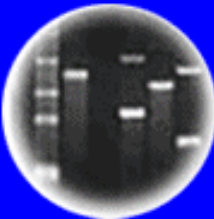


DNA
Genetic Code of Life



Entire Genetic Code
of a Bacteria



DNA Fingerprinting



Cloning: Ethical Issues
and Future Consequences



Plants of Tomorrow

HC70A & SAS70A Winter 2016 Genetic Engineering in Medicine, Agriculture, and Law

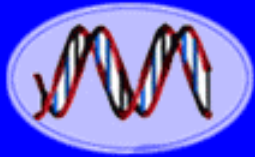
**Professors Bob Goldberg
& John Harada**

Lecture 2 The Age of DNA: What Is Genetic Engineering-Part Two

UCLA

UC DAVIS
UNIVERSITY OF CALIFORNIA

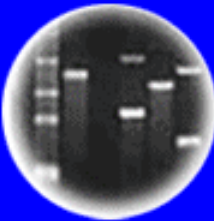
THEMES



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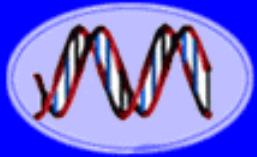


Cloning: Ethical Issues
and Future Consequences



Plants of Tomorrow

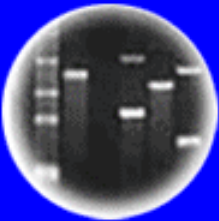
1. What is Genetic Engineering - A Review.
2. What Are the Ethical and Legal Issues That Arise Because of Recombinant DNA?
3. The Future is Here - Synthetic Genomes - Work of Craig Venter.
4. What Has and Can Be Done With Genetic Engineering- Spectacular Examples.
5. What Does Genetic Engineering Tell Us About Basic Genetic Processes in All Organisms?
6. Genetic Engineering - Anything New?
7. Are Vegetables Engineered - Demonstration.
8. Classical vs. 21st Century Genetic Engineering.
9. Is Science Hocus Pocus or a Precise Process?
10. Understanding How Genetic Engineering Uses Natural Rules of the Cell (i.e., It Isn't Magic)!



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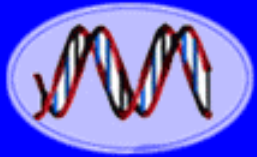
Plants of Tomorrow

Last Lecture - Age of DNA & Genetic Engineering: Part One

Today's Class - Age of DNA & Genetic Engineering: Part Two

Genetic Engineering - Spectacular Examples

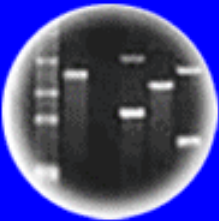
Genetic Engineering - Anything New?



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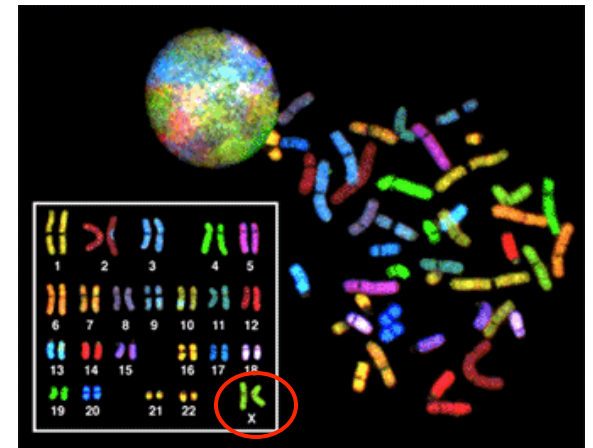
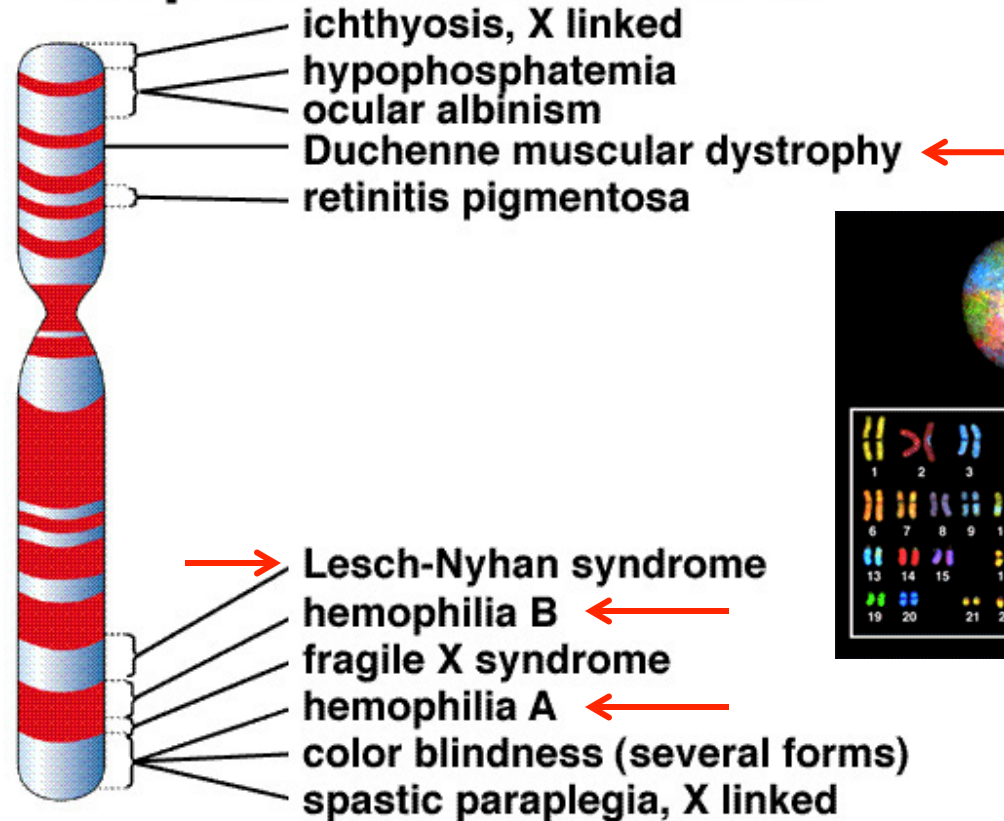


Plants of Tomorrow

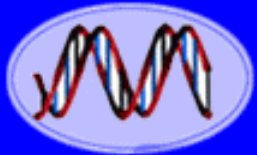
"Why" Clone Genes - Simply Put... Genomes & Chromosomes Contain Thousands of Genes

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Map of chromosome X



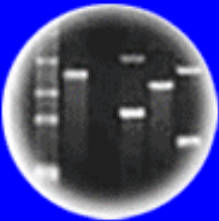
How Can a Single Gene Be Studied?



