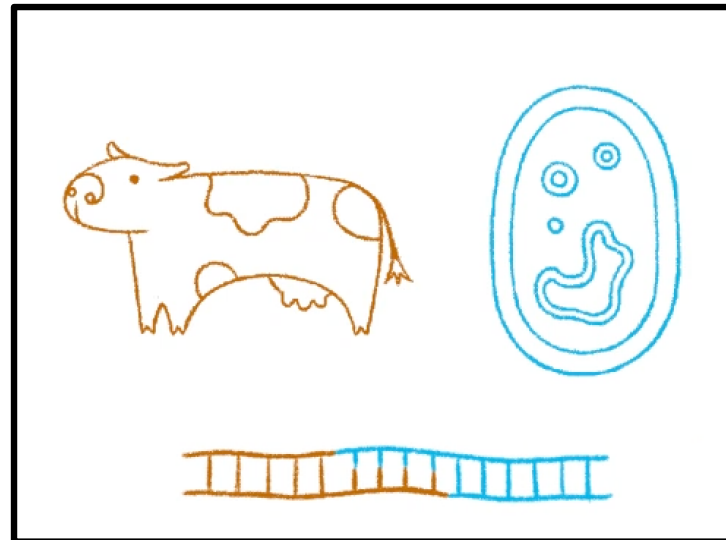
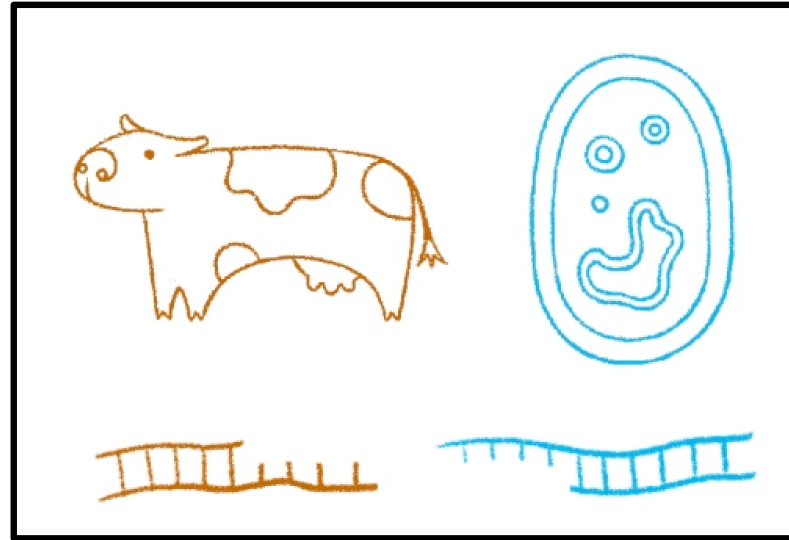


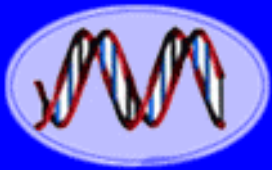
Cloning: Ethical Issues
and Future Consequences



Plants of Tomorrow

Restriction Enzymes Digest DNA At Specific DNA Sequences That Produce "Sticky Ends" That Can Be Used to Join ANY Two DNA Molecules

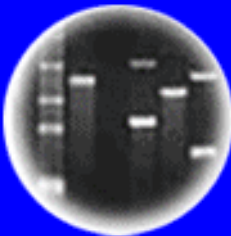




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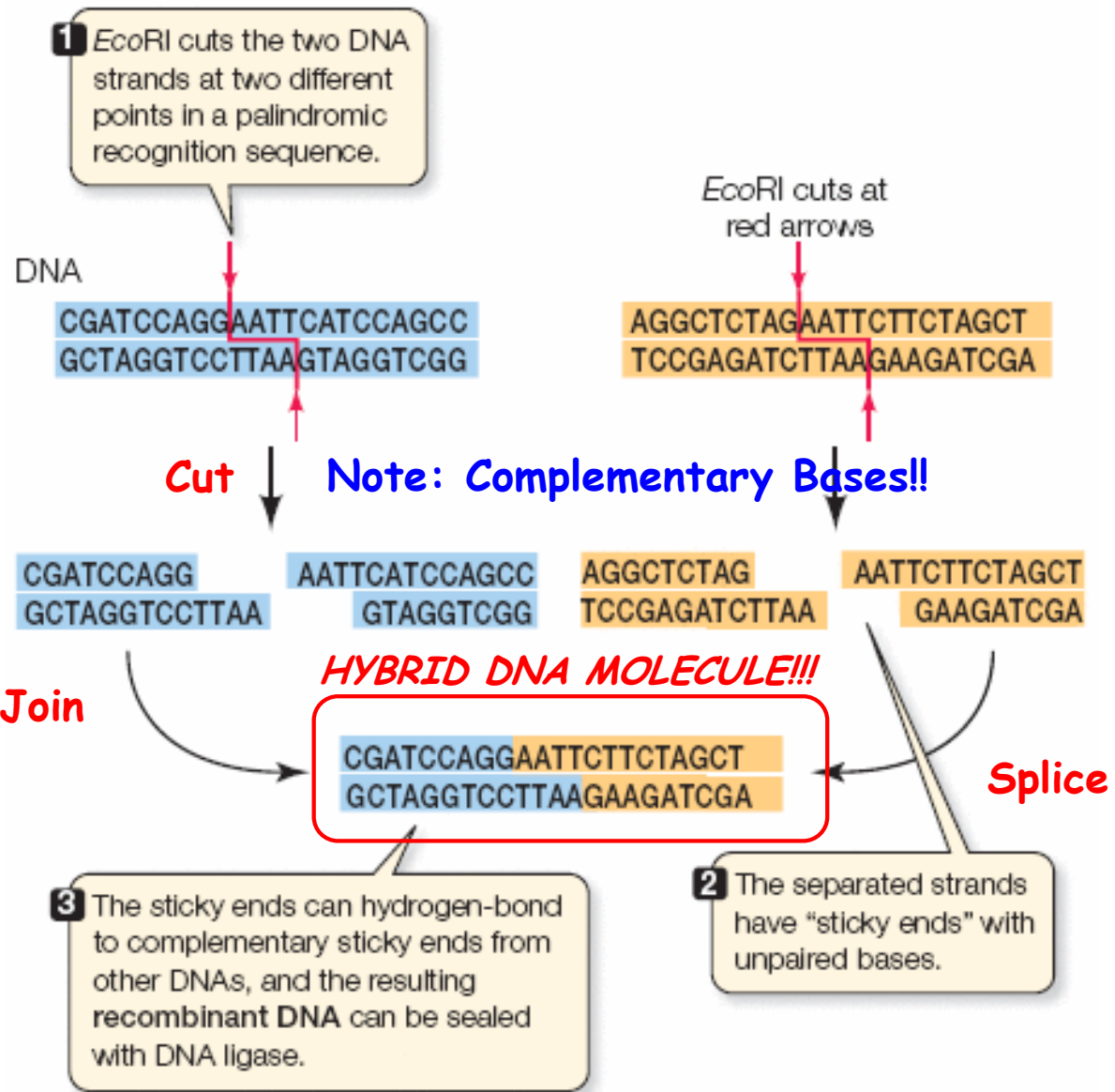


Cloning: Ethical Issues
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Plants of Tomorrow

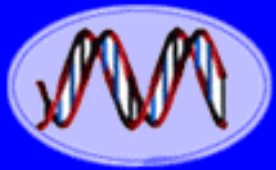
DNA Fragments of Different Origins "Cut" By the SAME Restriction Enzyme Can Re-Join and Form a **HYBRID DNA Molecule!!!**



The "Scissors" For Genetic Engineering

The Cohen-Boyer Experiment That Started the Gene Engineering Revolution

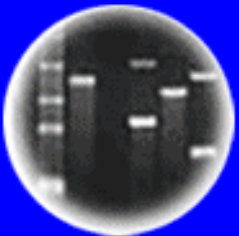
Genetic Engineering Technology Can Combine DNA (Genes) From Different Sources Leading to New Gene Combinations in Living Organisms (i.e., GMOs)!!



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DNA Fingerprinting



Cloning: Ethical Issues
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Plants of Tomorrow

Cut
↓
Join
↓
Splice

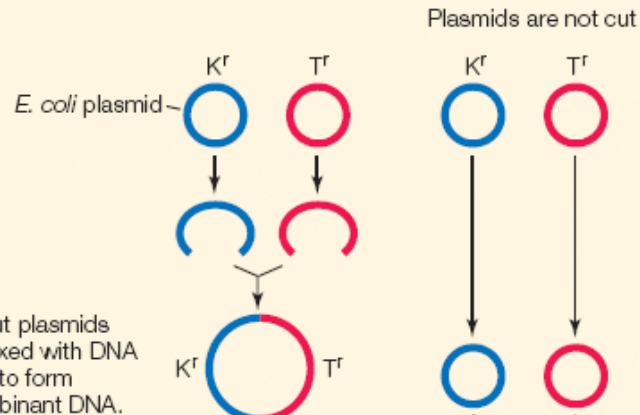
Genetically
Engineered
Bacteria!!!

Insert Back
Into Bacterial
Cell
Transform

EXPERIMENT

HYPOTHESIS: Biologically functional recombinant chromosomes can be made in the laboratory.

METHOD *E. coli* plasmids carrying a gene for resistance to either the antibiotic kanamycin or tetracycline are cut with a restriction enzyme.



RESULTS

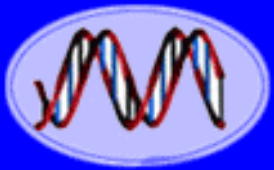
Some *E. coli* resistant to both antibiotics.

No *E. coli* doubly resistant.

CONCLUSION: Two DNA fragments with different genes can be joined to make a recombinant DNA molecule, and the resulting DNA is functional.

Hypothesis?
Predictions?

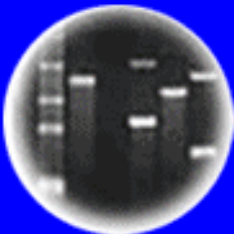
This
Was
the
FIRST
GMO!!!



