




DNA
Genetic Code of Life




Entire Genetic Code
of a Bacteria



DNA Fingerprinting



Cloning: Ethical Issues
and Future Consequences



Plants of Tomorrow

HC70A & SAS70A


Winter 2023

Genetic Engineering in Medicine, Agriculture, and Law

Professors Bob Goldberg & John Harada

Lecture 1

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




1



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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

2



NON
GMO
VERIFIED

The Politics of ... GMOs



NO ON **37**
STOP THE DECEPTIVE
FOOD LABELING SCHEME

Just Say
No To
GMO





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GMO
FREE
NJ



NO FRANKENFISH!
BAN GMO
SALMON!

To bolster the nation's blood supply, the Red Cross
genetically engineers giant mosquitoes that
instinctively deposit their loads in a blood bank.



GMO
FREE
FLORIDA



GMO CARROT



GMO SOYBEAN POD



YES
Right to
Know
AND UNLAWFUL THAMING FROM



NOV 11 2009
"I KNOW YOU TO
BE THE SPECIAL
FOODS SAVOR"

GMO
are safe for God sake


3



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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

Two New Laws Restrict Police Use of DNA Search Method

Supreme Court OKs DNA swab of people under arrest

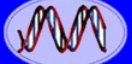

Supreme Court Supports Monsanto in Seed-Replication Case

Congress Passes Bill to Bar Bias Based on Genes

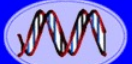

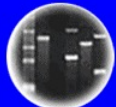


The USDA's new labeling for genetically modified foods goes into effect Jan. 1. Here's what you need to know.

In California, an army of genetically engineered mosquitoes awaits release. Will it backfire?

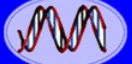
4

 DNA Genetic Code of Life  Entire Genetic Code of a Bacteria  DNA Fingerprinting  Cloning: Ethical Issues and Future Consequences  Plants of Tomorrow	<h2 style="color: blue;">Genetic Engineering in the News..</h2> <h3 style="color: red;">Medicine</h3>
	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 
	Genome-edited baby claim provokes international outcry
	By creating mouse eggs entirely from scratch, researchers raise the prospect of a futuristic fertility treatment
	COVID-19 brings a new dawn for messenger RNA vaccines


5

 DNA Genetic Code of Life  Entire Genetic Code of a Bacteria  DNA Fingerprinting  Cloning: Ethical Issues and Future Consequences  Plants of Tomorrow	<h2 style="color: blue;">Genetic Engineering in the News..</h2> <h3 style="color: red;">Agriculture</h3>
	Genetically Modified Salmon Is Safe To Eat, FDA Says
	GM Purple Tomato Gets Approval in the United States
	<i>By 'Editing' Plant Genes, Companies Avoid Regulation</i>
	GM Wheat Used to Make Bread with Less Gluten
	<i>GM banana shows promise against deadly fungus strain</i>
	US FDA declares genetically modified pork 'safe to eat'
	FDA Clears Marketing of Genome-Edited Beef Cattle


6




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Genetic Engineering in the News.. Future

Synthetic Biology Engineers the Next Genomic Revolution

Mouse embryos grown without eggs or sperm: why and what's next?

Cloned mice created from freeze dried skin cells in world first

What Makes Your Brain Different From a Neanderthal's?

100-year-old pandemic flu viruses yield new genomes

Airborne environmental DNA for terrestrial vertebrate community monitoring

7

And All the GMO Misconceptions!!!!!!





Mark Lynas



Diseases caused by GMO food:

- Carnosaur virus
- Dar-Kosis
- Vampirism
- Clone-Killing Microbes
- Black Trump Virus
- The Sickens/Imperial bioweapons project
- 171A/Project Blackwing
- Neurological Degeneration Syndrome, or NDS
- Hinamizawa Syndrome
- Hepatitis V
- Cluckitis
- Hot-Dog Fingers
- Ts-19
- Rozzle Thrilly Syndrome (RDS)
- Maternal Death Syndrome (MDS)
- Neurodermatitis
- Pain Mare Salts
- Known as the Bleedy Flux
- Stone Sickness
- Coffin Vampirism
- T4 Angel Virus
- Synaptic/Neuro Overstimulation Syndrome (SOS/NOS)
- Marble's Flu (MSEVFL)

Don't label GMOs



BAN THEM !!! A.H.



STOP GMO SALMON

Don't Trust The Feds



On GMOs, Pesticides & Chemicals

organicconsumers.org

GMO'S Are Bad For YOU!



8

NO
GMOs

The GMO "Controversy" is Mostly About Food & Crops & Not Science Based!!



- *Successful Well-Financed Anti-GMO "Propaganda" Campaign*
- *Bogus Science Studies Sensationalized by the Popular Media*
- *Organic Growers/Markets - Gain Market Share (Follow the \$!!)*
- *Anti-Globalization - Anti-Patent/Intellectual Property*
- *Anti-Industrial-Conventional Farming That Uses GMOs*
- *Anti-Large AgBiotech Companies*
- *Labeling - Right to Know and Choose What is Eaten*
- *Few Consumer Benefits to Date*
- *Ecological & Environmental Issues (e.g., Pollen Flow)*
- *Cultural Issues - Not "Natural"*
- *Lack of Public Science Awareness*
- *First World Problem*

Began in 1995 When the First GMO Was Approved For Commercialization




9

Safety Issues of Genetically Engineered Plants Have Been Investigated and Discussed For 40 Years - Thousands of Studies - Unanimous Conclusion - GMOs are Safe For Human Consumption!!

				
1982	1984	1985	1987	2001
				
2002	2004	2010	2011	2016

10



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So.... What is a GMO???

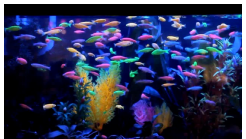


11


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?*

12

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?

13

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 in Their Blood Cells That They Weren't Born With That "Cures" a Lethal Genetic Disease?



A Genetically Engineered Baby Who Was Born a Permanently Altered Gene?

14



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

So.....What is a GMO?

15



Foods Made With GMO Ingredients?

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Plants of Tomorrow

16

So.....What is a GMO?



17



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What is Genetic Engineering and a Genetically Modified Organism?