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DNA Fingerprinting

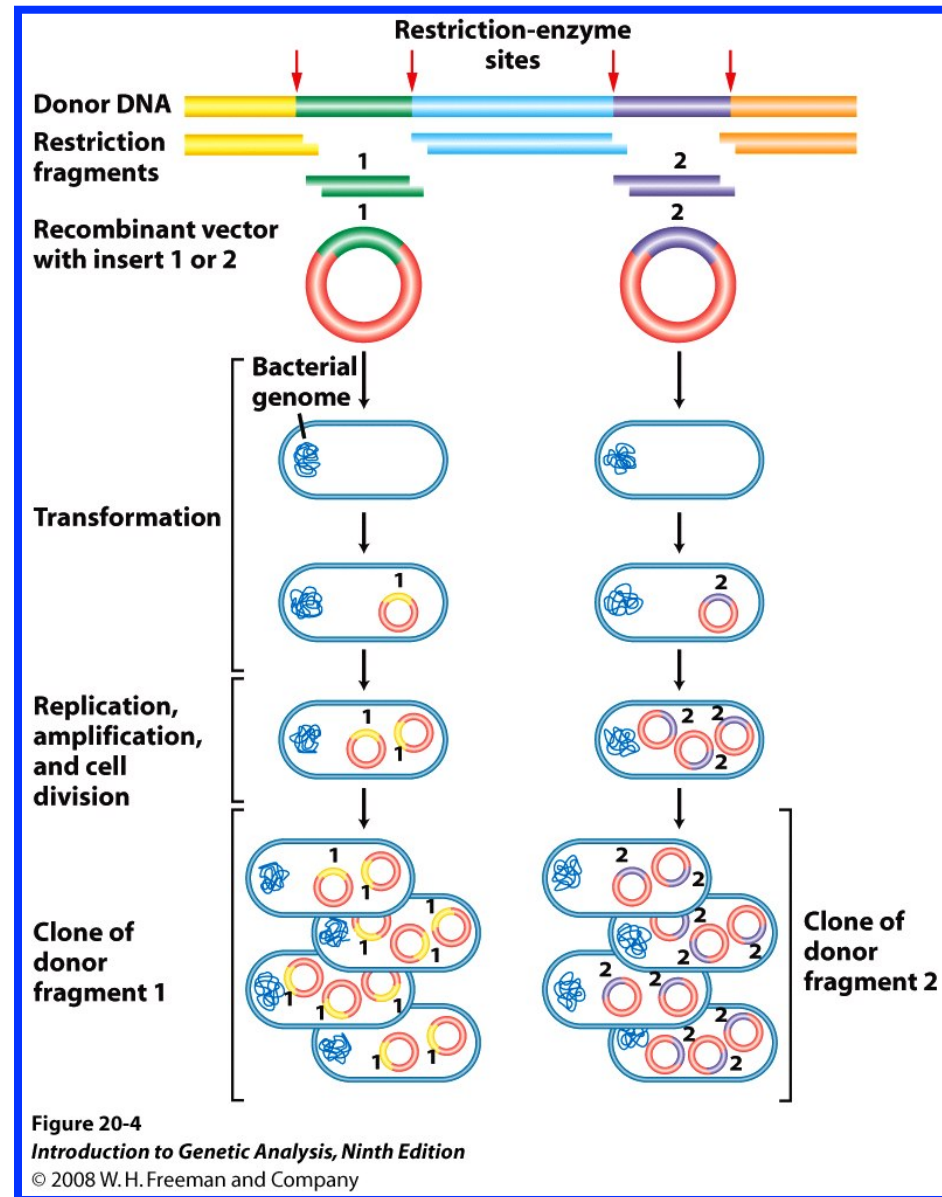


Cloning: Ethical Issues
and Future Consequences

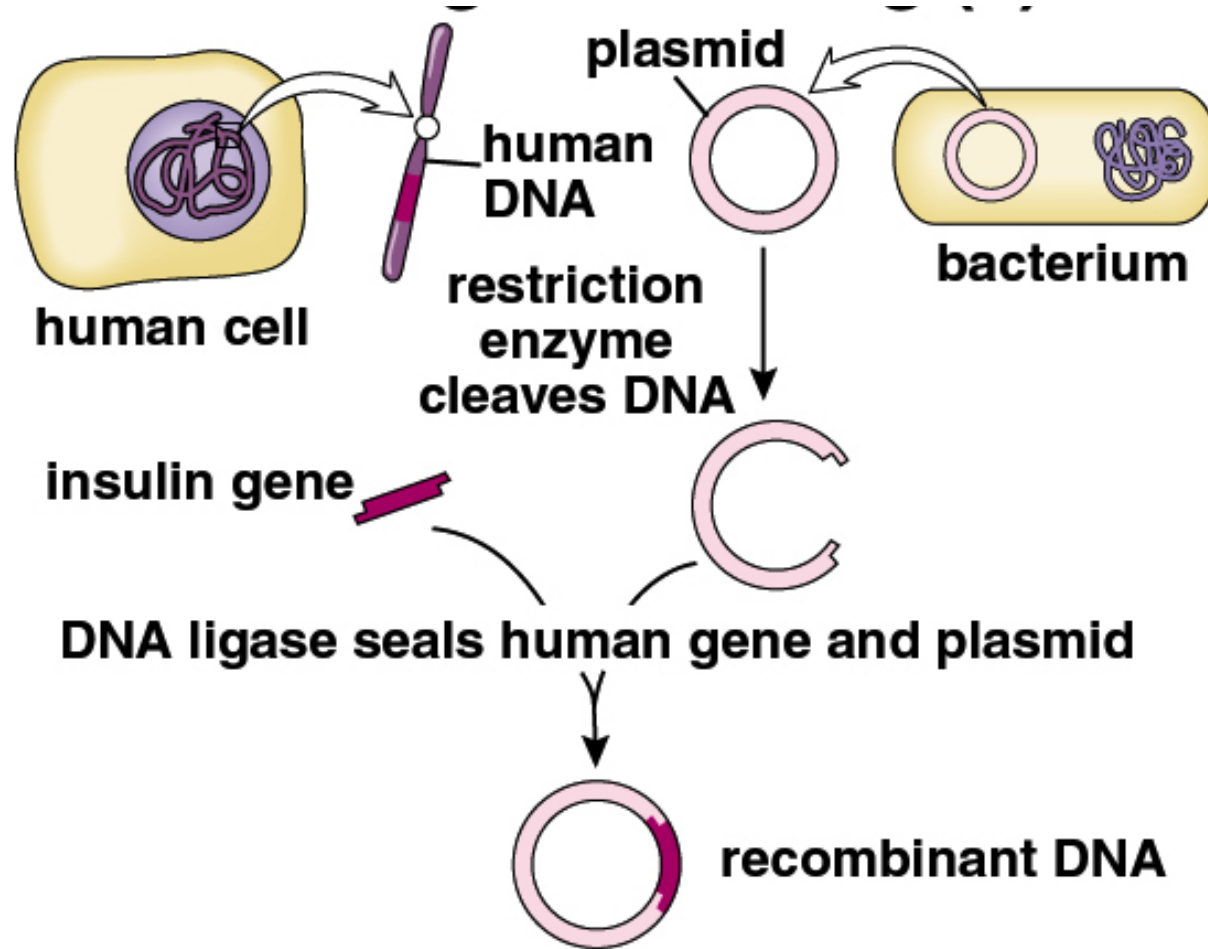


Plants of Tomorrow

Any Gene Can Be Isolated Using Genetic Engineering



For Example.....The Human Insulin Gene Can Be Separated From Other Human Genes and Cloned in Bacteria Using Recombinant DNA Methods!



And Used to Treat Diabetes!

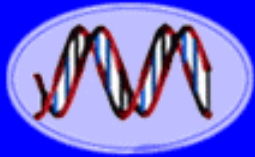


Recombinant DNA Manipulation Means.....

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!!

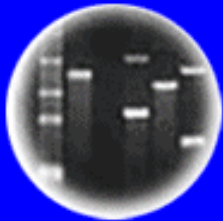




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Genetic Engineering.....

**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 40 Years From Experiments in
Biology Laboratories Around the Globe**

Has Changed Our Lives Dramatically!

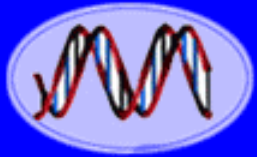
AndHas Led to Many New Legal and Ethical Issues

1. Patenting Genes, Cells, & Living Organisms?
2. Regulating Experimentation on DNA, Cells, Transgenic Organisms ("GMOs")?
3. Regulating the Release of Genetically Modified Organisms into the Environment?
4. Labeling of Genetically Modified Foods?
5. Genetic Testing: DNA Databases, Newborn Genetic Screening, Genetic Privacy, Involuntary or Voluntary Testing?
6. Genetic Discrimination?
7. Genetic Enhancement and Eugenics: Right to Enhance Your Child?
Editing the Human Germline!
8. Gender Selection and Prenatal Diagnosis of Genetic Diseases?
9. Gene Therapy: Correcting Human Genetic Diseases?
10. Human Cloning and Genetic Improvement?
11. Gene Testing Companies (e.g., 23andMe): Liability?
12. Synthetic Genomes: Constructing New Organisms (Genetic Engineering 2.0)?
13. Gene Drive Systems That Permanently Change Genes in a Population

Creating Life: Synthetic Microbes

J. Craig Venter

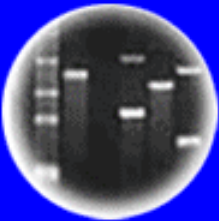
60 Minutes-December 2010



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What Can Be Done With Genetic Engineering?

A Few Examples of Genetic Engineering 1.0

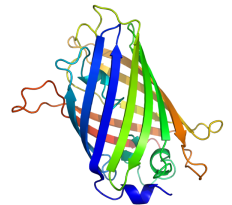
Using a Jellyfish Gene to Make Bacteria, Animals, and Plants Glow!!!!



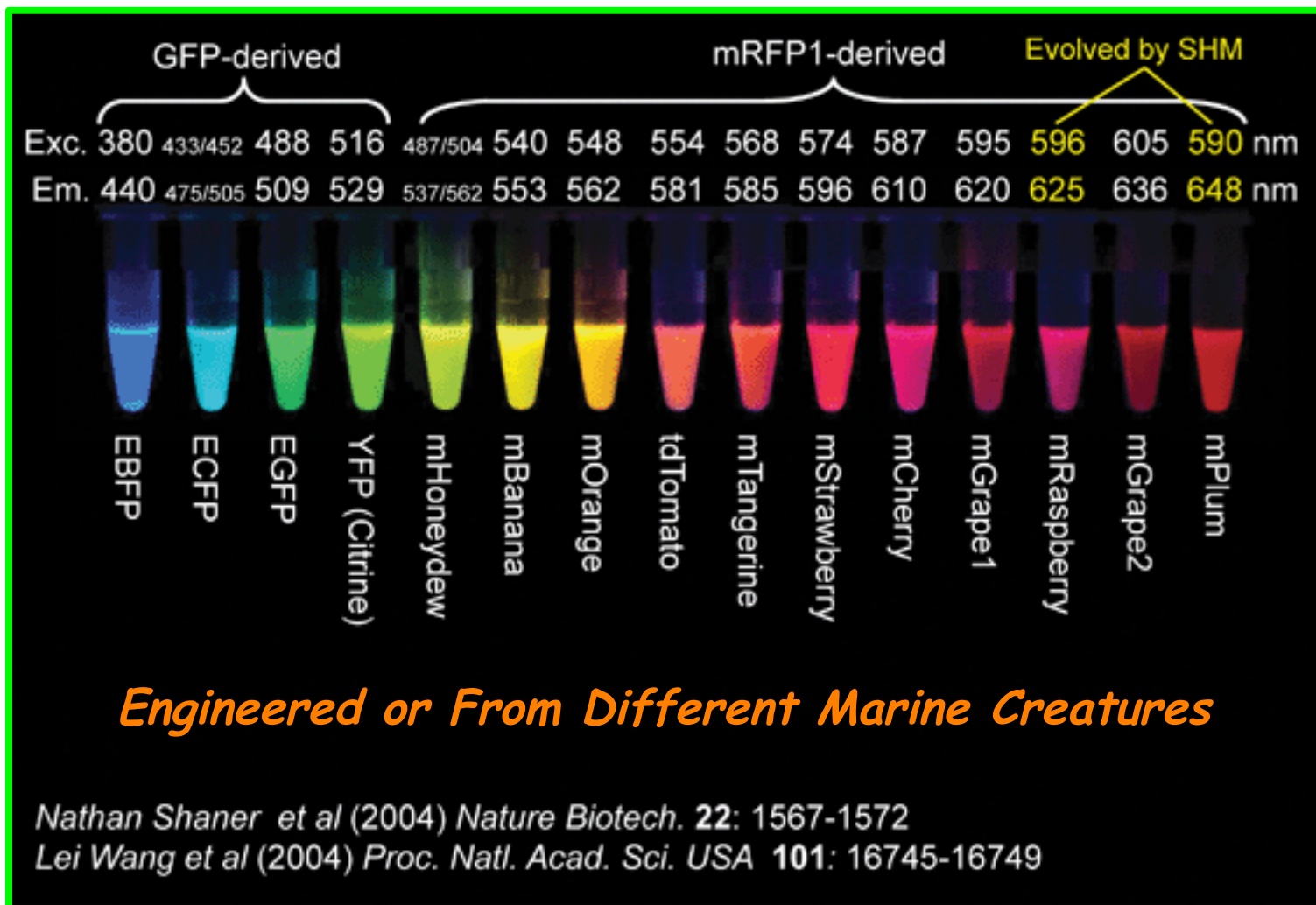
Green Fluorescence Protein (GFP)

(238 amino acids)

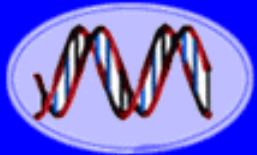
Nobel Prize in Chemistry - 2008 - Shimomura, Chalfie, & Tsien



There Are Many Different Kinds of Fluorescing Proteins!