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DNA Fingerprinting



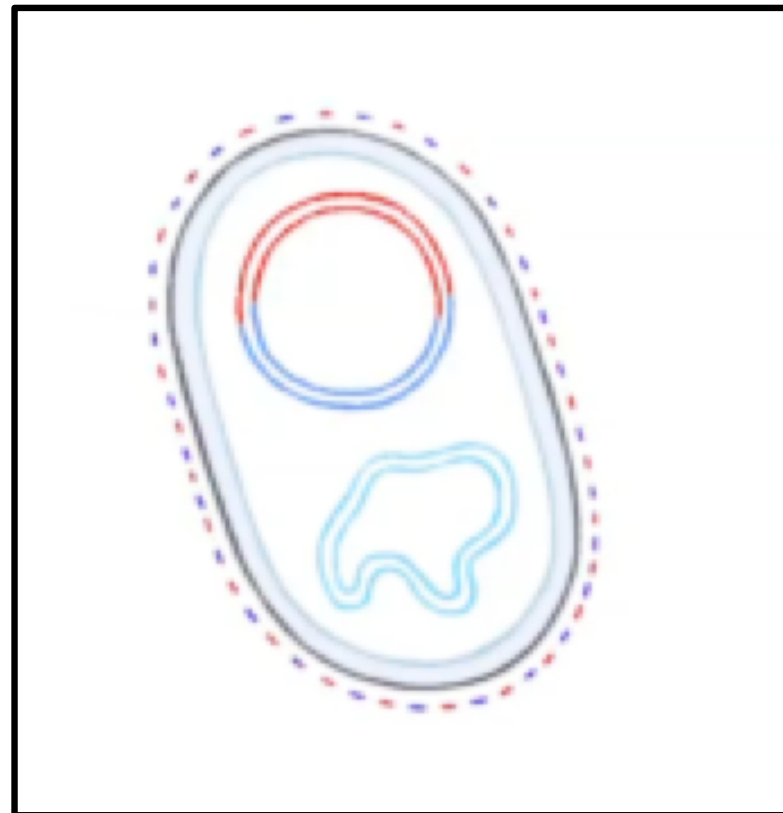
Cloning: Ethical Issues
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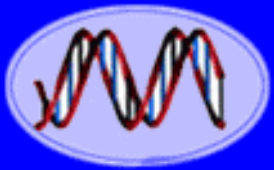


Plants of Tomorrow

Genetic Engineering Technology Can Combine DNA (Genes) From Different Sources Leading to New Gene Combinations!!

**Cohen & Boyer Created a Revolutionary New
Technology That Changed in Biology Forever
Recombinant DNA!!!!**

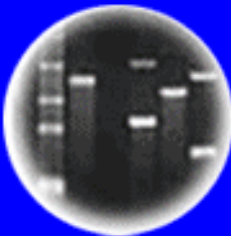




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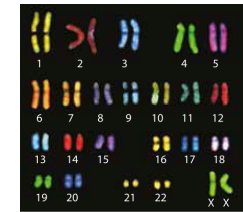
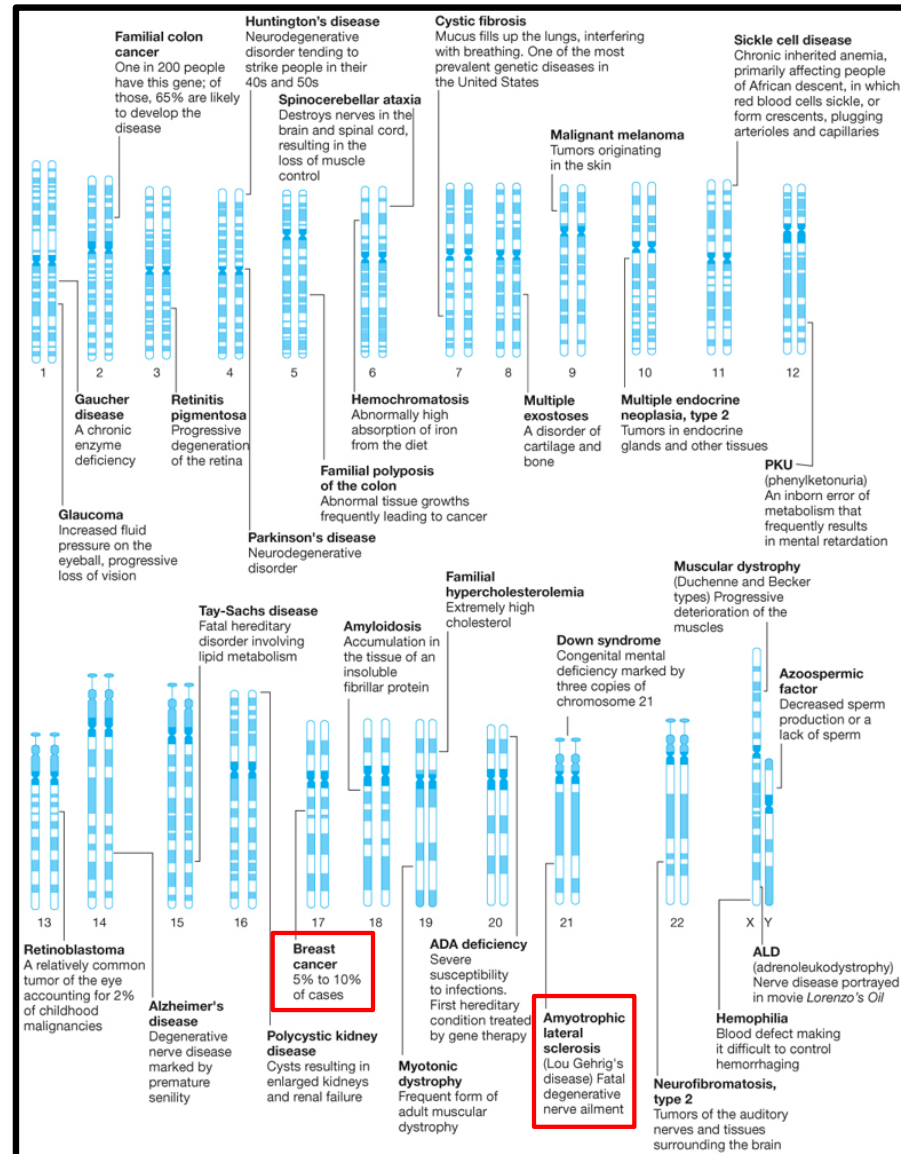


Cloning: Ethical Issues
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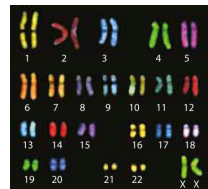


Plants of Tomorrow

"Why" Clone Genes - Simply Put... Genomes & Chromosomes Contain Thousands of Genes

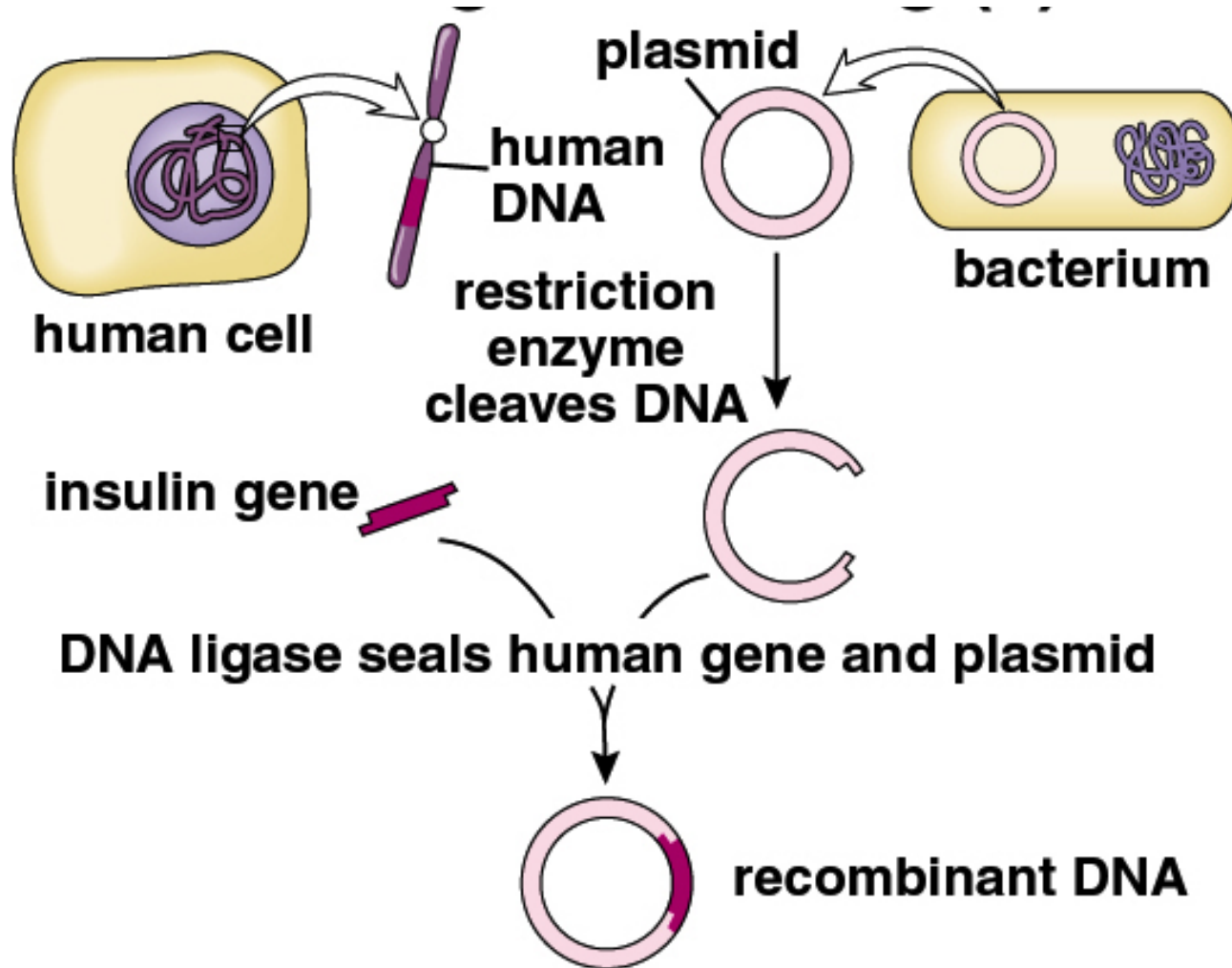


The Human Genome Has 25,000 Genes



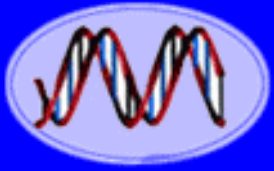
How Can a Single Gene Be Studied?