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





genetic engineering
jəˈnetɪk ˌɛnʒɪˈniəriŋ/
noun
noun: genetic engineering
the deliberate modification of the characteristics of an organism by manipulating its genetic material.



18



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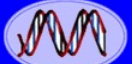
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Genetic Engineering is the TECHNIQUE! That Generates GMOs


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
4. **DNA Synthesis - Synthetic Genomes**
(5 Years)

*Breeding or DNA Manipulation - They Are the
SAME
&
Called **Gene Engineering**
So.....**WHAT IS A GMO??***

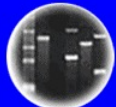
19




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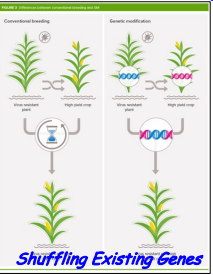
Cloning: Ethical Issues
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Four Genetic Engineering Techniques That Generate GMOs!!!

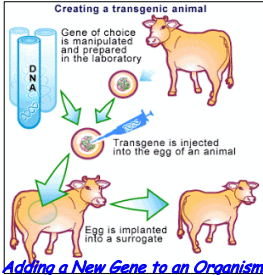
1. Classical Breeding



Shuffling Existing Genes

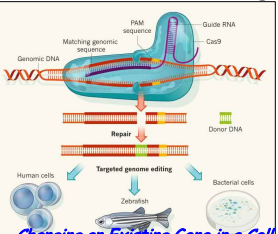
2. Transgenic Organism

Creating a transgenic animal



Adding a New Gene to an Organism

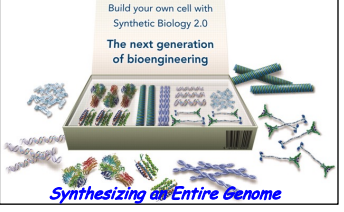
3. CRISPR Gene Editing



Changing an Existing Gene in a Cell

4. Synthetic Biology

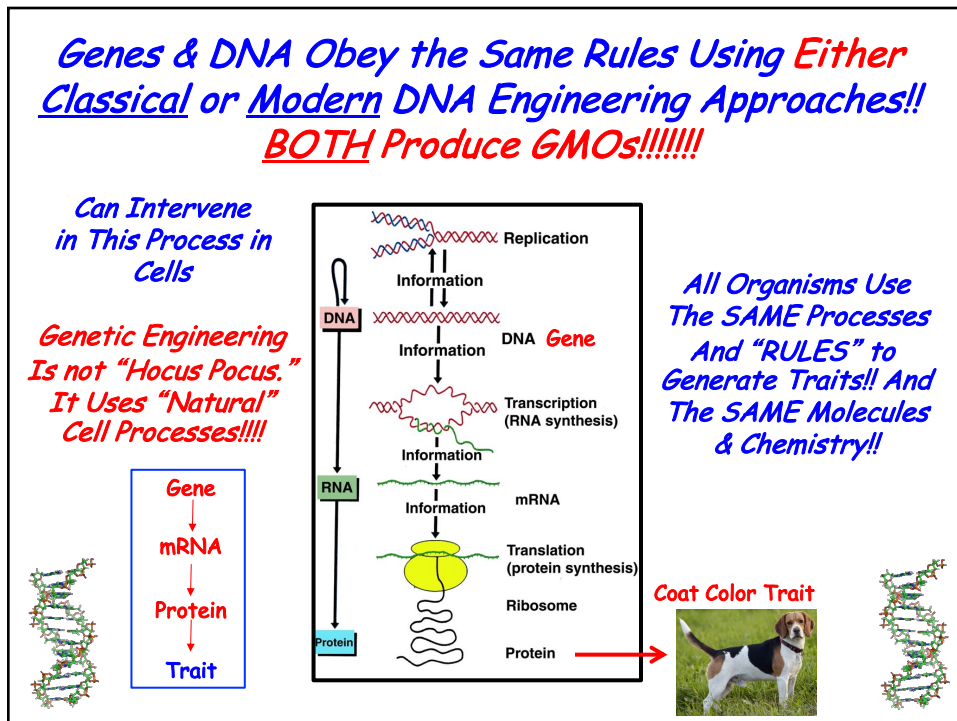
Build your own cell with
Synthetic Biology 2.0
The next generation
of bioengineering



Synthesizing an Entire Genome

20

10



21

Essential HC70A Theme!

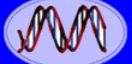
We Live in The Age of Genetic Engineering and DNA!

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!!!!

The slide features a collage of four images: a black and white dog, a Science magazine cover titled 'SYNTHETIC CHROMOSOMES', a bowl of colorful fruit, and a glowing green, stylized figure.


22




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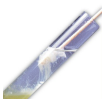
DNA Fingerprinting



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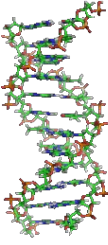
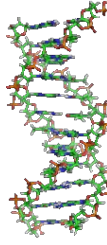
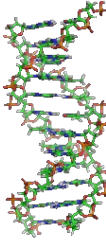


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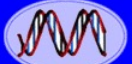


What Does Your DNA Look Like?


Have You Ever Seen or Touched Your Genes?

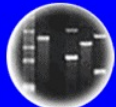
23




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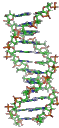
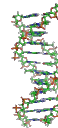
Cloning: Ethical Issues
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How Was Genetic Engineering Using DNA Invented?

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

24

DNA Genetic Engineering Has Been in the News For 50 Years!!! It's Old Technology!!!!!!

Gene Transplants Seen Helping Farmers and Doctors

By VICTOR K. MCELHENY MAY 20, 1974 **1974 (20 Years After Structure of DNA Discovered)**

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

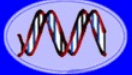
1977

Substance Usually Made in Brain Grown in Bacteria


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

1976

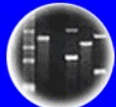
25




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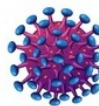
Cloning: Ethical Issues
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The Idea That DNA From Different Species Could Be Recombined Started With Viruses ~50 Years Ago!