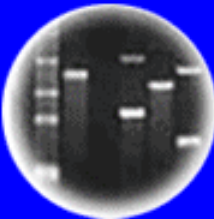
Nobel Prize in Chemistry – 2008 – Shimomura, Chalfie, & Tsien



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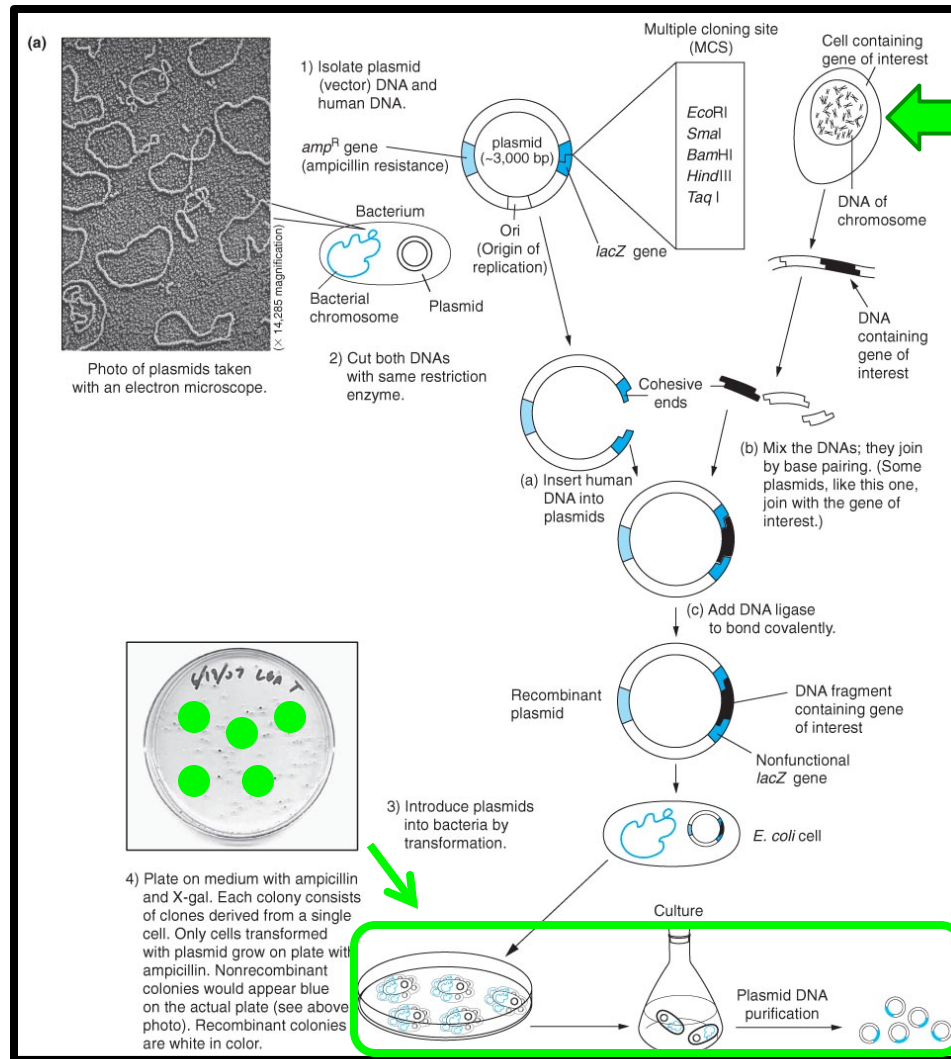
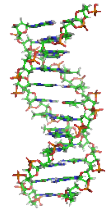


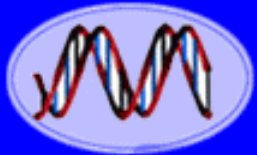
Cloning: Ethical Issues
and Future Consequences



Plants of Tomorrow

Using Recombinant DNA to Clone the Jellyfish GFP Gene

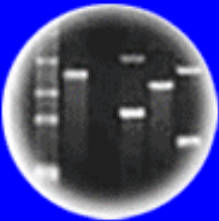




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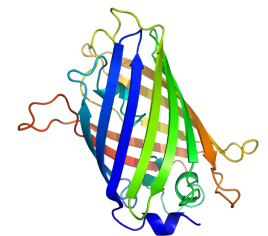
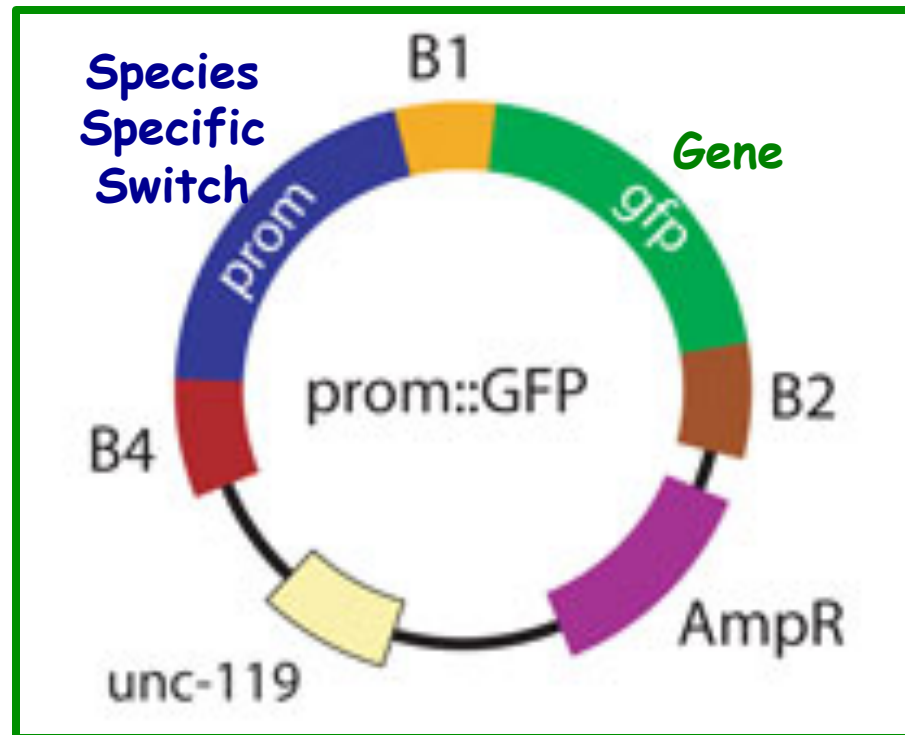
Cloning: Ethical Issues
and Future Consequences

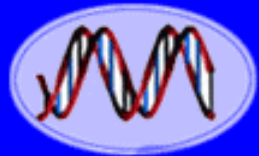


Plants of Tomorrow



A Recombinant Plasmid Containing the GFP Gene

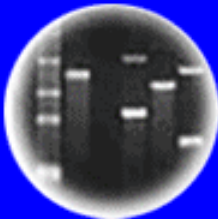




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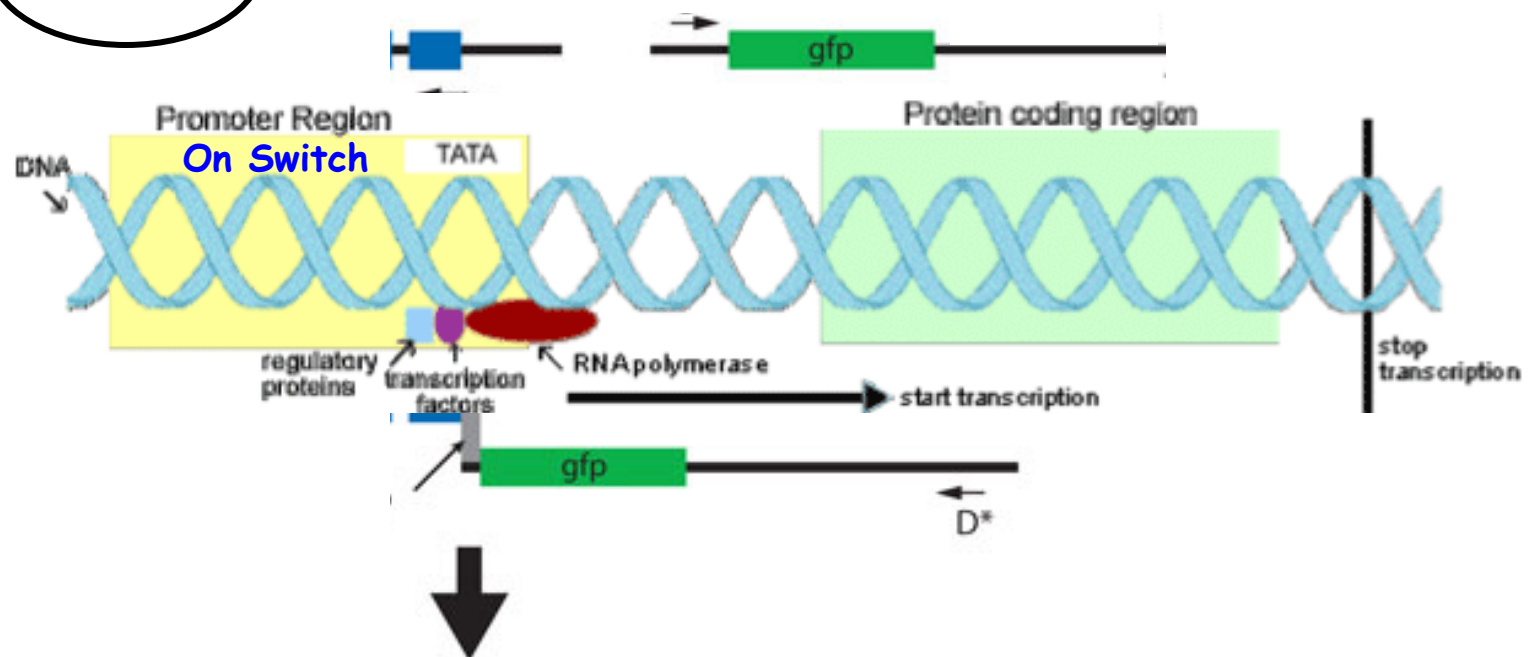
Plants of Tomorrow

Engineering the Jellyfish GFP Gene to Be Active in Different Organisms

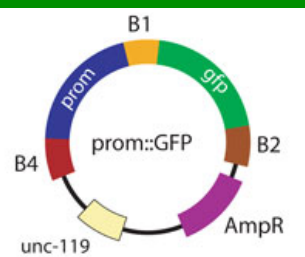
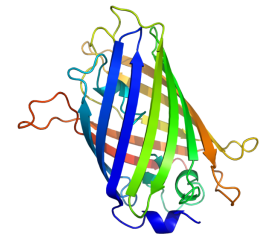
Isolate From
a Gene

Species-Specific
"On Switch"