For Example....The Human Insulin Gene Can Be Separated From Other Human Genes and Transferred to a Bacterial Cell Using Recombinant DNA Methods!



And Used to Treat Diabetes!

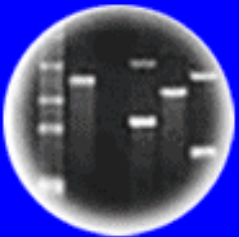




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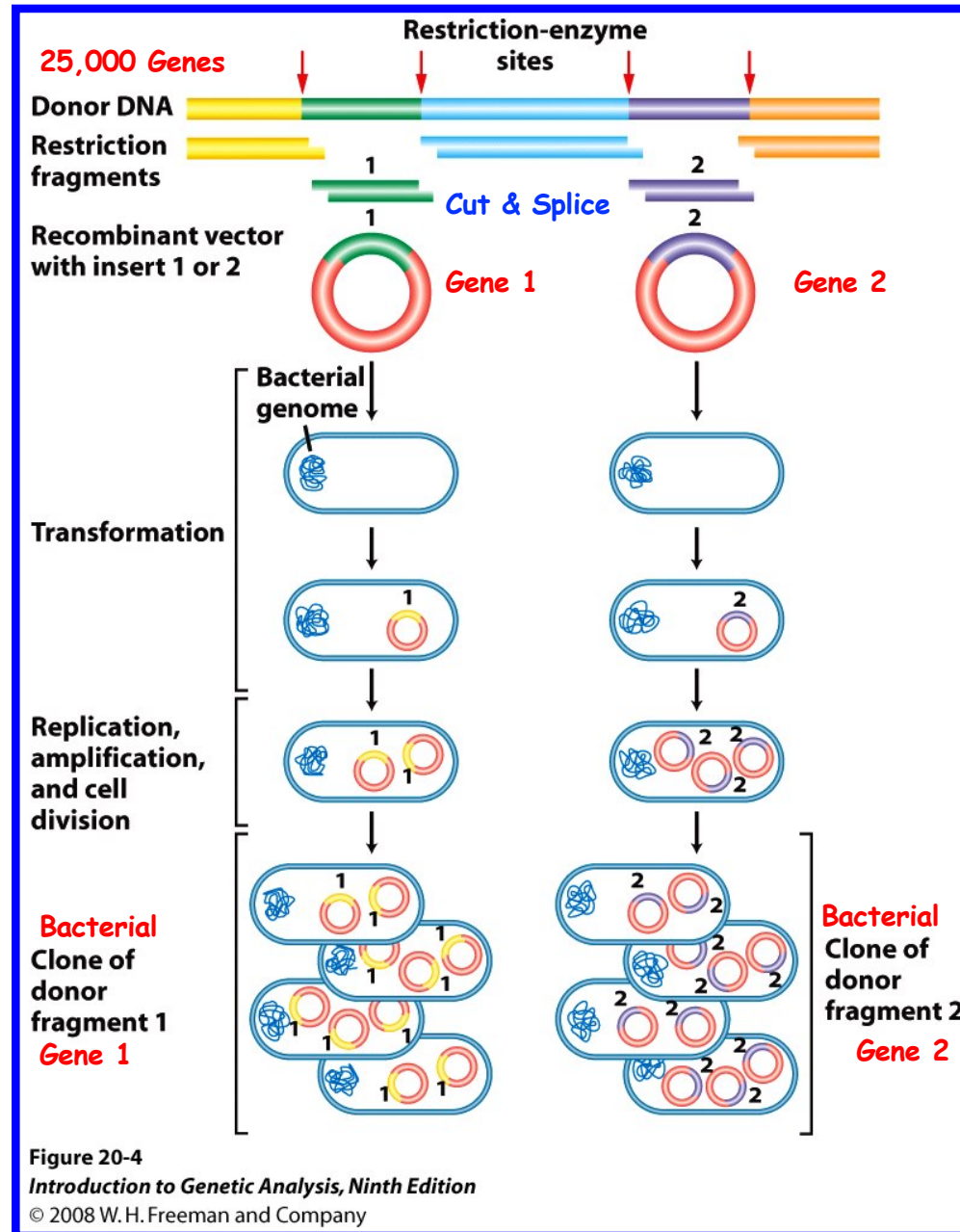


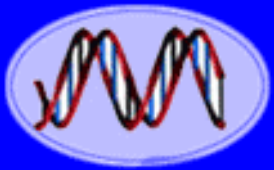
Cloning: Ethical Issues
and Future Consequences



Plants of Tomorrow

Any Gene Can Be Isolated & Transferred to Any Organism Using Genetic Engineering!!

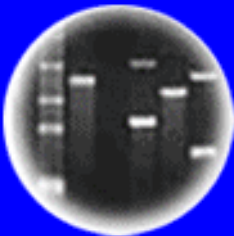




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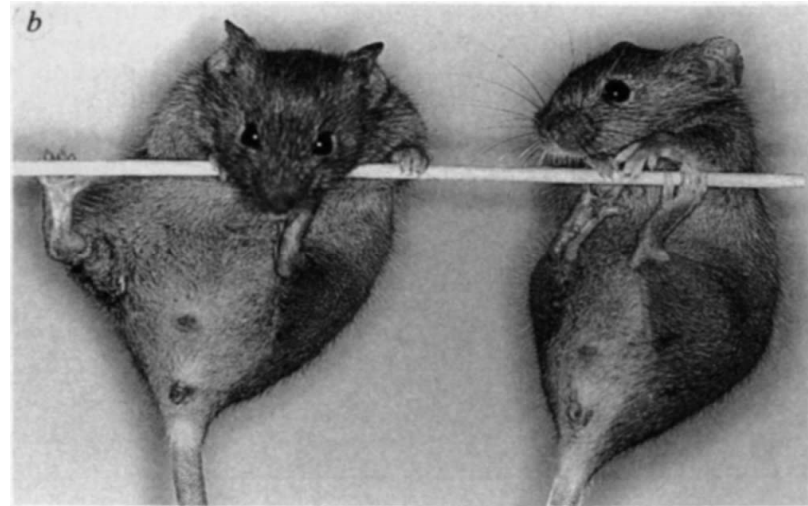


Cloning: Ethical Issues
and Future Consequences

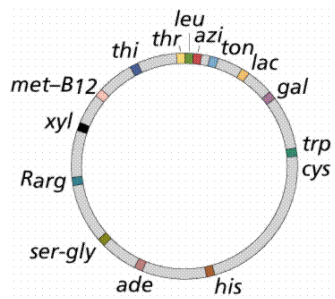


Plants of Tomorrow

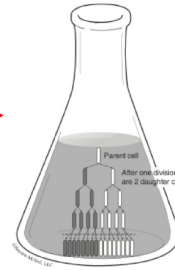
And Made to Perform Any Function That We Want Using Normal Cellular Processes!!



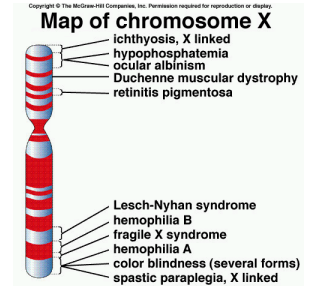
“Why” Clone Genes From An Organism’s Genome? An Essential HC70A Concept!



Cut & Splice



Cut & Splice



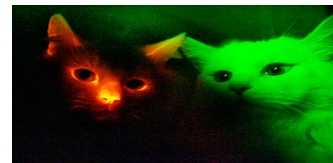
1. **PURIFY** Individual Genes From the Genome (e.g., One of 25,000 Human Genes) Using Restriction Enzymes & Plasmids (*Cut & Slice*)
2. **AMPLIFY** The Gene Within Plasmids in Bacterial Cells to Obtain Enough DNA For Study
3. **Use the Cloned Gene To:**
 - a) Study Gene Structure & Function (THE Major Use!)
 - b) Use to Convert Cells Into Factories To Make Drugs and Pharmaceuticals
 - c) Use to Diagnose Genetic Diseases
 - d) Use to Identify Individuals (e.g., paternity, forensics)
 - e) Use to Correct Genetic Disease
 - f) Use to Engineer New Crops and Farm Animals

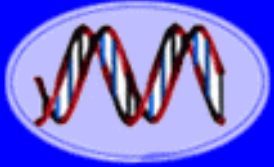
Genetic Engineering Has Lead to New Knowledge About How Cells and Genes Function and Has Lead to Applications That Have Improved Our Lives!!

Recombinant DNA Manipulation Means.....

1. Specific DNA/Genes Can Be Isolated From Any Organism
2. DNA Segments of Any Kind From Any Organism Can Be Combined (Genetic Engineering!!!!!!)
3. Isolated Genes Can Be Re-Inserted Into the Chromosomes of Any Organism and Made to Work
4. Genes and Genomes Can Be Synthesized and Made To Work in Any Organism

There Are NO Genetic Limits. All Biological Organisms Use the Same Genetic Rules. The Implications Are Enormous!!

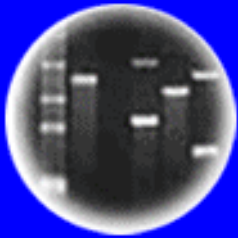




DNA
Genetic Code of Life



Entire Genetic Code
of a Bacteria



DNA Fingerprinting



Cloning: Ethical Issues
and Future Consequences



Plants of Tomorrow

Genetic Engineering.....

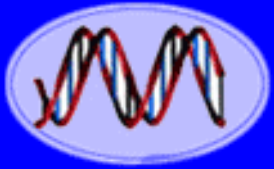
**Is the Most Revolutionary Technology in
Biology to Have Been
Invented in Human History!**

**Has Generated the Vast Majority of
New Biological Knowledge Over the
Past 45 Years From Experiments in
Biology Laboratories Around the Globe**

Has Changed Our Lives Dramatically!