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




HIV




Hepatitis B



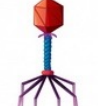
Ebola Virus



Adenovirus

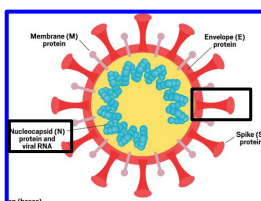


Influenza



Bacteriophage

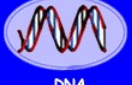
A Virus Consists of a Protein Protective Coat and a Nucleic Acid (DNA or RNA) Genome That Contains Its Genes




They Exist to Exist!!!

Coronavirus

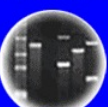
26




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A Hybrid DNA Molecule Was Produced By Combining the DNAs of a Monkey Virus With a Bacteria Virus (50 Years Ago!)

1972 Nobel Prize 1980

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 rejoin DNA after a foreign gene was spliced into it. These and other enzymes, captured from nature, could be used as tools in genetic engineering.

In creating hybrid DNA molecules, Berg employed the much-studied SV40 monkey virus and a bacterial virus known as the λ (lambda) bacteriophage. The SV40 virus has few genes, lacks a protein coat, and 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 stripped 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 accordance 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* stirred Berg to delay 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 Berg and his colleagues took this step shortly.) A symposium at Stanford University, in 1974, Berg published a widely discussed letter on the potential dangers of recombinant DNA research. Subsequently, a conference 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 “the fundamental studies of the biochemistry of nucleic acids, with particular emphasis on the mechanisms of DNA replication and the structure of the DNA double helix.”

THE NEW YORK TIMES MAGAZINE, October 1972

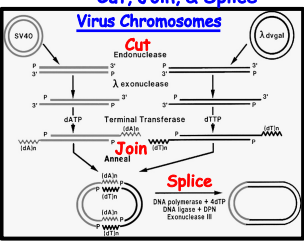
Biochemical Method for Inserting New Genetic Information into DNA of Simian Virus 40 (SV40) DNA Molecules Containing Lambda Phage Genes and the Galactose Operon of *Escherichia coli*

DAVID A. JACKSON, ROBERT H. JOHNSON, AND PAUL BERG

Simian Virus 40 **λ Bacteriophage**





“Cut, Join, & Splice” Virus Chromosomes




Nobel Prize


In Test Tube Only
Not Functional!!!



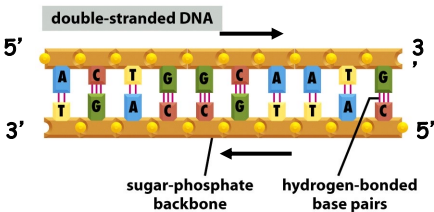
27



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




double-stranded DNA



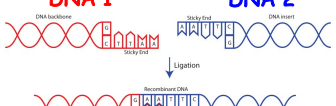
sugar-phosphate backbone **hydrogen-bonded base pairs**

DNA double helix



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

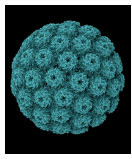

DNA 1 **DNA 2**



Hybrid DNA

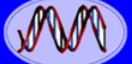
Simian Virus 40

λ Bacteriophage





Major Genetic Engineering Concept!!

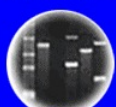
28




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Plants of Tomorrow

Modern Genetic Engineering of Living Cells (GMOs) Was Invented a Year Later & Caused a Revolution in Biology A Half a Century Ago!

Proc. Nat. Acad. Sci. USA
Vol. 70, No. 11, pp. 3240-3244 November 1973

This is the 50th 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!!



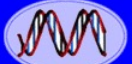
Herb Boyer

Original Question: Can an Antibiotic Resistance Gene Be Isolated and Studied?




Stanley Cohen


29




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and Future Consequences



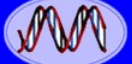
Plants of Tomorrow

Modern Genetic Engineering Was Invented 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



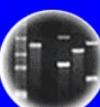
30




DNA
Genetic Code of Life




Entire Genetic Code of a Bacteria



DNA Fingerprinting

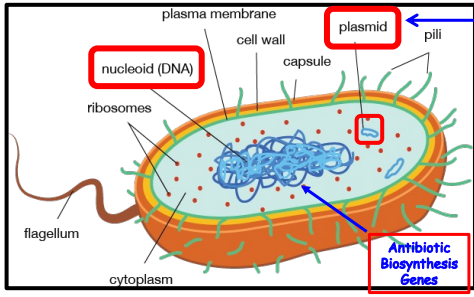


Cloning: Ethical Issues and Future Consequences



Plants of Tomorrow

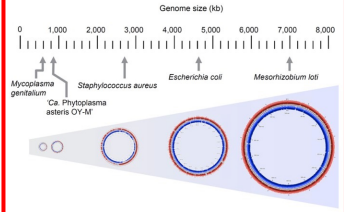
A Typical Bacterial Cell




Used For Genetic Engineering Carries Antibiotic Resistance Genes

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

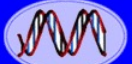
Bacterial Chromosomes Are Circular & Contain 500 to 7500 Genes






Humans Have Linear Chromosomes With 25,000 Genes

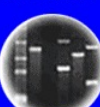
31




DNA
Genetic Code of Life




Entire Genetic Code of a Bacteria



DNA Fingerprinting



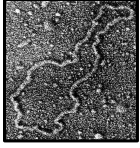
Cloning: Ethical Issues and Future Consequences