Jellyfish GFP
Gene

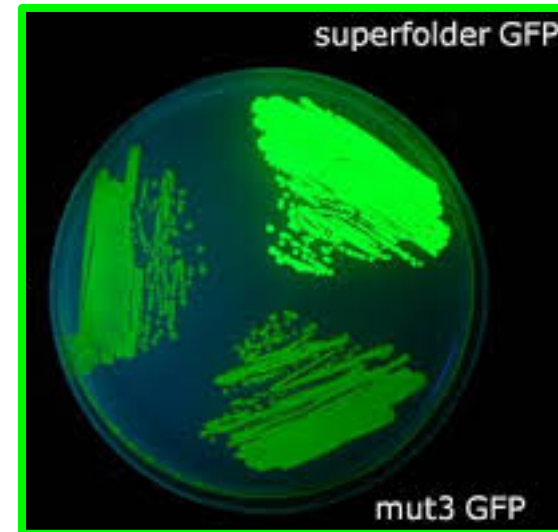
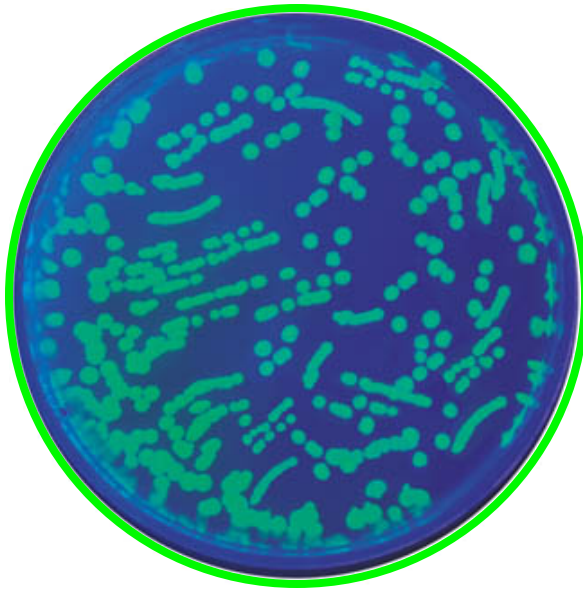


Engineered Chimeric GFP Gene

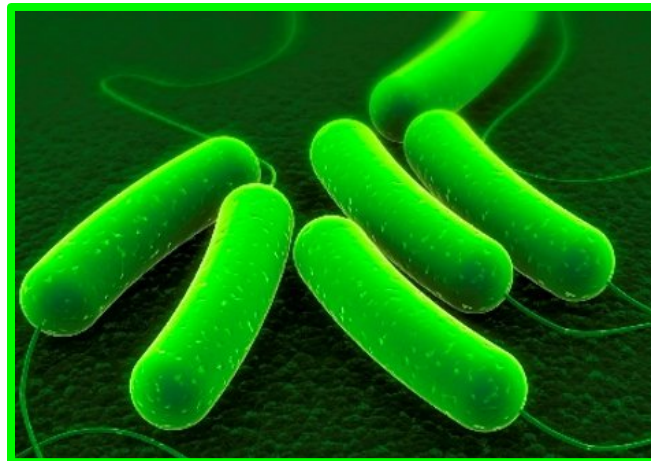


GloColi - *E. coli* Engineered With the Jellyfish GFP Gene!

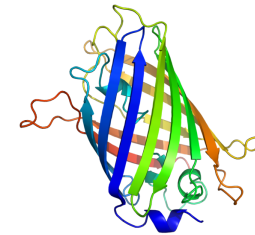
What Are
the
Conceptual
Implications
of This
Experiment?



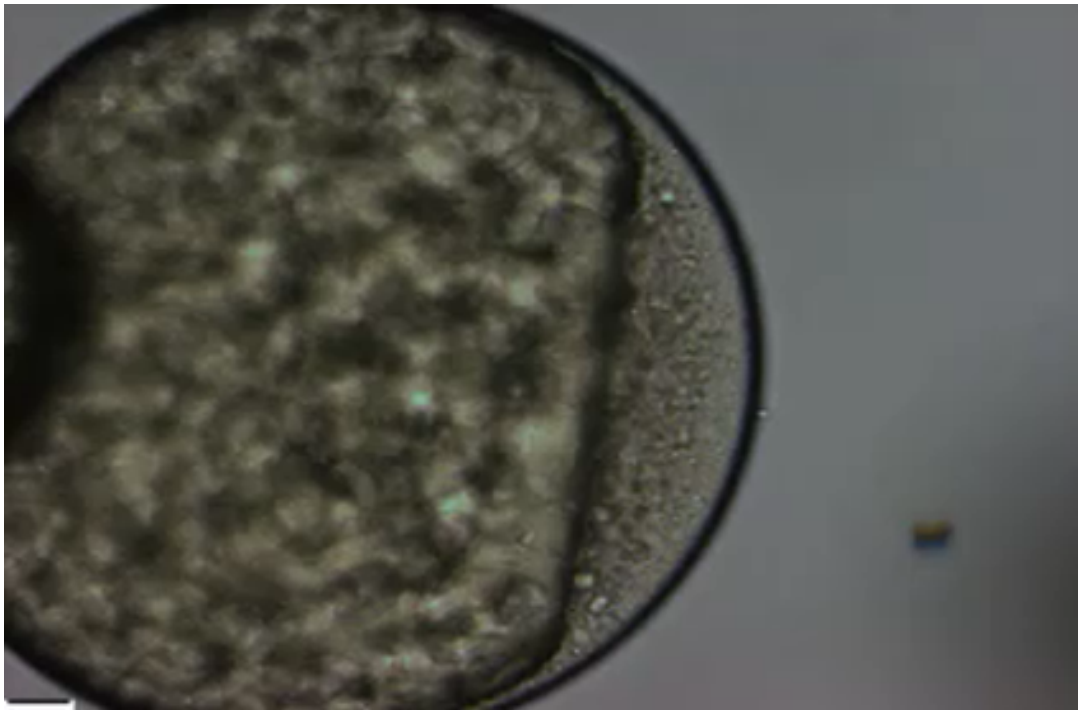
E. Coli Switch +
Jellyfish GFP Gene



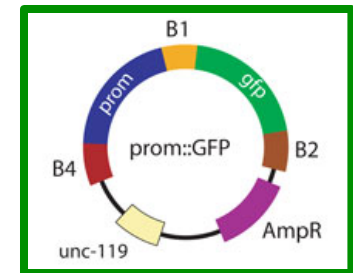
E. Coli Synthesizes
GFP Protein!



Engineering a “GloFish”

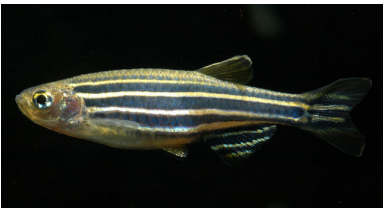
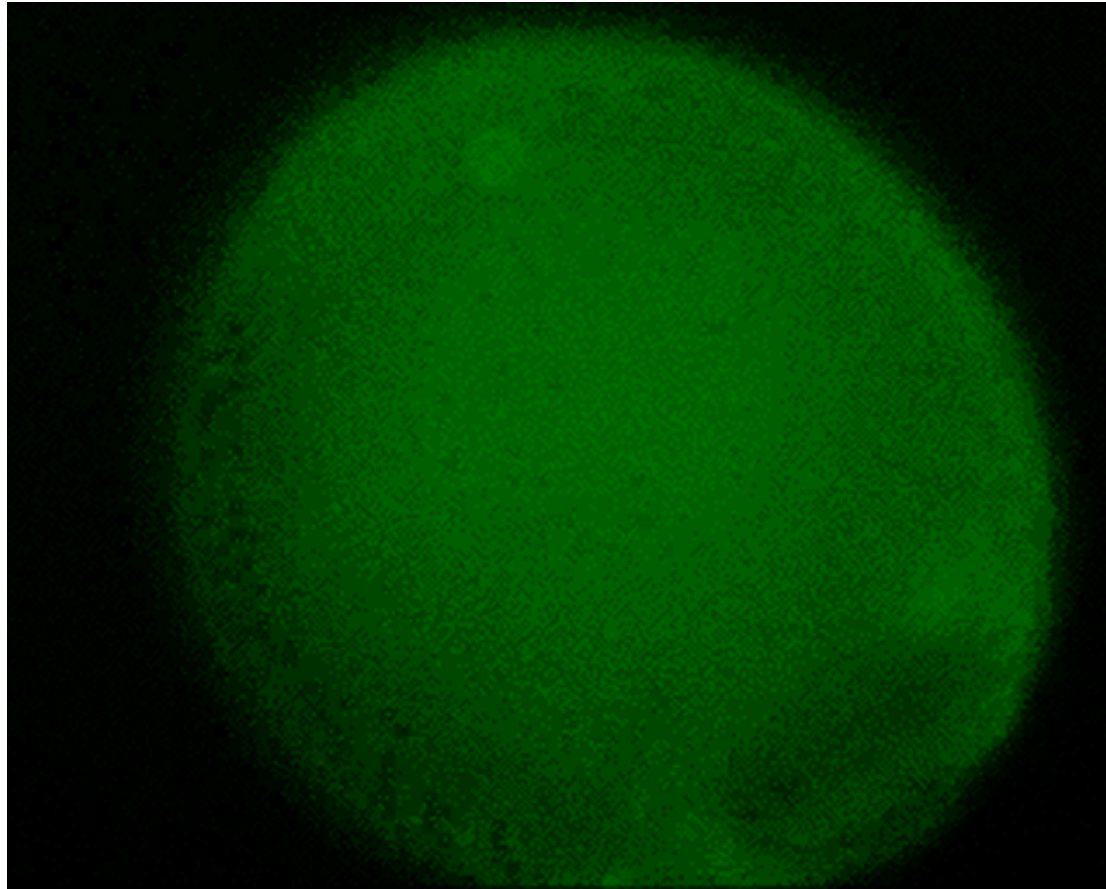


Zebrafish
Danio rerio



.....Using Genetic Engineering To Insert
A Jellyfish Gene into a Zebrafish Egg!

A “GloFish” Embryo!!

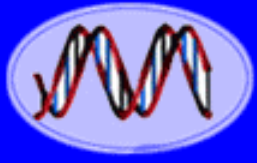


Zebrafish - Danio rerio

Genetically Engineered “GloFish!!”



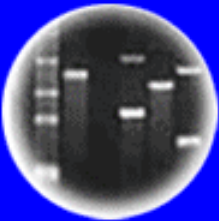
**Note Different Fluorescing Colors - Due to
Different Jellyfish Genes**



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DNA Fingerprinting



Cloning: Ethical Issues
and Future Consequences



Plants of Tomorrow

GloFish Can Be Sold In California

(But Not in Canada, or Europe)

- **Cal. Depart. of Fish and Game Code § 15007 (2007) Regulation** Makes it illegal to spawn, cultivate, or incubate any transgenic fish in the state controlled waters of the Pacific Ocean.
- **Cal. Depart. of Fish and Game Code Ruling (2015)**
The Dept. of Fish and Game will propose the addition of an exception to Section 1.92 that would allow the sale of transgenic tropical aquarium fish that the Dept. has determined pose no foreseeable risk or harm to native fish or wildlife.