AndHas Led to Many New Legal and Ethical Issues

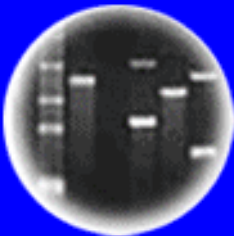
1. Genetic Enhancement and Eugenics: Right to Enhance Your Child?
2. Gender Selection and Prenatal Diagnosis of Genetic Diseases?
3. Gene Therapy: Correcting Human Genetic Diseases?
4. Genetic Testing: DNA Databases, Newborn Genetic Screening, Genetic Privacy, Involuntary or Voluntary Testing?
5. Genetic Discrimination?
6. Human Cloning and Genetic Improvement?
7. Gene Testing Companies (e.g., 23andMe): Liability?
8. Patenting Genes, Cells, & Living Organisms?
9. Regulating Experimentation on DNA, Cells, Transgenic Organisms ("GMOs")?
10. Regulating the Release of Genetically Modified Organisms into the Environment?
11. Labeling of Genetically Modified Foods?
12. Synthetic Genomes: Constructing New Organisms?



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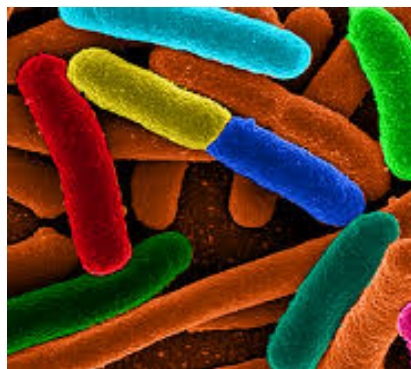


Plants of Tomorrow

Genetic Engineering Has Been A Major Source of Drugs To Treat Human and Animal Diseases Over the Past 30 Years!



Bacteria



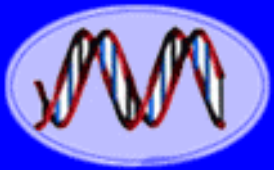
Crops



Livestock



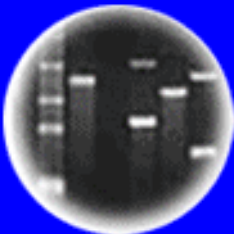
Drugs Manufactured Using Genetic Engineering



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Cloning: Ethical Issues
and Future Consequences



Plants of Tomorrow

TABLE 1.2 Examples of Recombinant Proteins Manufactured from Cloned Genes

Product	Application
Blood Factor VIII (clotting factor)	Treat hemophilia
Epidermal growth factor	Stimulate antibody production in patients with immune system disorders
Growth hormone	Correct pituitary deficiencies and short stature in humans; other forms are used in cows to increase milk production
Insulin	Treat diabetes
Interferons	Treat cancer and viral infections
Interleukins	Treat cancer and stimulate antibody production
Monoclonal antibodies	Diagnose and treat a variety of diseases including arthritis and cancer
Tissue plasminogen activator	Treat heart attacks and stroke

TABLE 1.1 *2016—Top 10 Biotechnology Drugs (Each with Worldwide Sales over \$5 Billion)

Drug Name	Developer	Drug Type	Function (Treatment of Human Disease Conditions)
Humira	AbbVie	Antibody (monoclonal)	Rheumatoid arthritis, Crohn's disease, Ulcerative colitis
Harvoni	Gilead Sciences	Small molecule	Hepatitis C
Rituxan	Roche	Antibody (monoclonal)	Non-Hodgkin's lymphoma
Revlimid	Celgene	Small molecule	Multiple myeloma
Avastin	Roche	Antibody (monoclonal)	Colorectal cancer; breast cancer; non-small cell lung cancer; ovarian, brain, and cervical cancer
Herceptin	Roche	Antibody (monoclonal)	Breast cancer, gastric cancer
Enbrel	Amgen	Recombinant protein	Rheumatoid arthritis, psoriasis
Pevnar 13	Pfizer	Vaccine	Pneumococcal (<i>Streptococcus Pneumoniae</i>) antibacterial vaccine
Lantus	Sanofi	Peptide	Diabetes mellitus types I and II
Neulasta	Amgen	Recombinant protein	Anemia (neutropenia/leukopenia)

*Data based on the most recent source available at the time of publication: Morrison C, Lähtenmäki R. Public biotech in 2016—the numbers. *Nat Biotechnol.* 2017;35:623–629.

Genetic Engineering Gave Birth to DNA Sequencing and Now Your Genome Can Be Decoded Very Quickly and Inexpensively (\$1,000)!!

DNA sequencer raises doctors' hopes for personalized medicine

The device could accelerate the use of genetic information in everyday medical care, physicians hope, improving diagnoses and treatments.



PRENATAL DIAGNOSIS *~10% of DNA in Maternal Plasma is From the Fetus*

Maternal Plasma DNA Sequencing Reveals the Genome-Wide Genetic and Mutational Profile of the Fetus
Science Translational Medicine, December 8, 2010

MinIon DNA Sequencer

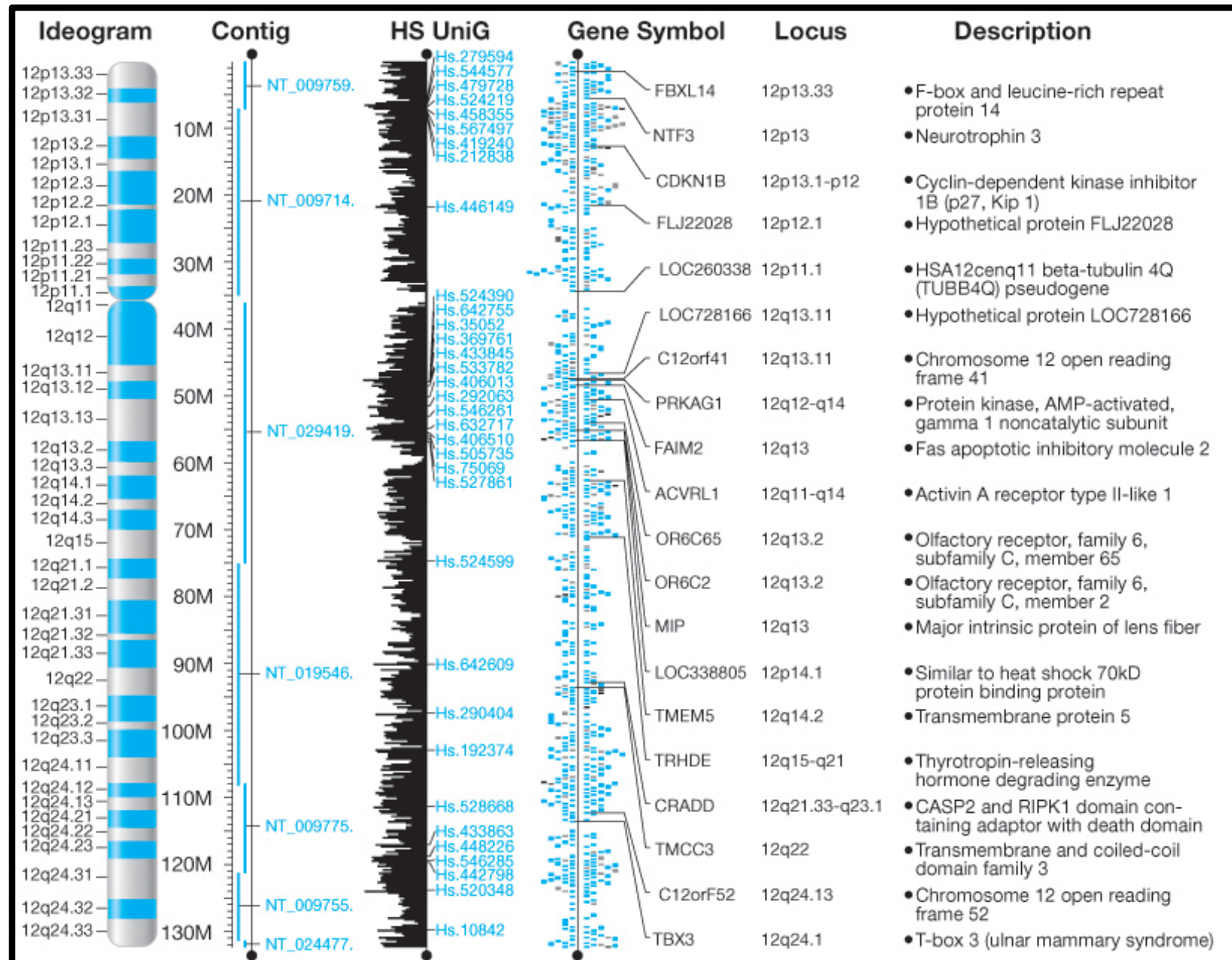


Genome-Wide Detection of Single-Nucleotide and Copy-Number Variations of a Single Human Cell

Science, December 20, 2012

The Era of Personalized Genomes is Here!

Knowledge of Human Gene Sequences Can Lead to Tests For Specific Genetic Disorders and Much More!



Genetic Engineering Has Enabled DNA Tests For Hundreds of Disease Genes and Human Traits - Generating Personalized Gene Profiles



GENETIC TESTING
NHGRI FACT SHEETS
genome.gov

Genetic Tests Can Help to:

- Diagnose Your Disease
- Pinpoint Genetic Factors That Caused Your Disease
- Predict How Severe Your Disease Might Be
- Choose the Best Medicine and Correct Dose
- Discover Genetic Factors That Increase Your Disease Risk
- Find Genetic Factors That Could Be Passed to Your Children
- Screen Newborns for Certain Treatable Conditions

DECEMBER 24, 2012

Egypt Divided / Pot's Big Moment / Best of 2012 Movies, Music, Books & More

TIME

Want to Know My Future?