Plants of Tomorrow


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

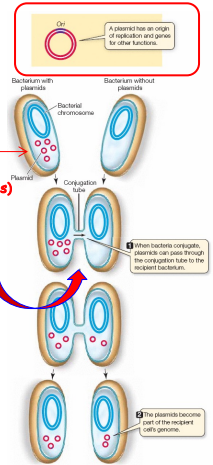
Electron Micrograph



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

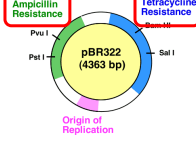
Bacteria Mating





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

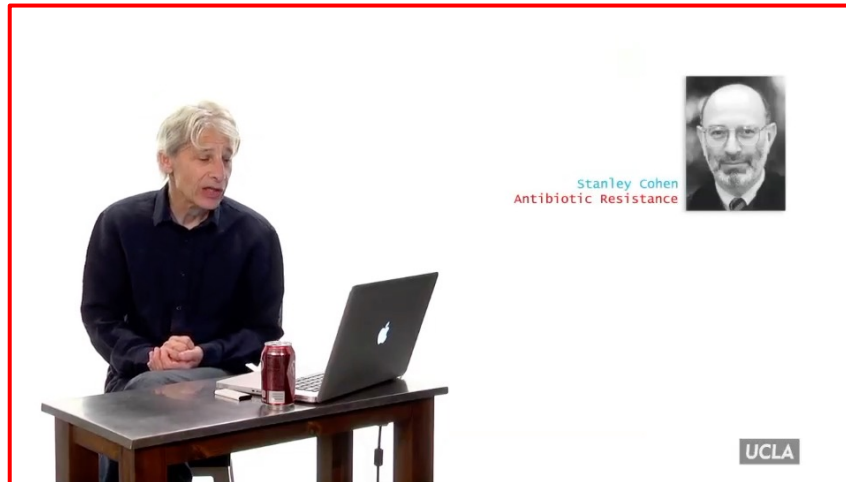
Stanley Cohen



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

32

Antibiotic Resistance - Use in Genetic Engineering



Think About a World With No Effective Antibiotics!!!
20% of Deaths Before Antibiotics Were Pneumonia & Tuberculosis

33



DNA
Genetic Code of Life



Entire Genetic Code
of a Bacteria



DNA Fingerprinting



Cloning: Ethical Issues
and Future Consequences



Plants of Tomorrow

Plasmid Properties Making Them Ideal For Genetic Engineering



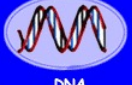





1. Small DNA Molecule That Can Replicate Into Many Copies
2. Easy to Isolate & Put Back In Cells
3. Have Antibiotic Resistance Genes - Can Identify Bacteria With a Plasmid
4. Easy To Manipulate & Modify With Foreign Genes

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


34




DNA
Genetic Code of Life



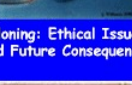
Entire Genetic Code
of a Bacteria



DNA Fingerprinting




Cloning: Ethical Issues
and Future Consequences



Plants of Tomorrow

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



Herb Boyer

Restriction Enzymes

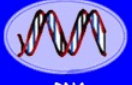
"Killer" Virus

- 1 A restriction enzyme cleaves the incoming phage DNA at restriction sites.
- 2 Other enzymes degrade the phage DNA into smaller fragments.
- 3 Methyl groups at the restriction sites block the restriction enzyme and protect the bacterial DNA from being cleaved.


Protection of Bacterial Chromosome

Restriction Enzymes Protect Bacteria From "Killer" Viruses!


35




DNA
Genetic Code of Life



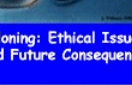
Entire Genetic Code
of a Bacteria



DNA Fingerprinting



Cloning: Ethical Issues
and Future Consequences




Plants of Tomorrow


Enzymes Are Proteins That Catalyze or Facilitate Chemical Reactions

© E.M. Collins 2001

substrate

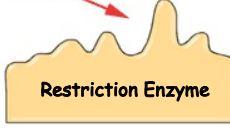


products



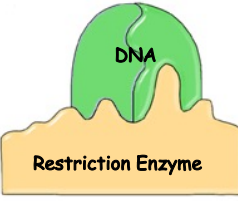
bonds in substrate are weakened

active site




Restriction Enzyme

enzyme



Restriction Enzyme

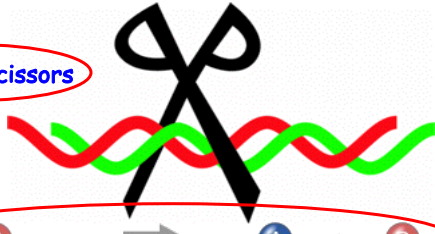
enzyme-substrate




Restriction Enzyme

enzyme

Molecular Scissors

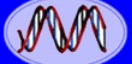


A + B




Werner Arber
Noble Prize
1978


36




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DNA Fingerprinting

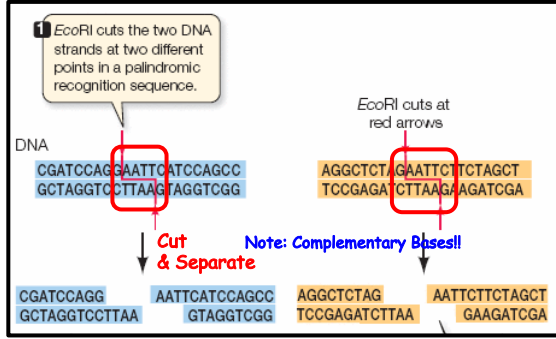


Cloning: Ethical Issues
and Future Consequences



Plants of Tomorrow

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



1 EcoRI cuts the two DNA strands at two different points in a palindromic recognition sequence.

EcoRI cuts at red arrows

DNA

CGATCCAGGAATTCATCCAGCC
GCTAGGTCCTTAAGTAGGTCGG

AGGCTCTAGAATTCCTTAGCT
TCCGAGATCTTAAAGATCGA

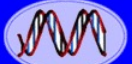
Cut & Separate

Note: Complementary Bases!!


CGATCCAGG AATTCATCCAGCC AGGCTCTAG AATTCCTTAGCT
GCTAGGTCCTTAA GTAGGTCGG TCCGAGATCTTAA GAAGATCGA

The “Scissors” For Genetic Engineering

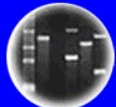
37




DNA
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Entire Genetic Code
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DNA Fingerprinting

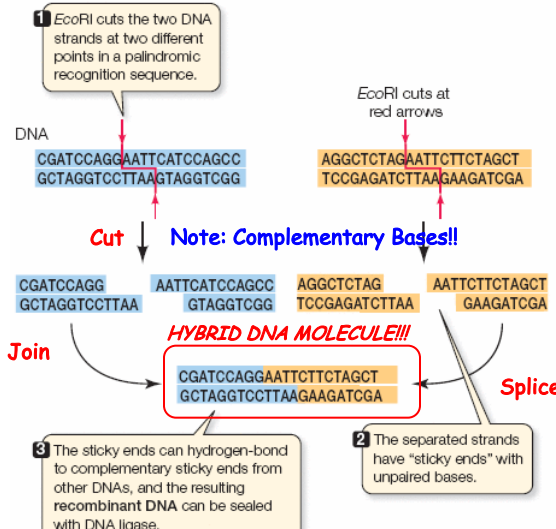


Cloning: Ethical Issues
and Future Consequences



Plants of Tomorrow

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



1 EcoRI cuts the two DNA strands at two different points in a palindromic recognition sequence.

EcoRI cuts at red arrows

DNA

CGATCCAGGAATTCATCCAGCC
GCTAGGTCCTTAAGTAGGTCGG

AGGCTCTAGAATTCCTTAGCT
TCCGAGATCTTAAAGATCGA

Cut

Note: Complementary Bases!!