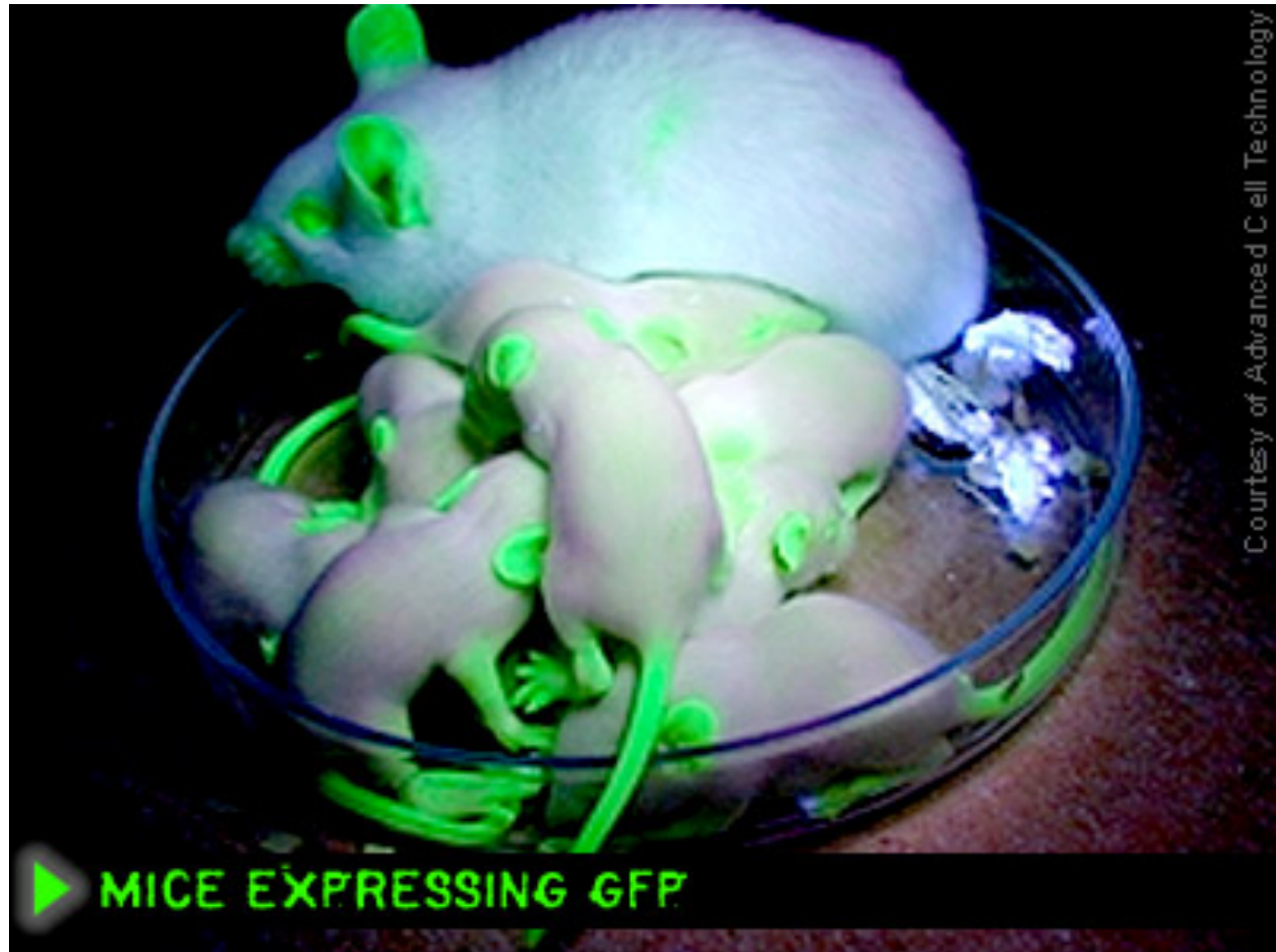
Genetic Engineering & the Law!!



How About a GloFly!



What About “GloMice!!!”



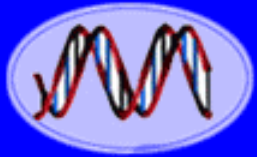
And Glo Monkeys, Cats and Pigs as Well!!



Engineering a GloPlant With the Same Jellyfish Gene!!!



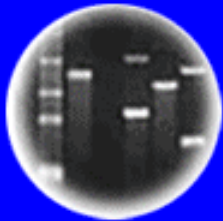
*What are the Philosophical and Biological
Implications of These Experiments?*



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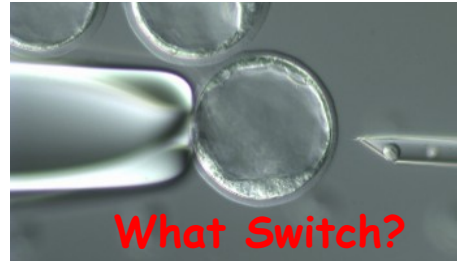
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Does Engineering Different Organisms With a Chimeric GloFish Gene Indicate that Genes Work Independently of Other Genes?

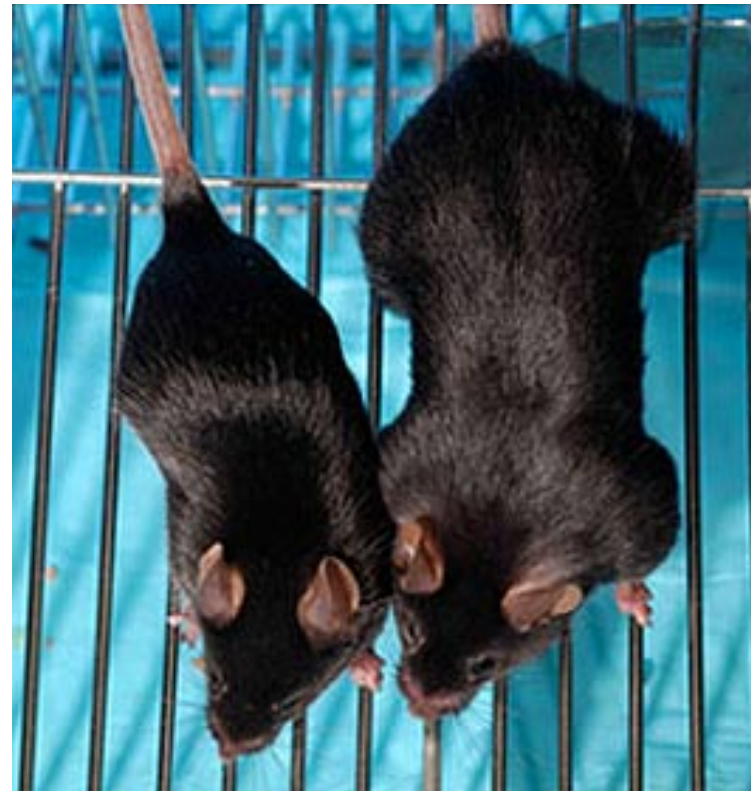
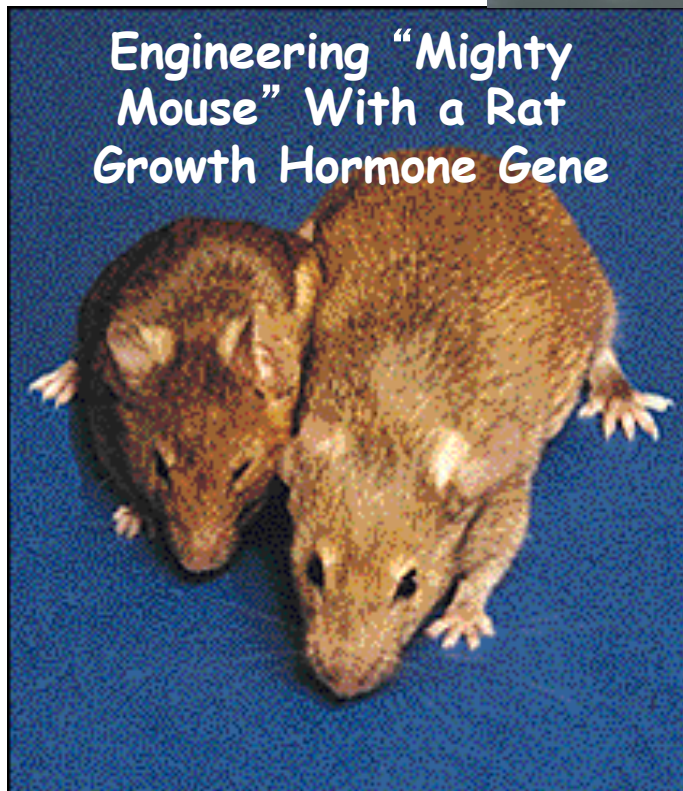
- a. Yes
- b. No

Dramatic growth of mice that develop from eggs microinjected with metallothionein–growth hormone fusion genes

**Richard D. Palmiter^{*}, Ralph L. Brinster[†], Robert E. Hammer[†],
Myrna E. Trumbauer[†], Michael G. Rosenfeld[‡], Neal C. Birnberg[§]
& Ronald M. Evans[§]**



**Nature,
December, 1982
~33 Years Ago!**

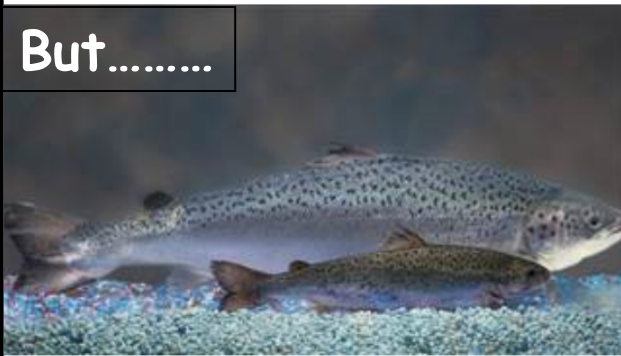


How About a Salmon That Grows Faster (*Not Bigger*) Using a Fish Growth Hormone Gene?

Genetically Engineered Salmon Approved for Consumption


By ANDREW POLLACK NOV. 19, 2015

But.....