Alzheimer's, Dementia, Cancer, Hemochromatosis, Cystic fibrosis, Tay-Sachs disease, Burkitt's lymphoma, Malignant melanoma, Phenylketonuria, Prostate cancer, Obesity, Parkinson's, Glaucoma, Huntington's disease, Epilepsy, Asthma, Diabetes, Colon cancer, Breast cancer

New genetic tests can point to risks—but not always a cure

BY BONNIE ROCHMAN

www.time.com

And Before Birth!!!



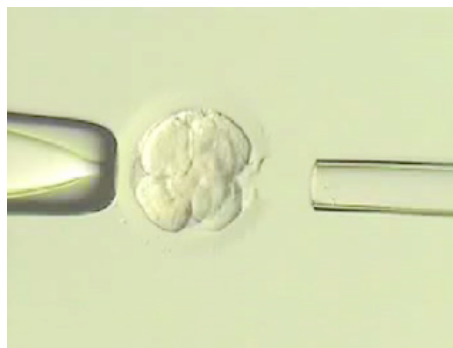
Made Possible Because of Genetic Engineering!

Determining the Genetic Identity of a Human Embryo Before Implantation!



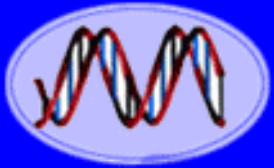
Prenatal Genetic Diagnosis (PGD)

Fertility Clinics Scan for the Strongest Embryo



DNA Testing Has Led To Inexpensive Home DNA Testing Kits!

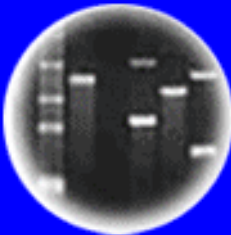




DNA
Genetic Code of Life



Entire Genetic Code
of a Bacteria



DNA Fingerprinting



Cloning: Ethical Issues
and Future Consequences



Plants of Tomorrow

....Leading To a New Set of Ethical Issues & Controversies

**F.D.A. Orders Genetic Testing Firm to
Stop Selling DNA Analysis Service**

Poking Holes in Genetic Privacy


**I Had My DNA Picture Taken, With
Varying Results**

**Why You Shouldn't Trust
Newfangled Gene Tests**

DIRECT-TO-CONSUMER GENETIC TESTS

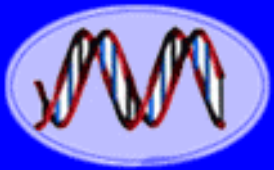
**Misleading Test Results Are Further Complicated by
Deceptive Marketing and Other Questionable
Practices**

Contradictory Risk Predictions for Prostate Cancer and Hypertension

	Gender	Age	Condition	Company 1	Company 2	Company 3	Company 4
	Male	48	Prostate cancer	Average	Average	Below average	Above average
			Hypertension	Average	Below average	Above average	Not tested

Source: GAO.

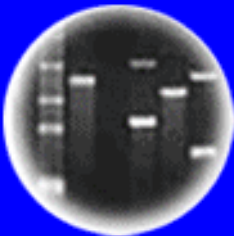




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Plants of Tomorrow

Genetic Engineering Has Led to the Era of Human Gene Engineering - Using Gene Therapy to Cure Lethal Genetic Diseases

Alabama Man Free of Sickle Cell After Gene Therapy

In A First, An Experimental Drug May Help Boys With Muscular Dystrophy

Immune systems of 'bubble babies' restored by gene therapy, UCLA researchers find

Gene therapy trial 'cures children'

In Girl's Last Hope, Altered Immune Cells Beat Leukemia

DNA-swap technology almost ready for fertility clinic

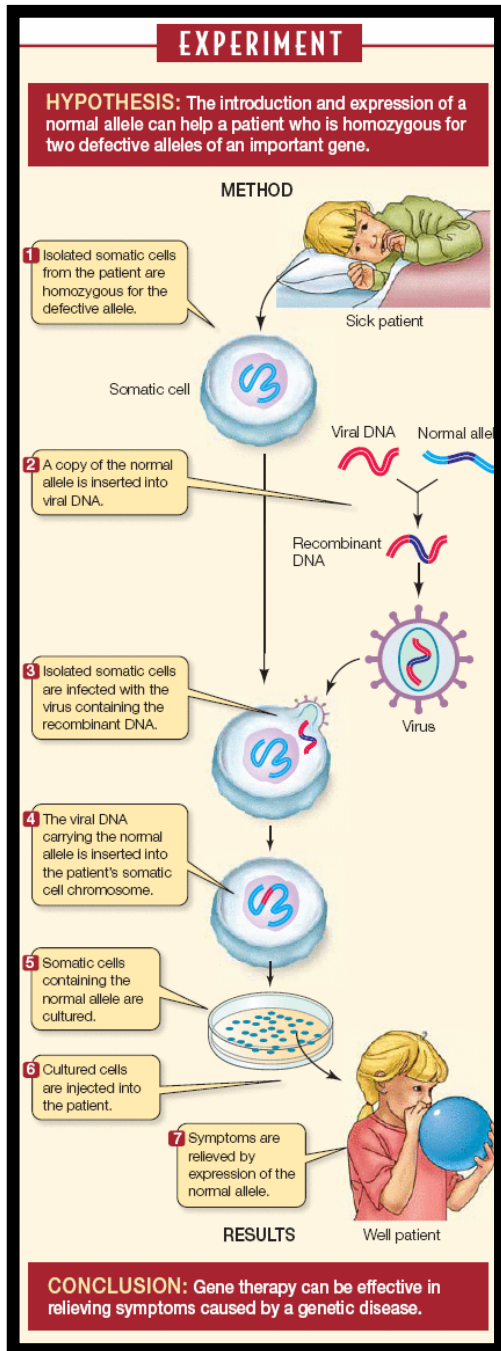
Humans Have Been Genetically Engineered To Cure a Lethal Genetic Disease (SCID) - Human GMOs!

Gene therapy cures 'bubble boy disease'

31 Jan 2009, 1128 hrs IST, AP

Several People are Alive Because They Have Been Engineered With an ADA Gene

The Age of Human Genetic Engineering Began More Than Twenty Years Ago - SCID Treated With Normal ADA Gene!!!



The new england journal of medicine

established in 1812

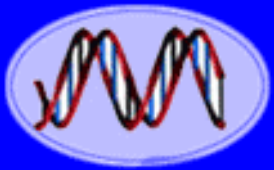
january 29, 2009

vol. 360 no. 5

Gene Therapy for Immunodeficiency Due to Adenosine Deaminase Deficiency

Gene Therapy with the Adenosine Deaminase (ADA) Gene

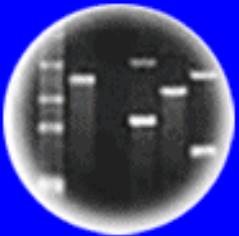




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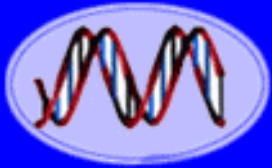


Plants of Tomorrow



And More Recently The Era of
Correcting, or Editing, Defective
Genes in the Germline (e.g., Eggs)
Has Arrived!!!!

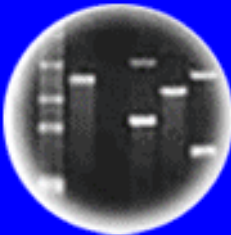




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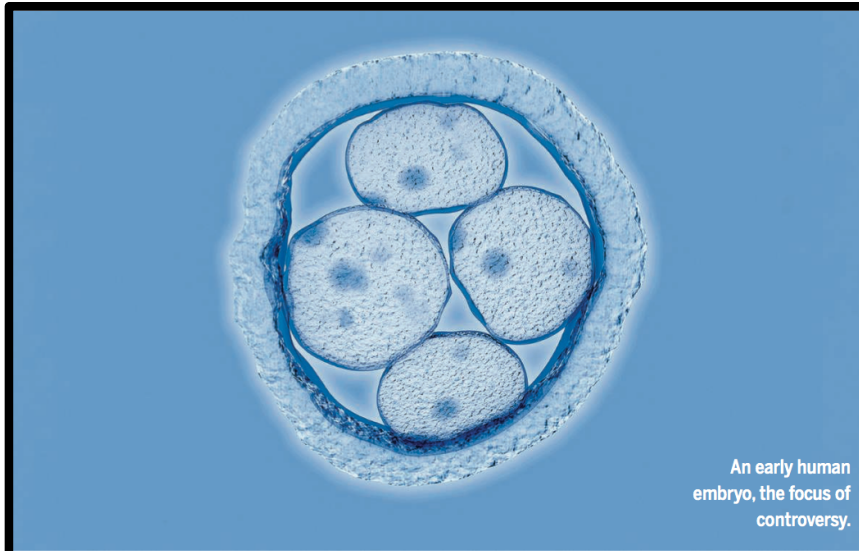
DNA Fingerprinting



Cloning: Ethical Issues
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Plants of Tomorrow



An early human
embryo, the focus of
controversy.

BIOETHICS

Embryo engineering alarm

Researchers call for restraint in genome editing

Genome-edited baby claim provokes international outcry

Scientists Seek Ban on Method of Editing the Human Genome

By NICHOLAS WADE MARCH 19, 2015

A group of leading biologists on Thursday called for a worldwide moratorium on use of a new genome-editing technique that would alter human DNA in a way that can be inherited.

Genetic Engineering Has Made the Field of **Ancient DNA** Possible - Going Back in Time to Understand Human Origins

Science, May 7, 2010 (328, 710-722)

A Draft Sequence of the Neandertal Genome

From a 45,000 Year-Old Bone!