CGATCCAGG AATTCATCCAGCC AGGCTCTAG AATTCCTTAGCT
GCTAGGTCCTTAA GTAGGTCGG TCCGAGATCTTAA GAAGATCGA

Join

HYBRID DNA MOLECULE!!!

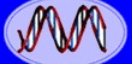
Splice

2 The separated strands have “sticky ends” with unpaired bases.


3 The sticky ends can hydrogen-bond to complementary sticky ends from other DNAs, and the resulting recombinant DNA can be sealed with DNA ligase.

The “Scissors” For Genetic Engineering


38




DNA
Genetic Code of Life




Entire Genetic Code
of a Bacteria



DNA Fingerprinting





Cloning: Ethical Issues
and Future Consequences



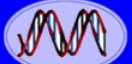
Plants of Tomorrow

Restriction Enzymes Animated!






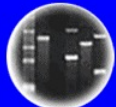
39




DNA
Genetic Code of Life




Entire Genetic Code
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DNA Fingerprinting



Cloning: Ethical Issues
and Future Consequences



Plants of Tomorrow

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)!!

Cut
↓
Join
↓
Splice

Genetically Engineered Bacteria!!!

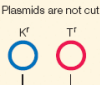
Insert Back Into Bacterial Cell Transform

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.

Plasmids are not cut




E. coli plasmid -




The cut plasmids are mixed with DNA ligase to form recombinant DNA.

The plasmids are put into *E. coli*

RESULTS



Some *E. coli* resistant to both antibiotics.



No *E. coli* doubly resistant.

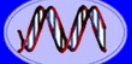
CONCLUSION: Two DNA fragments with different genes can be joined to make a recombinant DNA molecule, and the resulting DNA is functional.

Hypothesis?
Predictions?

This Was the FIRST GMO!!!

40

20



DNA
Genetic Code of Life



Entire Genetic Code
of a Bacteria



DNA Fingerprinting



Cloning: Ethical Issues
and Future Consequences



Plants of Tomorrow

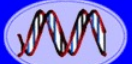
Genetic Engineering Technology Can Combine DNA (Genes) From Different Sources Leading to New Gene Combinations!!

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




UCLA

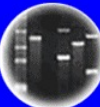
41




DNA
Genetic Code of Life




Entire Genetic Code
of a Bacteria



DNA Fingerprinting

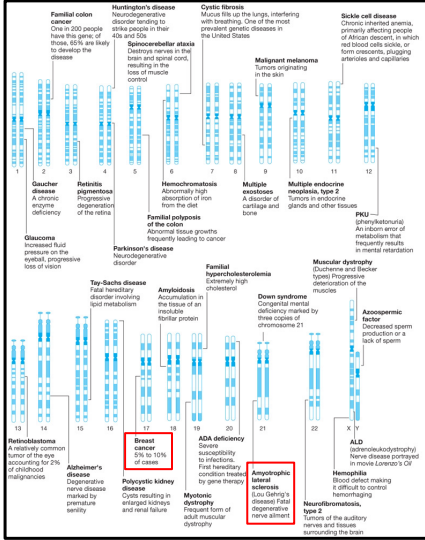


Cloning: Ethical Issues
and Future Consequences



Plants of Tomorrow

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

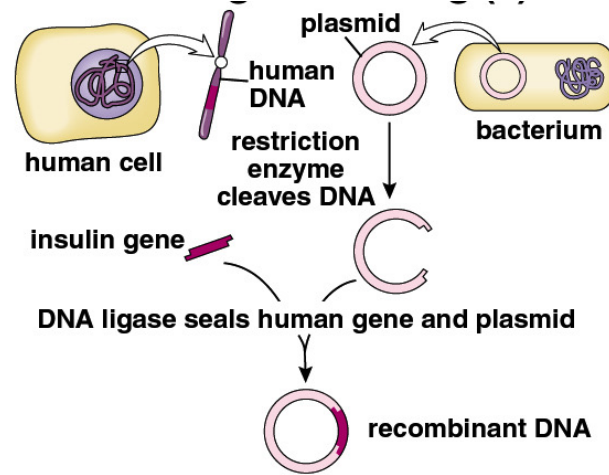


The
Human
Genome
Has
25,000
Genes

How Can a Single Gene Be Studied?

42

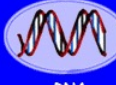
For Example.....The Human Insulin Gene Can Be Separated From Other Human Genes and Transferred to a Bacterial Cell Using Recombinant DNA Methods!



And Used to Treat Diabetes!



43



DNA
Genetic Code of Life



Entire Genetic Code
of a Bacteria



DNA Fingerprinting

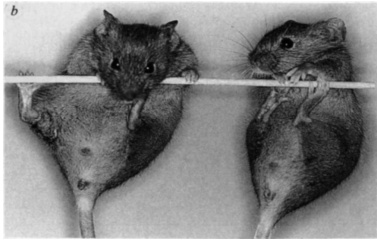


Cloning: Ethical Issues
and Future Consequences



Plants of Tomorrow

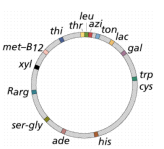
And Made to Perform Any Function That We Want Using Normal Cellular Processes!!

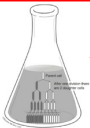


44

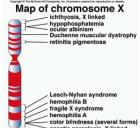
“Why” Clone Genes From An Organism’s Genome?
An Essential HC70A Concept!



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!!

45

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!!