GMO Salmon

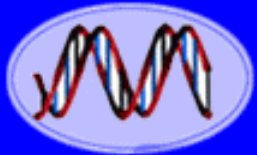
FDA won't be able to allow the sale of genetically modified salmon until it has a plan for labeling the fish. And out of FDA's budget "not less than \$150,000 shall be used to develop labeling guidelines and implement a program to disclose to

consumers whether salmon offered for sale to consumers is a genetically engineered variety." When FDA [approved GM salmon last month](#) it said companies didn't have to label it, provoking the fury of anti-GMO groups. 

What Are The Issues?

- a. Regulation?
- b. Environment?
- c. Same as "Natural" Salmon for Food?
- d. Consumer Acceptance of GMOs?
- e. All of the Above?

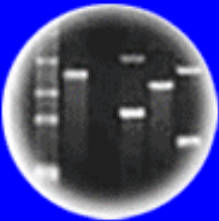
Genetically Modified Salmon Is Safe To Eat, FDA Says



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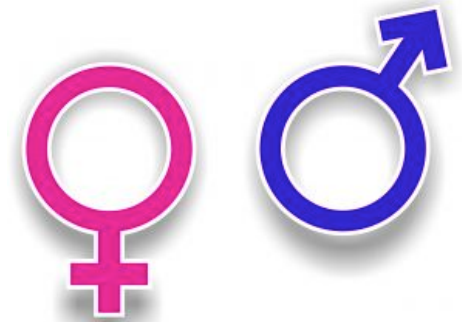
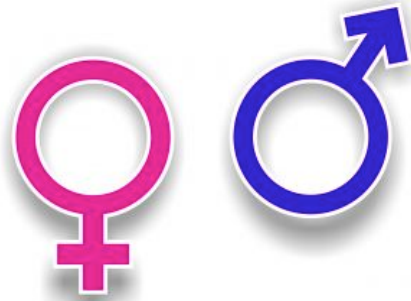
DNA Fingerprinting



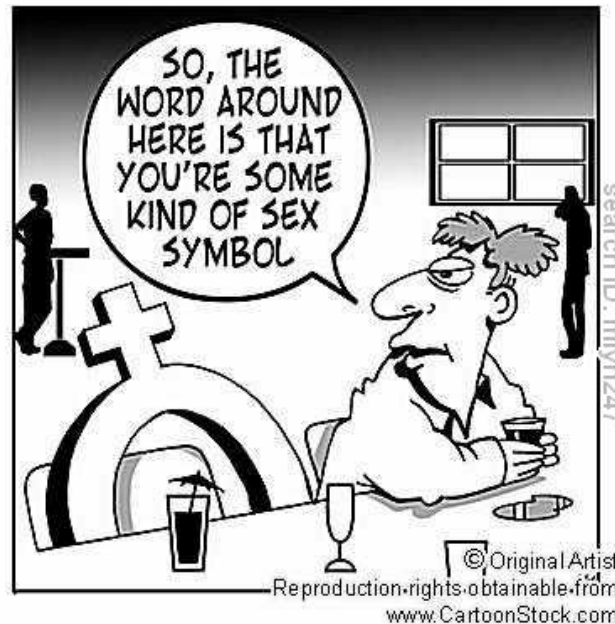
Cloning: Ethical Issues
and Future Consequences



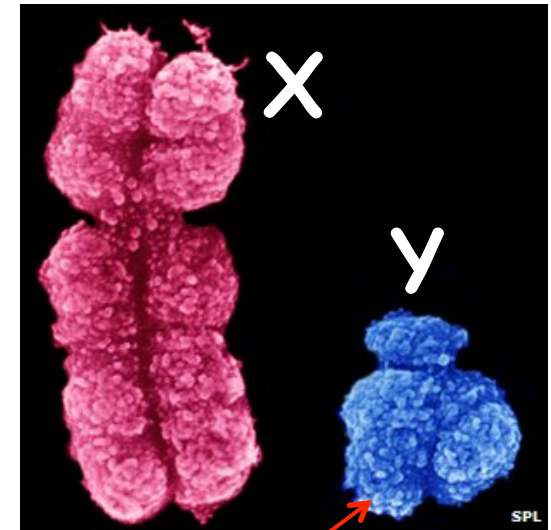
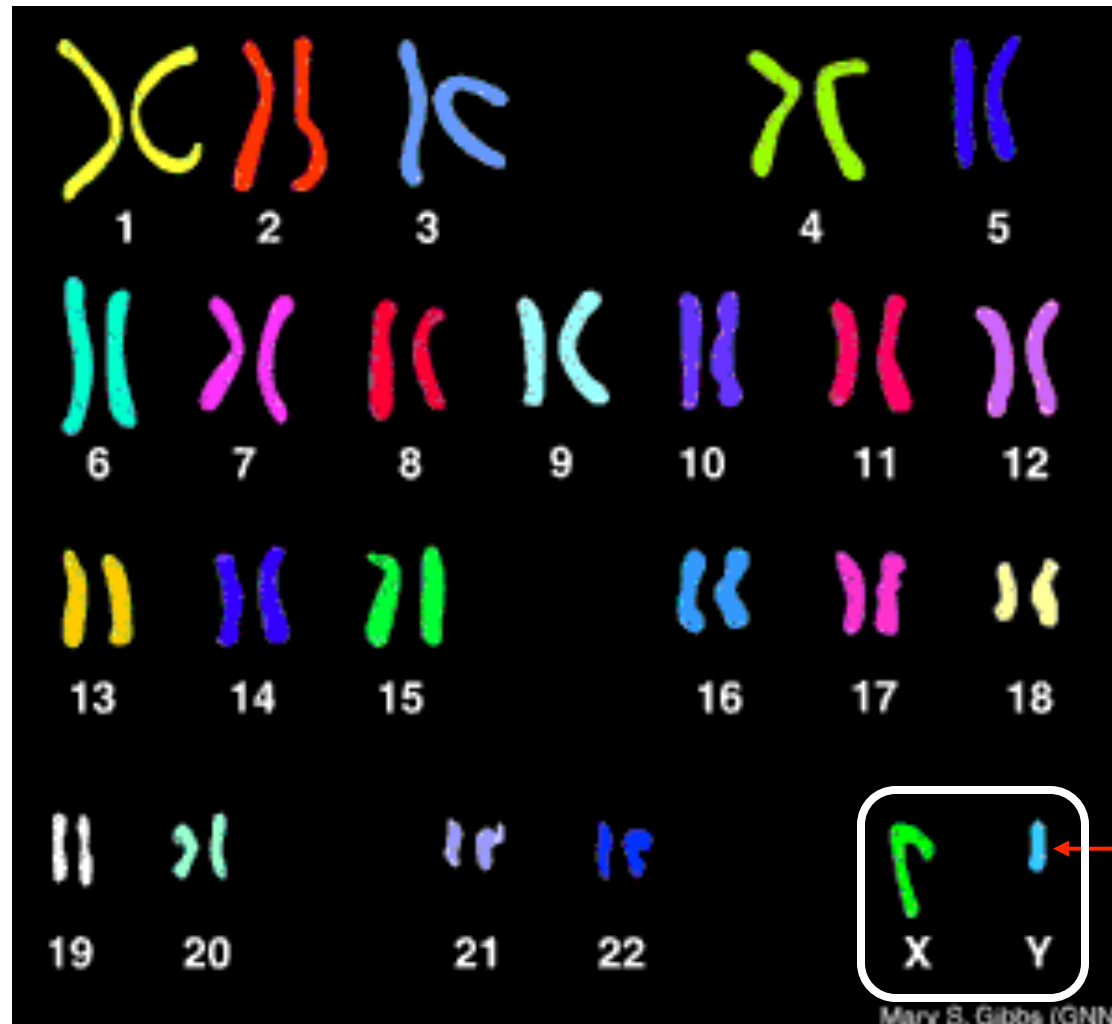
Plants of Tomorrow



How About Changing The Sex Of An Organism?



Males and Females Differ By the Presence or Absence Of the Y Chromosome (simplistically!!)