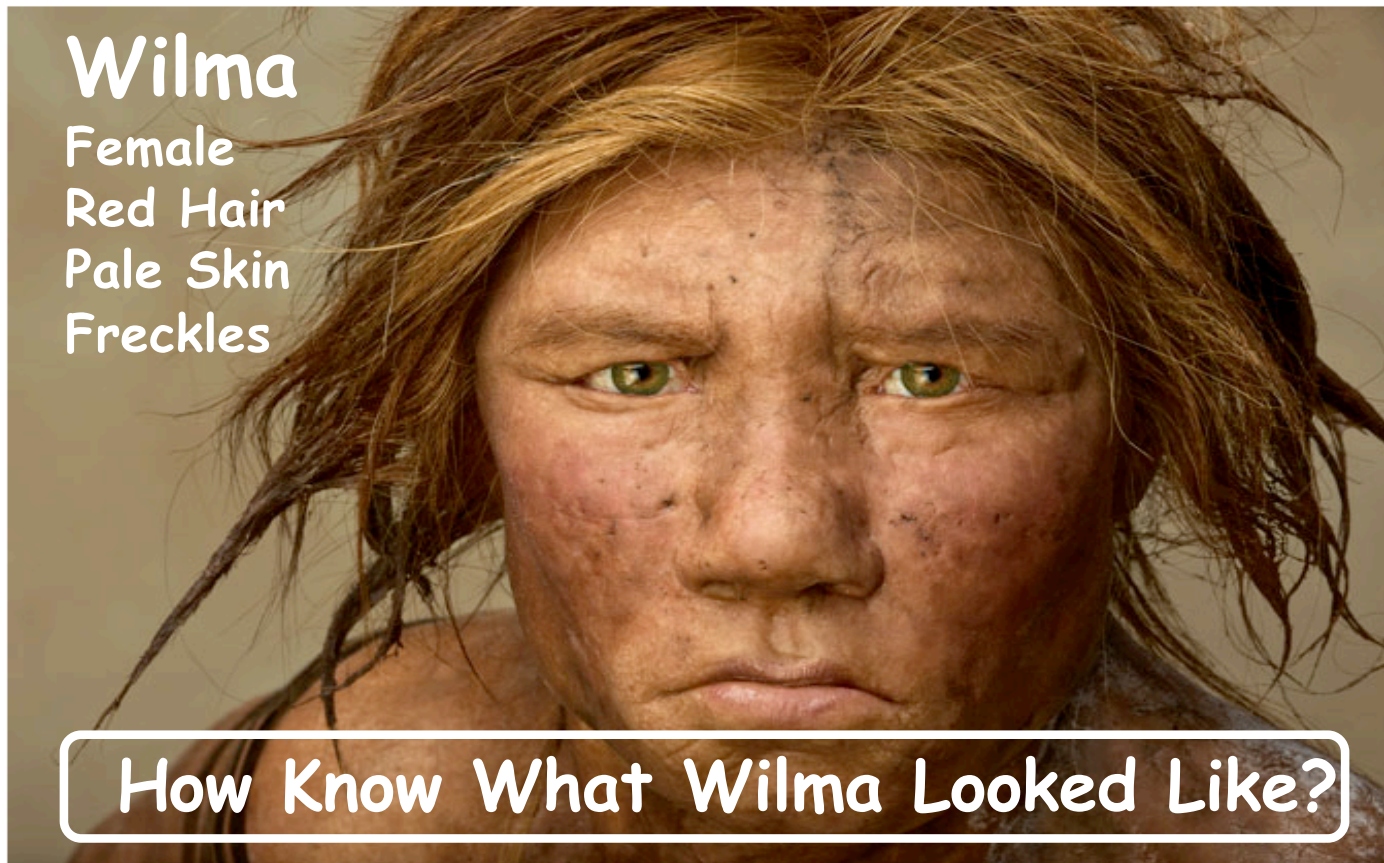
Wilma

Female

Red Hair

Pale Skin

Freckles



How Know What Wilma Looked Like?

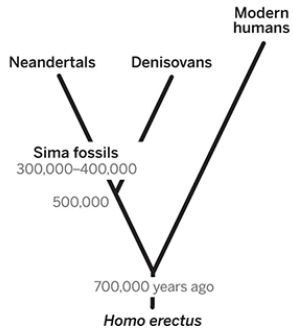
Reconstruction by Kennis & Kennis / Photograph by Joe McNally

For the first time, a Neanderthal female peers from the past in a reconstruction informed by both fossil anatomy and ancient DNA. At least some of her kind carried a gene for red hair and pale skin.

Genetic Engineering Has Led to Remarkable New Insights into Human Origins and Ancestry

Deeper branches

Putting the Sima fossils on the Neanderthal lineage implies an earlier split between modern and some archaic humans.



The Shaping of Modern Human Immune Systems by Multiregional Admixture with Archaic Humans

www.sciencemag.org SCIENCE VOL 334 7 OCTOBER 2011

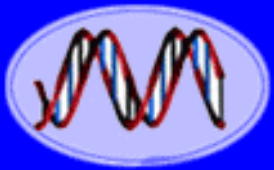
Comparing
40,000 Year-
Old
Fossil Genomes
to Our Genome
Reveals
Ancient
"Matings"
Between
Different
Human
Ancestor
Lineages!!



We Have
Neanderthal
Genes in Our
Chromosomes

It's All in the DNA!

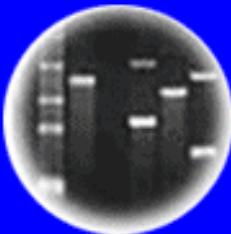
Nature Reviews | Genetics
September, 2011



DNA
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Entire Genetic Code
of a Bacteria



DNA Fingerprinting



Cloning: Ethical Issues
and Future Consequences



Plants of Tomorrow

Inexpensive Home DNA Testing Kits Can Determine a Person's Ancestry!



And New Ethical Issues

- Surprise Ethnic Identity
- Identity of Biological Parents & Relatives
 - Genetic Privacy
- Unauthorized Use in Identifying Criminals

I Have ~3% Neanderthal DNA in My Genome - A Relic of Ancient Migration and Mating Tens of Thousand of Years Ago!

How Did I Learn That?

This lab estimates your genome-wide percentage of Neanderthal ancestry

Got Neanderthal DNA?

Your Neanderthal DNA might actually be doing you some good

An estimated 2.6% of your DNA is from Neanderthals.

Bob Goldberg (you)



2.6%

33rd percentile

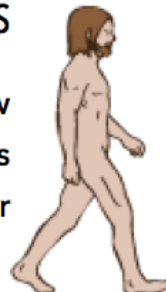
Average European user



2.7%

MODERN HUMANS

- Higher brow
- Narrower shoulders
- Slightly taller



NEANDERTHALS

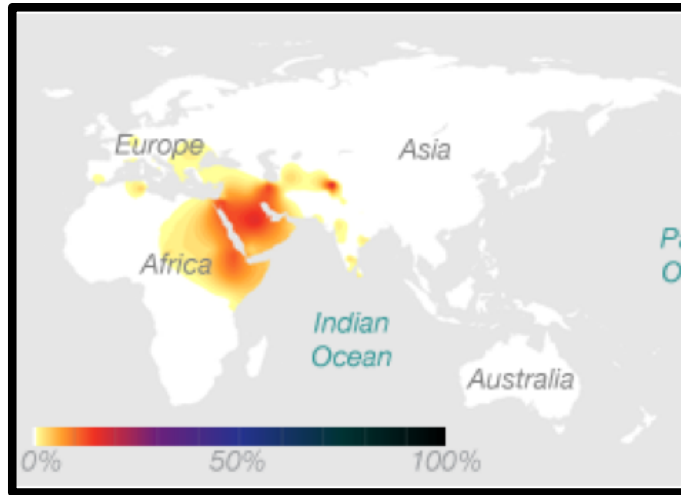
- Heavy eyebrow ridge
- Long, low, bigger skull
- Prominent nose with developed nasal chambers for cold-air protection



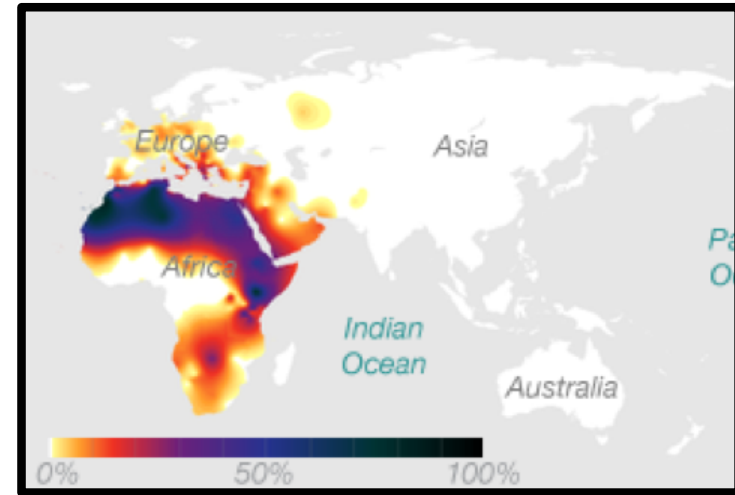
Without Genetic Engineering and DNA Sequencing Technologies This Could Not Have Been Done

Home DNA Testing Has Revealed My Ancestry (No Surprises!)

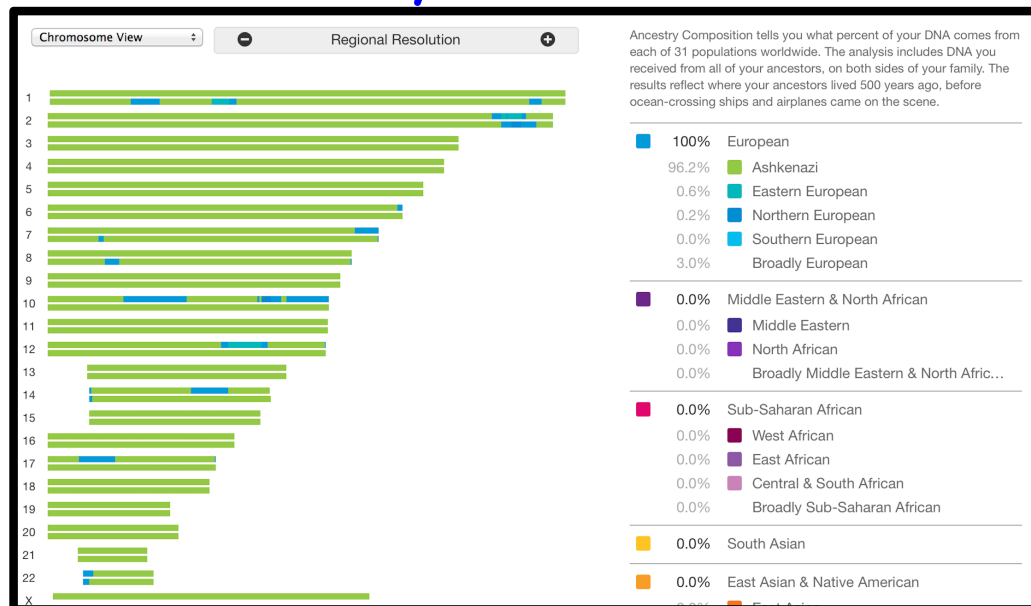
Mom



Dad



My Chromosomes

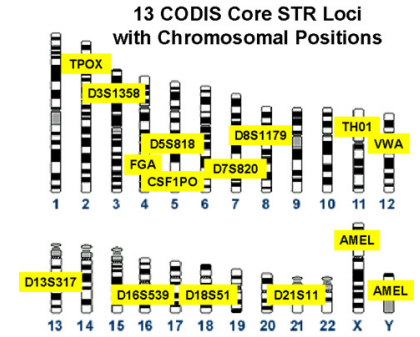


DNA Has Impacted the Law & Forensics in **Dramatic Ways!!!**

Combined DNA Index System (CODIS) of DNA Profiles



- Convicted Felons
- Suspects Arrested For Felonies
- DNA Samples From Crime Scenes
- Unidentified Human Remains
- Relatives of Missing Persons