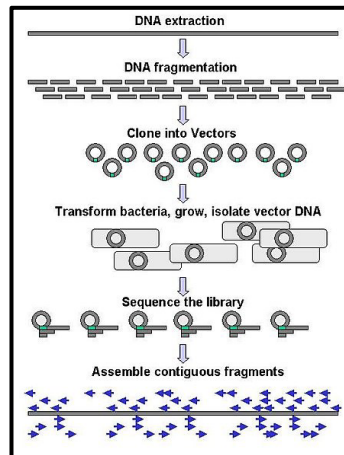




46

Recombinant DNA Manipulation Also.....

STARTED the DNA Sequencing Revolution - Sequencing Specific Cloned DNA Fragments - Leading to Whole Genome Sequencing & Identifying Every Gene in a Genome - Including Humans!



47

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

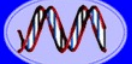





Sequencing projects will screen 200,000 newborns for disease genes

A more-inclusive genome project aims to capture all of human diversity

The Era of Personalized Genomes is Here!

48

 DNA Genetic Code of Life	<h2 style="text-align: center;">Genetic Engineering & DNA Sequencing</h2> <div style="border: 2px solid blue; padding: 10px; text-align: center; margin: 10px 0;"> <p>Are the Most Revolutionary Technologies in Biology to Have Been Invented in Human History!</p> </div> <div style="border: 2px solid red; padding: 10px; text-align: center; margin: 10px 0;"> <p>Have Generated the Vast Majority of New Biological Knowledge Over the Past 50 Years From Experiments in Biology Laboratories Around the Globe</p> </div> <div style="border: 2px solid blue; padding: 10px; text-align: center; margin: 10px 0;"> <p>Has Changed Our Lives Dramatically!</p> </div>
 Entire Genetic Code of a Bacteria	
 DNA Fingerprinting	
 Cloning: Ethical Issues and Future Consequences	
 Plants of Tomorrow	

49

<h3 style="text-align: center;">AndHas Led to Many New Legal and Ethical Issues</h3>
<ol style="list-style-type: none"> 1. <u>Genetic Enhancement</u> and Eugenics: Right to Enhance Your Child? 2. Gender Selection and <u>Prenatal Diagnosis</u> of Genetic Diseases? 3. <u>Gene Therapy</u>: Correcting Human Genetic Diseases? 4. <u>Genetic Testing</u>: DNA Databases, Newborn Genetic Screening, Genetic Privacy, Involuntary or Voluntary Testing? 5. Genetic Discrimination? 6. Human Cloning and <u>Genetic Improvement</u>? 7. <u>Patenting Genes, Cells, & Living Organisms</u>? 8. Regulating the Release of Genetically Modified Organisms into the <u>Environment</u>? 9. <u>Labeling of Genetically Modified Foods</u>? 10. Synthetic Genomes: <u>Constructing New Organisms</u>?

50



DNA
Genetic Code of Life



Entire Genetic Code
of a Bacteria



DNA Fingerprinting



Cloning: Ethical Issues
and Future Consequences



Plants of Tomorrow

A Few Examples of 21st Century DNA Applications That Have Affected Society and Knowledge About Ourselves

Essential HC70A Concept: They Could Not Have Been Developed Without the Invention of Genetic Engineering Because They Require Specific Genes or DNA Sequences!!!

Which You Will Learn the Basis of in HC70A!





51



DNA
Genetic Code of Life



Entire Genetic Code
of a Bacteria



DNA Fingerprinting



Cloning: Ethical Issues
and Future Consequences



Plants of Tomorrow

Genetic Engineering Has Been A Major Source of Drugs To Treat Human and Animal Diseases Over the Past 40 Years!

Insulin





GENETICALLY ENGINEERED DRUGS AND VACCINES

COVID Vaccine

↓



Bacteria



Crops

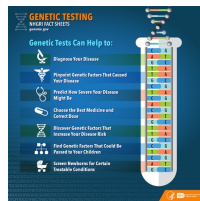


Livestock



52

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



And
Before Birth!!!



Made Possible Because of Genetic Engineering!

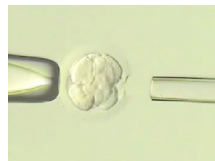
53

Determining the Genetic Identity of a Human Embryo Before Implantation!

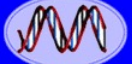


Prenatal Genetic Diagnosis (PGD)


Fertility Clinics Scan for the Strongest Embryo



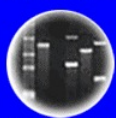
54




DNA
Genetic Code of Life




Entire Genetic Code
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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**

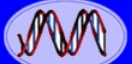
Contradictory Risk Predictions for Prostate Cancer and Hypertension

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.

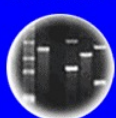
55




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DNA Fingerprinting



Cloning: Ethical Issues
and Future Consequences



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

56

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

EXPERIMENT

HYPOTHESIS: The introduction and expression of a normal allele can help a patient who is homozygous for two defective alleles of an important gene.

METHOD

1. Isolated somatic cells from the patient are homozygous for the defective allele.
2. A copy of the normal allele is inserted into viral DNA.
3. Isolated somatic cells are infected with the virus containing the recombinant DNA.
4. The viral DNA carrying the normal allele is inserted into the patient's somatic cell chromosomes.
5. Somatic cells containing the normal allele are cultured.
6. Cultured cells are injected into the patient.
7. Symptoms are relieved by expression of the normal allele.

RESULTS

CONCLUSION: Gene therapy can be effective in relieving symptoms caused by a genetic disease.

Gene therapy cures 'bubble boy disease'

31 Jan 2009, 1128 hrs IST, AP

The Age of Human Genetic Engineering Began More Than 25 Years Ago - SCID Treated With Normal ADA Gene!!!


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

The new england journal of medicine

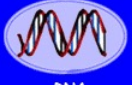
established in 1812 January 29, 2009 vol. 360 no. 5

Gene Therapy for Immunodeficiency Due to Adenosine Deaminase Deficiency


Gene Therapy with the Adenosine Deaminase (ADA) Gene



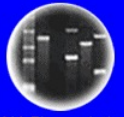
57




DNA
Genetic Code of Life




Entire Genetic Code of a Bacteria




DNA Fingerprinting




Cloning: Ethical Issues and Future Consequences




Plants of Tomorrow

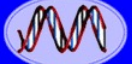





And More Recently The Era of Correcting, or Editing, Defective Genes in the Germline (e.g., Eggs) Has Arrived!!!!