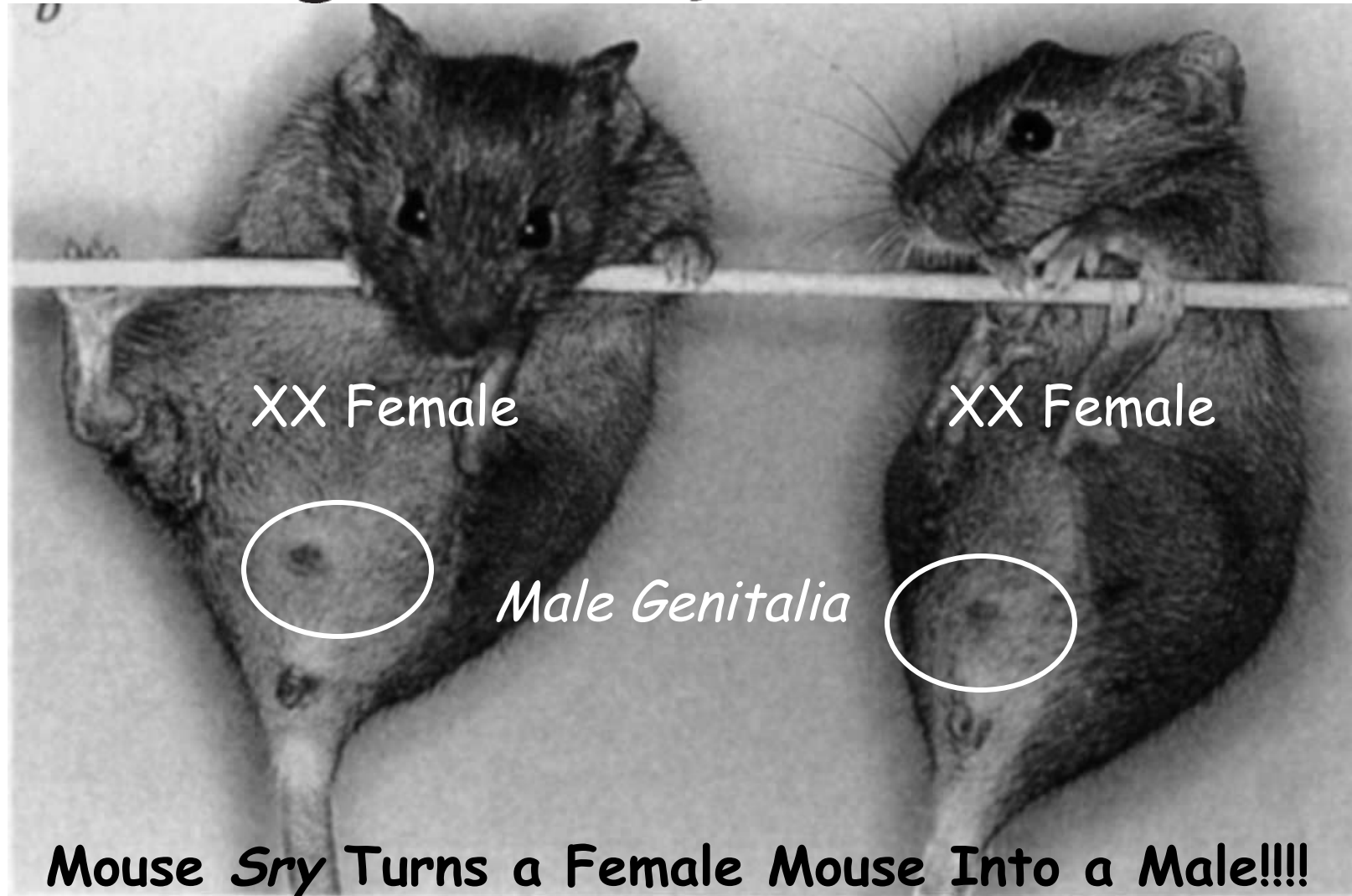


*Male SRY Gene
(Sex Determining
Region Y)*

The Human SRY Gene For Maleness Controls Gender

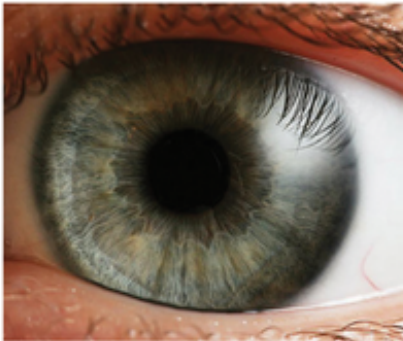
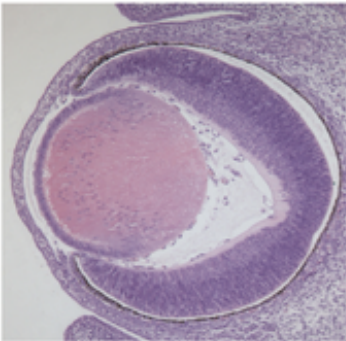
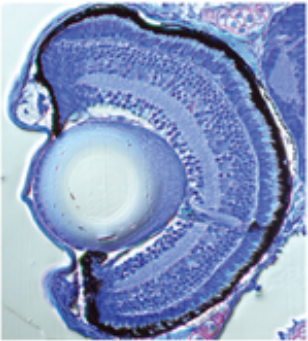

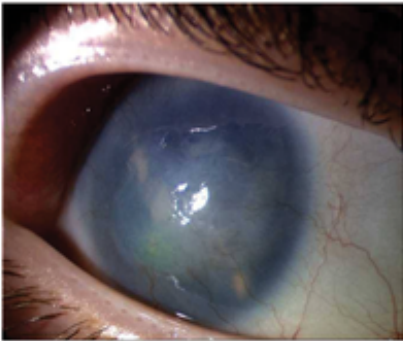
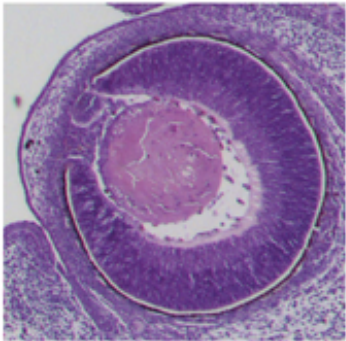
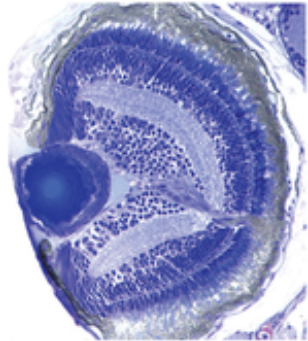
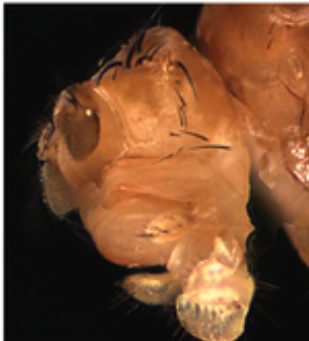
Male development of chromosomally female mice transgenic for *Sry*

Nature, May 9, 1991

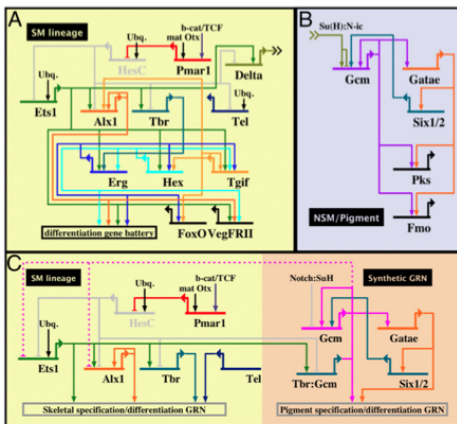


Functional Proof That Sry Controls Male Development

Using Genetic Engineering to Change Body Architecture-Engineering Eyes on a Fly's Leg With a Single Gene!

	Human	Mouse	Zebrafish	<i>Drosophila</i>
WT				
mut				
	<i>PAX6</i> ^{+/-}	<i>Pax6</i> ^{-/-}	<i>pax6b</i> ^{-/-}	<i>ey</i> ^{-/-}
EQs	cornea opaque <u>iris absent</u> retina degenerate lens opaque aqueous humor of eyeball increased pressure	eye decreased size lens fused_to cornea iris morphology anterior chamber absent	eye decreased size lens decreased size retina malformed	eye absent

Induction of Ectopic Eyes by Targeted Expression of the *eyeless* Gene in *Drosophila* *Science* 267, 1788, 1995



Mouse PAX-6 Gene (*eyeless* in flies)
Engineered To Work

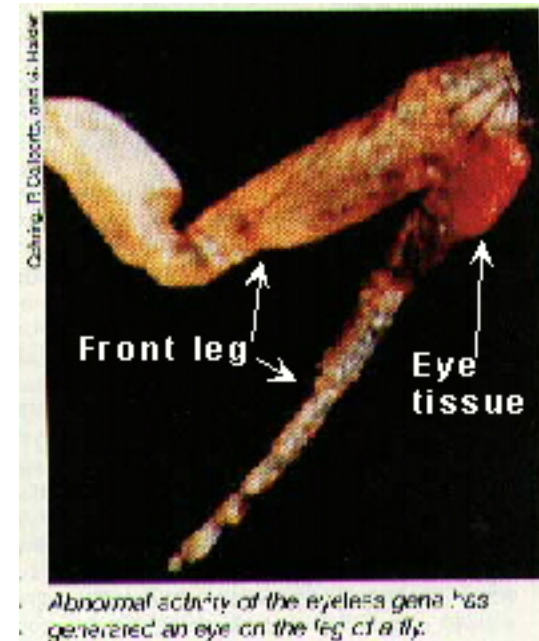


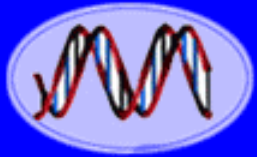
Different Fly Regions

Fly Leg Switch + Mouse Eye Gene



What Does
This
Experiment
Tell Us About
Mouse & Fly
Eye Genes?

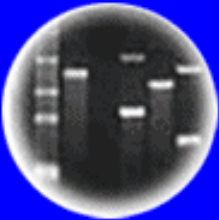




DNA
Genetic Code of Life



Entire Genetic Code
of a Bacteria



DNA Fingerprinting



Cloning: Ethical Issues
and Future Consequences



Plants of Tomorrow

What About Inserting **Bacterial** **Genes** Into **Plants** To Produce a Result With Significant Agricultural Application?

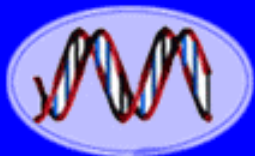
GARDEN GUIDE **SUNSET**

WHAT TO DO IN YOUR GARDEN IN SEPTEMBER

Southern California Checklist

✓ PROTECT CABBAGE CROPS. The minute you plant a brassica, squadrons of cabbage white butterflies seem to descend on it to lay their eggs. The easiest way to thwart them is to cover your cabbage crops with row covers right from the start. The next best option is spraying with *Bacillus thuringiensis* to kill the young caterpillar larvae. ♦

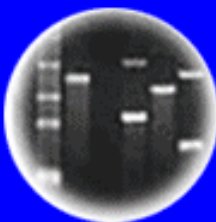
DEBRA LAMBERT



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Plants of Tomorrow

How to Use Bt Pesticide as an Organic Pest Control

Learn how to use Bt pesticide to kill cabbage worms, tomato hornworms and other pests in your organic vegetable garden.

By Barbara Pleasant
April 24, 2013



Bt is one of the safest natural pesticides you can use to control caterpillar pests without harming beneficial insects.

Photo Courtesy Safe Brand



FOR ORGANIC GARDENING

OMRI[®]
Listed



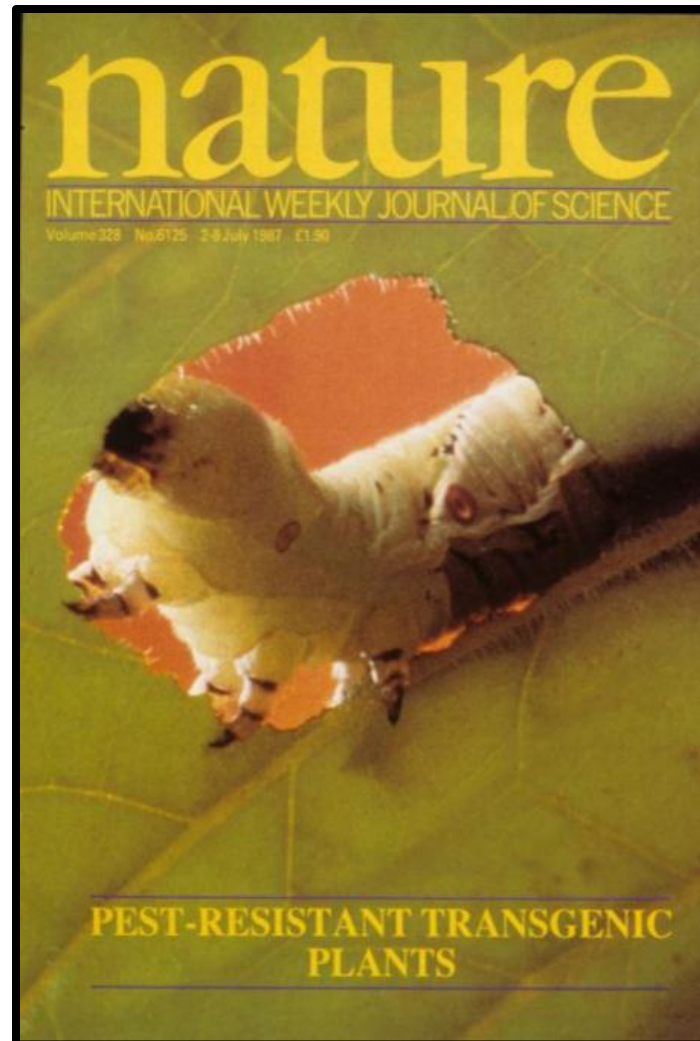
Active Ingredient:
Bacillus thuringiensis subspecies *kurstaki* strain SA-12 solids,
spores and Lepidopteran active toxins (At least 6 million
viable spores per mg)*98.35%
Other Ingredients:1.65%
Total: 100.00%

*The percent active ingredient does not indicate product performance and potency measurements are not federally standardized.