NDIS Statistics

National DNA Index System

| [CODIS Home Page](#) | [FBI Home Page](#) |

October 2018

Offender Profiles 13,566,716
Arrestee Profiles 3,323,611
Forensic Profiles 752,508
Database "Hits" 440,346

**King vs. Maryland SCOTUS
4th Amendment Case**

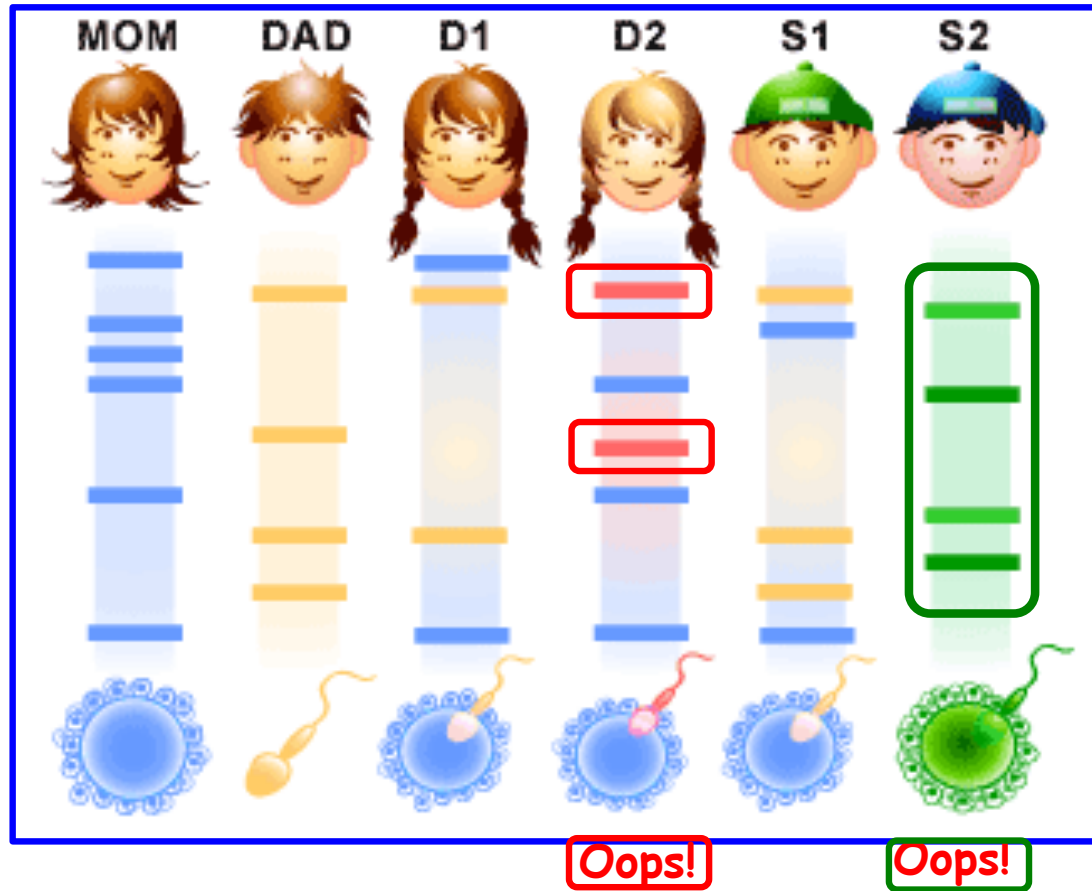
assisting 428,808 investigations



DNA Fingerprints Can Identify Individuals They Don't "Lie"

DNA Fingerprints

*Sometimes
They
Reveal
Unexpected
Results!*



*What is YOUR
DNA
Fingerprint?*

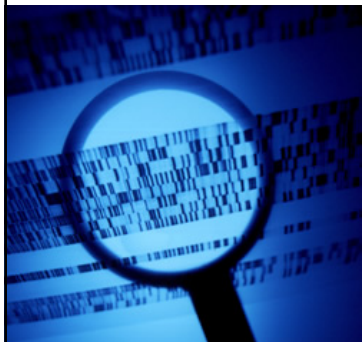
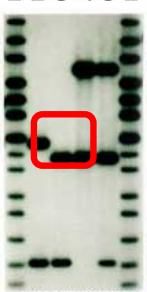
Paternity Exclusion

LADDER
Mother
Child
Alleged Father
C/AF Mix
LADDER



Paternity Inclusion

LADDER
Mother
Child
Alleged Father
C/AF Mix
LADDER



FORENSICS

Familial DNA Testing Scores A Win in Serial Killer Case



Proud of their work. A familial DNA search by forensic scientists in California led to the arrest of Lonnie Franklin, the suspected Grim Sleeper killer.

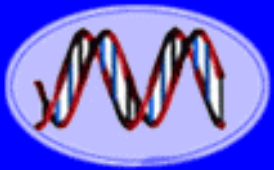
Grim Sleeper Caught By DNA!!

Others Set Free By DNA Evidence



15th Person Cleared by DNA in Dallas. Charles Chatman was released from state custody Jan. 3 in Dallas, after serving nearly 27 years in prison for a rape he didn't commit. He is the 15th Dallas man to be cleared by DNA testing after being wrongfully convicted. After his hearing, he hugged Judge John Creuzot, who advocated for testing in the case. Innocence Project of Texas Attorney Jeff Blackburn (left) represents Chatman.

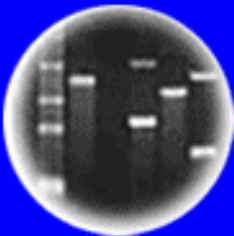
- 281 Post-Conviction DNA Exonerations Since 1989
- 17 of 281 People Exonerated Were on Death Row
- Average Time Served Was 13 Years
- Average Age at Time of Wrongful Conviction Was 27
- **75% of Wrongful Convictions Due to Eyewitness Misidentification**
- 50% of Wrongful Convictions Due to Improper Forensic Science, Such As Hair Sample, Shoe Print, & Bite Mark Comparisons



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DNA Fingerprinting



Cloning: Ethical Issues
and Future Consequences



Plants of Tomorrow

DNA Fingerprints Can Also Be Used To Uncover Fraud

May 26, 2011

Tests Reveal Mislabeling of Fish

By ELISABETH ROSENTHAL

Scientists aiming their gene sequencers at commercial seafood are discovering rampant labeling fraud in supermarket coolers and restaurant tables: cheap fish is often substituted for expensive fillets, and overfished species are passed off as fish whose numbers are plentiful.



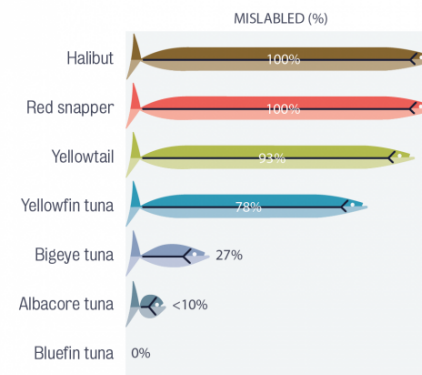
Herbal supplements fail DNA test in New York investigation of store brands

Just 21% of test results verified that DNA from plants listed on labels were what was inside, with only 4% of Walmart products passing test



HIGH RATES OF MISLABELING IN LA SUSHI RESTAURANTS

UCLA researchers used DNA barcoding to assess seafood served in Los Angeles restaurants from 2012 to 2015. They found 47 percent of fish had been mislabeled overall. However, mislabeling was inconsistent across different fish species, as shown below.



SOURCE: Demian A. Willetto, et al., UCLA Department of Ecology and Evolutionary Biology. Graphic reporting by Evlet Chin, Science and Health editor. Graphic by Jason Farwell, Daily Brain staff.



Genetic Engineering Has Led to Crops Grown For Human And Animal Consumption

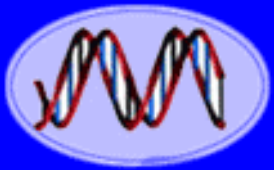


*Crops That Are
Grown For For
Human & Animal
Consumption*



Genetic Engineering of Photosynthesis Increases Plant Size!

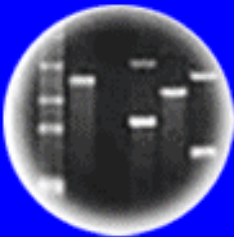
1/3/19



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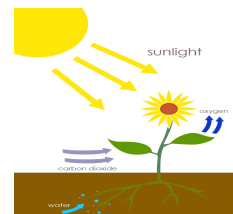
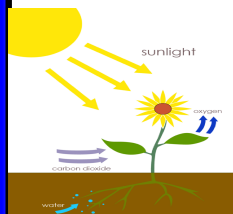
DNA Fingerprinting

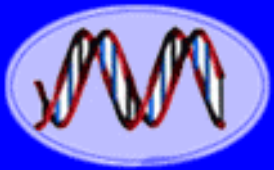


Cloning: Ethical Issues
and Future Consequences



Plants of Tomorrow

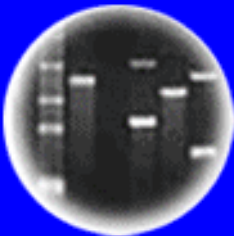




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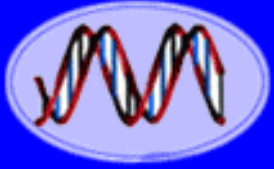


Plants of Tomorrow

Genetic Engineering Faster Growing Salmon For More Productive Aquafarms!