58




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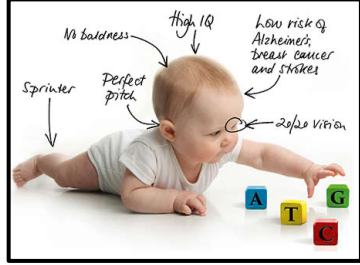


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Has the Era of Human Genetic Engineering Arrived Directing Our Own Evolution???



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.

59

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

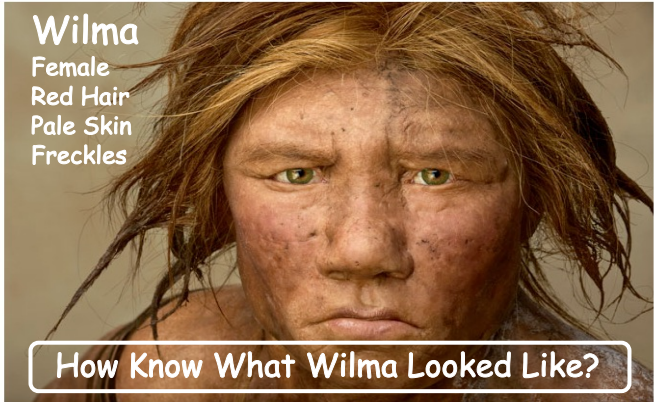
Science, May 7, 2010 (328, 710-722)

A Draft Sequence of the Neanderthal Genome

What Makes Your Brain Different From a Neanderthal's?

From a 45,000 Year-Old Bone!

Wilma
Female
Red Hair
Pale Skin
Freckles



Thousands of Ancient Human Genomes Have Now Been Sequenced!!

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.

60

**.....And 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.

Neanderthals Denisovans Modern humans
Sima fossils 300,000-100,000
700,000 years ago
Homo erectus

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

61

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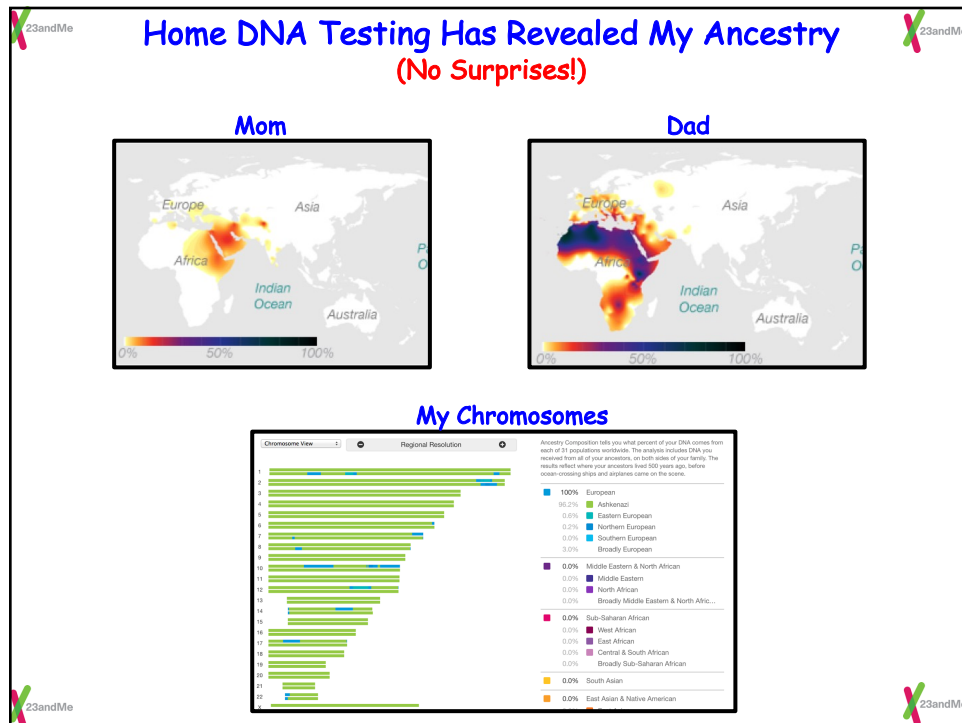
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Inexpensive Home DNA Testing Kits Can Determine YOUR Ancestry!