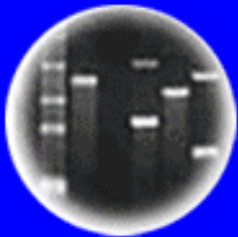
GMO salmon caught in U.S. regulatory net, but Canadians have eaten 5 tons



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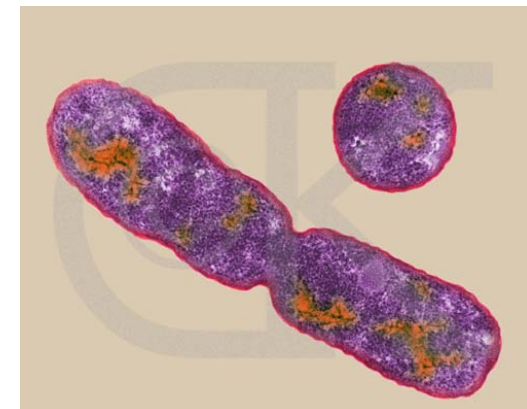
Plants of Tomorrow



Finally....We Have Entered a New Era of Genetic Engineering The Era of Synthetic Biology

Genetic Engineering Can Be Used To
Synthesize and Engineer Entire
Chromosomes From Chemicals and
Create Synthetic Microbes in a
Test Tube

Synthetic Genomes &
Chromosomes
40 Years After the
Invention of Genetic
Engineering



Creation of a Bacterial Cell Controlled by a Chemically Synthesized Genome

May 20, 2010

Researchers Say They Created a 'Synthetic Cell'

By NICHOLAS WADE

The genome pioneer J. Craig Venter has taken another step in his quest to create synthetic life, by synthesizing an

July 14, 2011

Genetic Code of E. Coli Is Hijacked by Biologists

Science, July 15, 2011

By NICHOLAS WADE

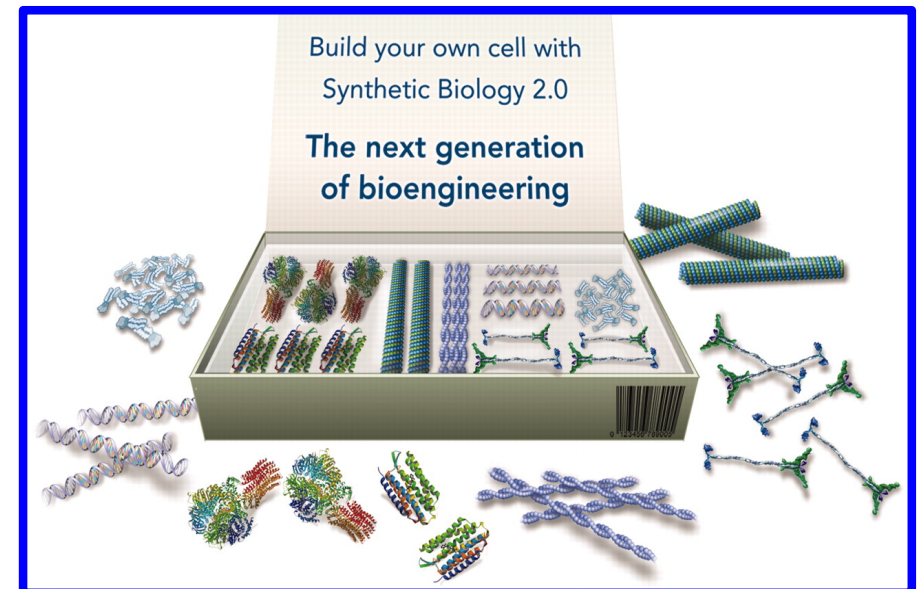
Synthetic Generation of Influenza Vaccine Viruses for Rapid Response to Pandemics

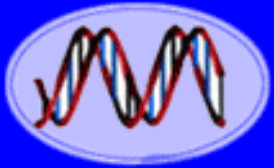
Sci. Transl. Med., May 15, 2013,

Think of the Possibilities.....

George Church: De-Extinction Is a Good Idea

Reviving mammoths and other extinct creatures is a good idea

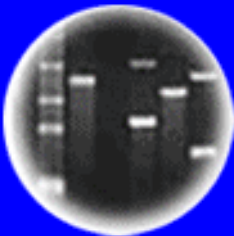




DNA
Genetic Code of Life



Entire Genetic Code
of a Bacteria



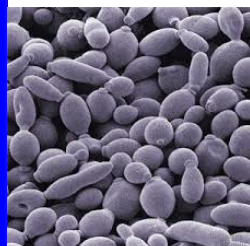
DNA Fingerprinting



Cloning: Ethical Issues
and Future Consequences

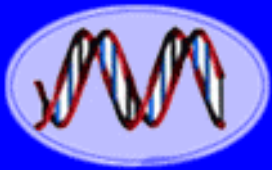


Plants of Tomorrow



A Yeast Cell With Chromosomes Synthesized in the Laboratory From A, G, C, & T DNA Bases !!!!

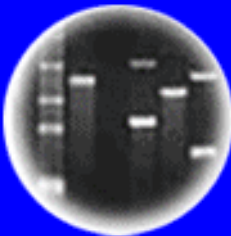




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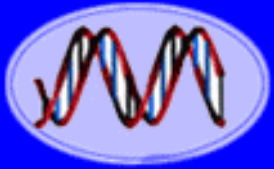


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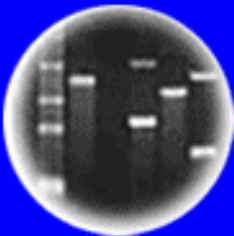
These Are These Issues That Will Be Covered in HC70A & the Science Driving the Genetic Engineering Technology Revolution



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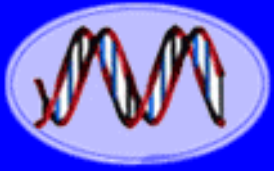
HC70A Winter 2020

Genetic Engineering in Medicine, Agriculture, and Law

Professor Bob Goldberg

Class Announcements

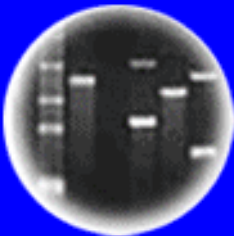
1/7/20



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The Long Distance Connection! HC70A & PLS530 Winter 2020

The central image is a map of the United States with green state boundaries. A red arrow points from the Tuskegee University location in the Southeast to the UCLA location in the West. Two inset photos are included: one showing Professor Bob Goldberg at UCLA interacting with students, and another showing Tuskegee students visiting UCLA.

UCLA
Professor Bob Goldberg

TUSKEGEE UNIVERSITY
Professor Channapatna Prakash

TUSKEGEE

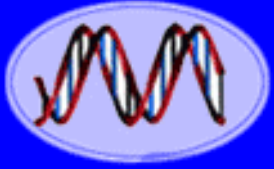
UCDAVIS

TUSKEGEE

UCLA

Tuskegee Students Visited UCLA

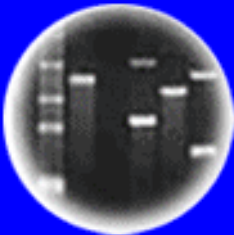
*A Model For Cross-Campus
Interactive Learning*



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HC70A Winter 2020 (UCLA) Genetic Engineering in Medicine, Agriculture, and Law

Discussion Coordinator

Dr. Kelli Henry

Learning Assistants

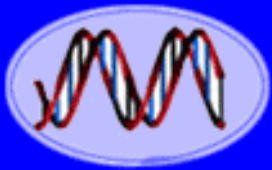
Pierce Ford

Madelyn Gehrich

Ava Gordon

Course Administrator

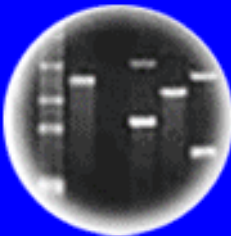
Dr. Lauren Bowman



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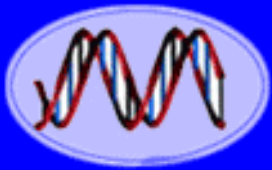
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PLSO559 Winter 2020 (Tuskegee) Genetic Engineering in Medicine, Agriculture, and Law

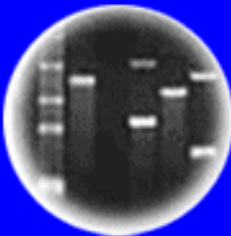
Professor Channapatna Prakash



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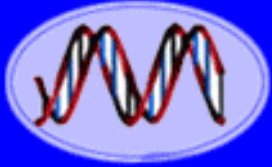
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Discussion Tomorrow

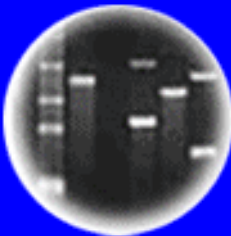
- Your Perceptions of Genetic Engineering & Its Applications
- Fill Out Survey Handed Out at the End of Class & Hand In Tomorrow in Discussion
- Be Prepared For a Lively Discussion



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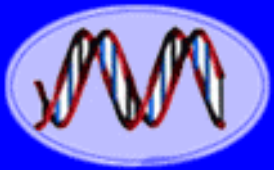
What Can You Do This Quarter?

- **Study the Lecture Slides**
- **Read Articles For Discussion**
- **Read Text to Reinforce Lecture Concepts**
- **Ask Questions**

- **Work Together**

Come to My Office Hours Friday

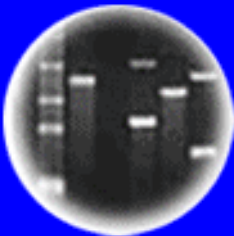
1:30-3:00 -Terasaki 4121



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Pick Up After Class

1. Survey
2. Syllabus