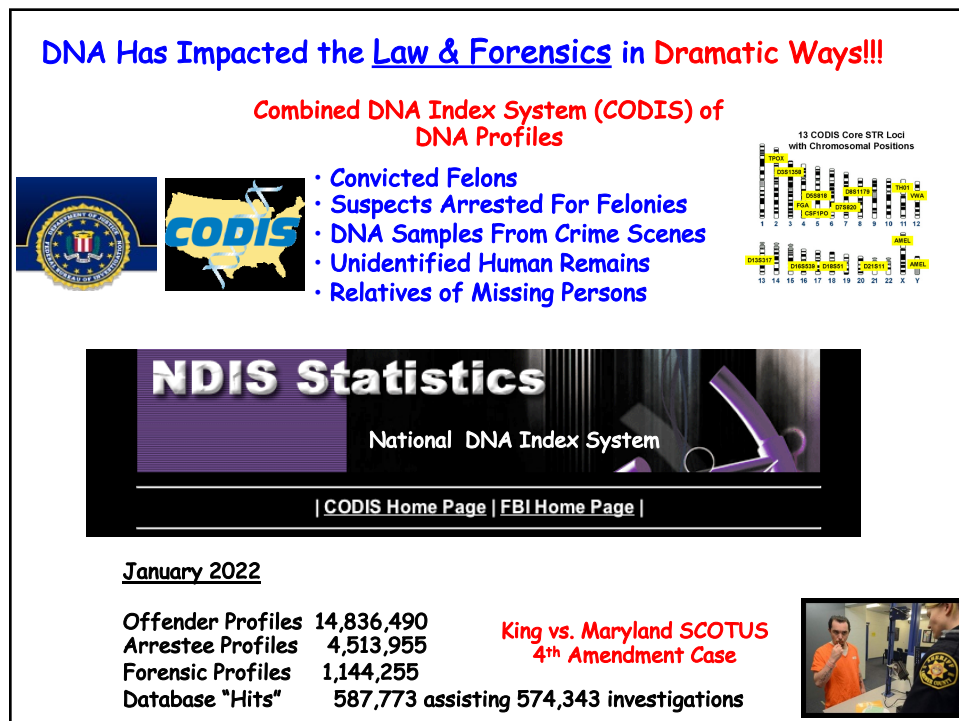
And New Ethical Issues

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

62



63




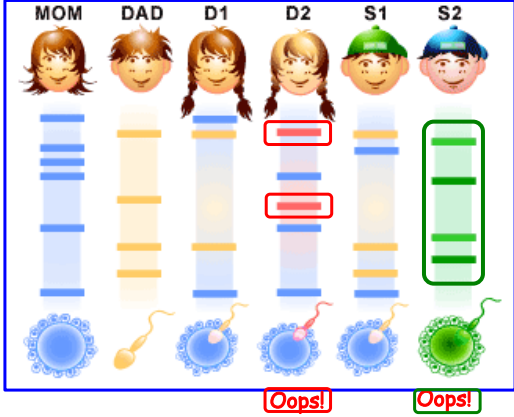
64

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

DNA Fingerprints

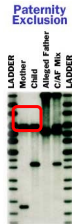
Sometimes They Reveal Unexpected Results!






What is YOUR DNA Fingerprint?

Paternity Exclusion



Paternity Inclusion



65

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

66



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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 2002 to 2010. They found 41 percent of fish had been mislabeled overall. However, mislabeling was inconsistent across different fish species, as shown below.

Fish Species	Mislabeled (%)
Halibut	100%
Red snapper	100%
Yellowtail	91%
Yellowfin tuna	73%
Bigeye tuna	27%
Albacore tuna	<10%
Bluefin tuna	0%

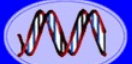
©2010, Thomas A. Minello, et al., UCLA Department of Ecology and Evolutionary Biology. Graphic reporting by Kristin Olin, Thomas and Kristin Minello. Credit: Kristin Minello, UCLA Press Office.




**FISH OF INFERIOR QUALITY ARE
OFTEN SUBSTITUTED FOR HIGHER
VALUE VARIETIES**



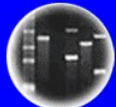
67




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Genetic Engineering Faster Growing Salmon For More Productive Aquafarms!



HOW THEY COMPARE

GM salmon
Length: 24ins
Weight: 6.6lb

Farm salmon
Length: 13ins
Weight: 2.8lb

*Both fish are 18 months

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

68



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**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**

**And Perhaps Bring Back the "Dead" -
Long Extinct Organisms!!!**

**Synthetic Genomes &
Chromosomes
50 Years After the
Invention of Genetic
Engineering**



69

2 JULY 2010 VOL 329 SCIENCE www.sciencemag.org

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

By NICHOLAS WADE *Science*, July 15, 2011


Sci. Transl. Med., May 15, 2013

Synthetic Generation of Influenza Vaccine Viruses for Rapid Response to Pandemics

Think of the Possibilities.....

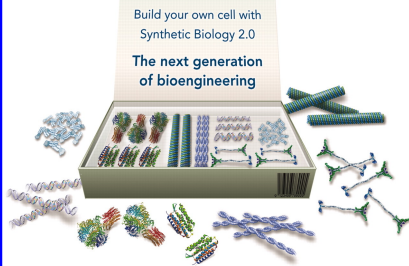
**George Church: De-Extinction
Is a Good Idea**

Reviving mammoths and other extinct creatures is a good idea

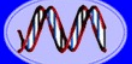


Build your own cell with
Synthetic Biology 2.0


The next generation
of bioengineering




70




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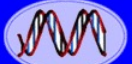


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A Yeast Cell With Chromosomes Synthesized in the Laboratory From A, G, C, & T DNA Bases !!!!

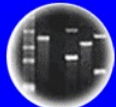
71




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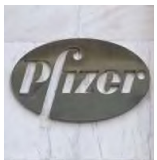
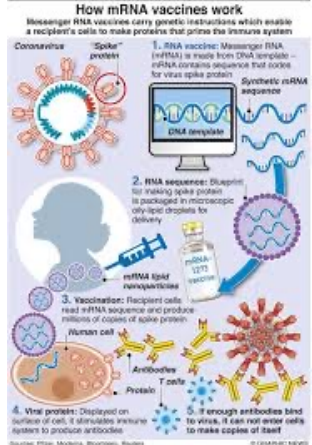

Cloning: Ethical Issues
and Future Consequences

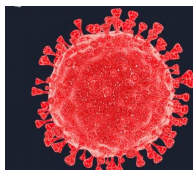


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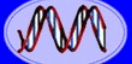
COVID Vaccines Synthesized in the Laboratory From A, G, C, & U RNA Bases !!!!

mRNA Vaccines








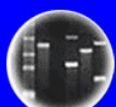
72




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

73




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and Future Consequences



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HC70A/SAS70A Winter 2023

Genetic Engineering in Medicine,
Agriculture, and Law

Professors Bob Goldberg & John Harada

Class Announcements
1/10/23

74


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HC70A/SAS70A Winter 2023

Genetic Engineering in Medicine, Agriculture, and Law

Course Administrator
Dr. Lauren Bowman


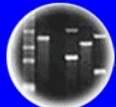
Discussion Coordinator
Dr. Kelli Henry


Learning Assistants
Shally Li
Gwyneth Schoenbaum

Welcome UC Davis
Professor John Harada & Class




75

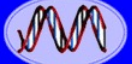





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Discussion Tomorrow

- Your Perceptions of Genetic Engineering & Its Applications
- Fill Out Survey Downloaded From Bruin Learn Website and Upload It Before Tomorrow's Discussion
- Be Prepared For a Lively Discussion
- I Will Discuss Unique Aspects of HC70A and Grading

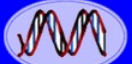

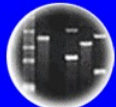


76


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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
 - *Monday 4:00 - 5:30 pm*

77


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Syllabus & Survey Can Be Downloaded From Bruin Learn Website After Class

I Will Answer Your Questions
About HC70A At the
Beginning of Discussion
Tomorrow

78