Transgenic plants protected from insect attack

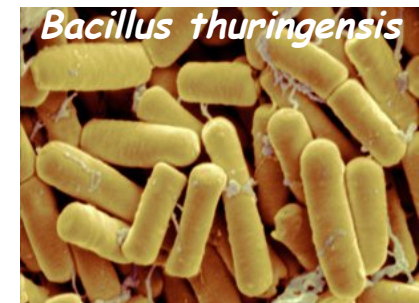
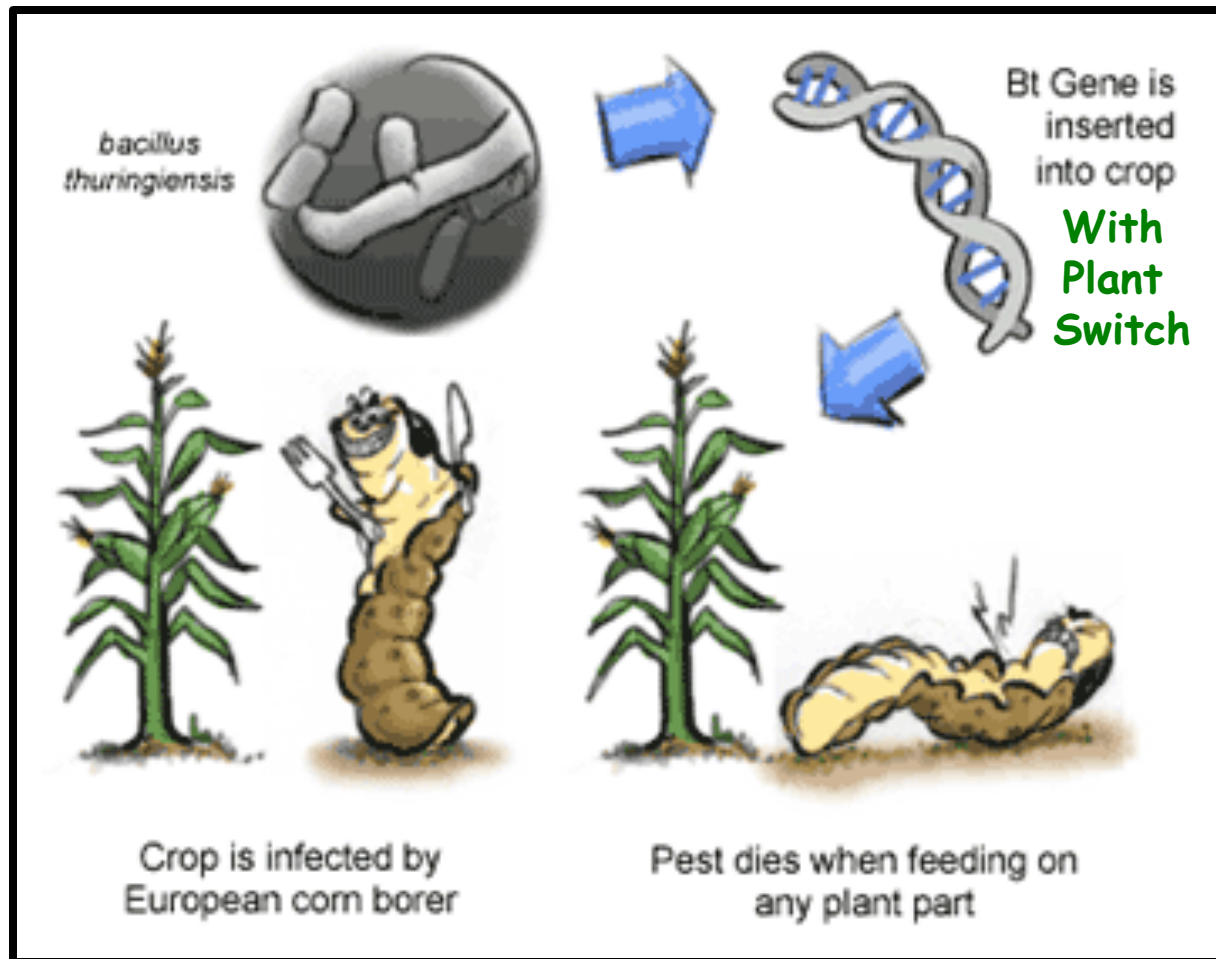
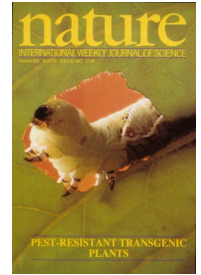
Mark Vaeck, Arlette Reynaerts, Herman Höfte, Stefan Jansens, Marc De Beuckeleer, Caroline Dean*, Marc Zabeau, Marc Van Montagu & Jan Leemans

Plant Genetic Systems NV, Jozef Plateaustraat 22, B-9000 Gent, Belgium

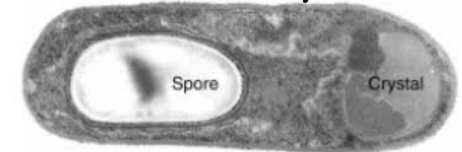


*July, 1987
28 Years Ago
Old Technology!*

Crops Can Be Engineered With Bt For Insect Resistance

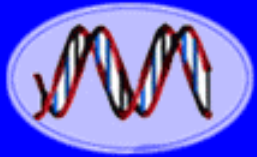


Bt Toxin in Spores



Genetic Engineering a Plant to Resist Worms! Implications For Agriculture

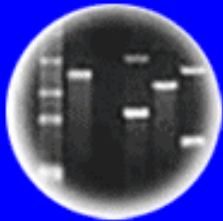




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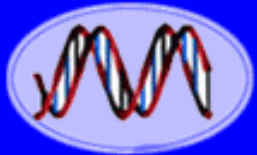
Plants of Tomorrow

Question

Does the Same Bt Protein in Engineered Crops
& Organic Sprays Protect Plants From Insect
Damage?

- a. Yes
- b. No

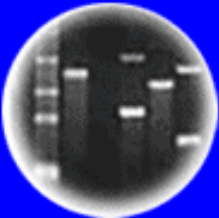
What Can We Infer FROM These Genetic Engineering Experiments About How Genes “Work” and Genetic Processes in All Living Organisms?



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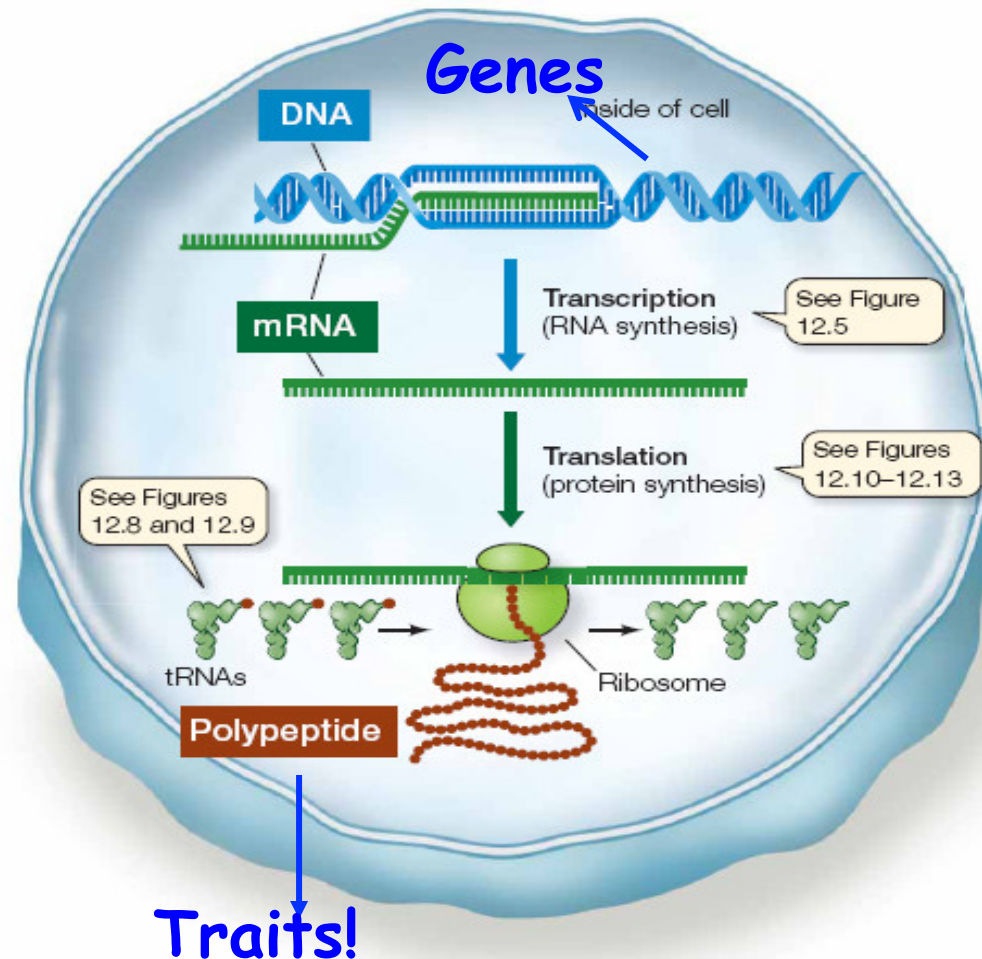
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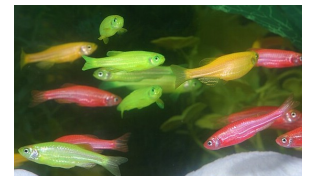


Plants of Tomorrow

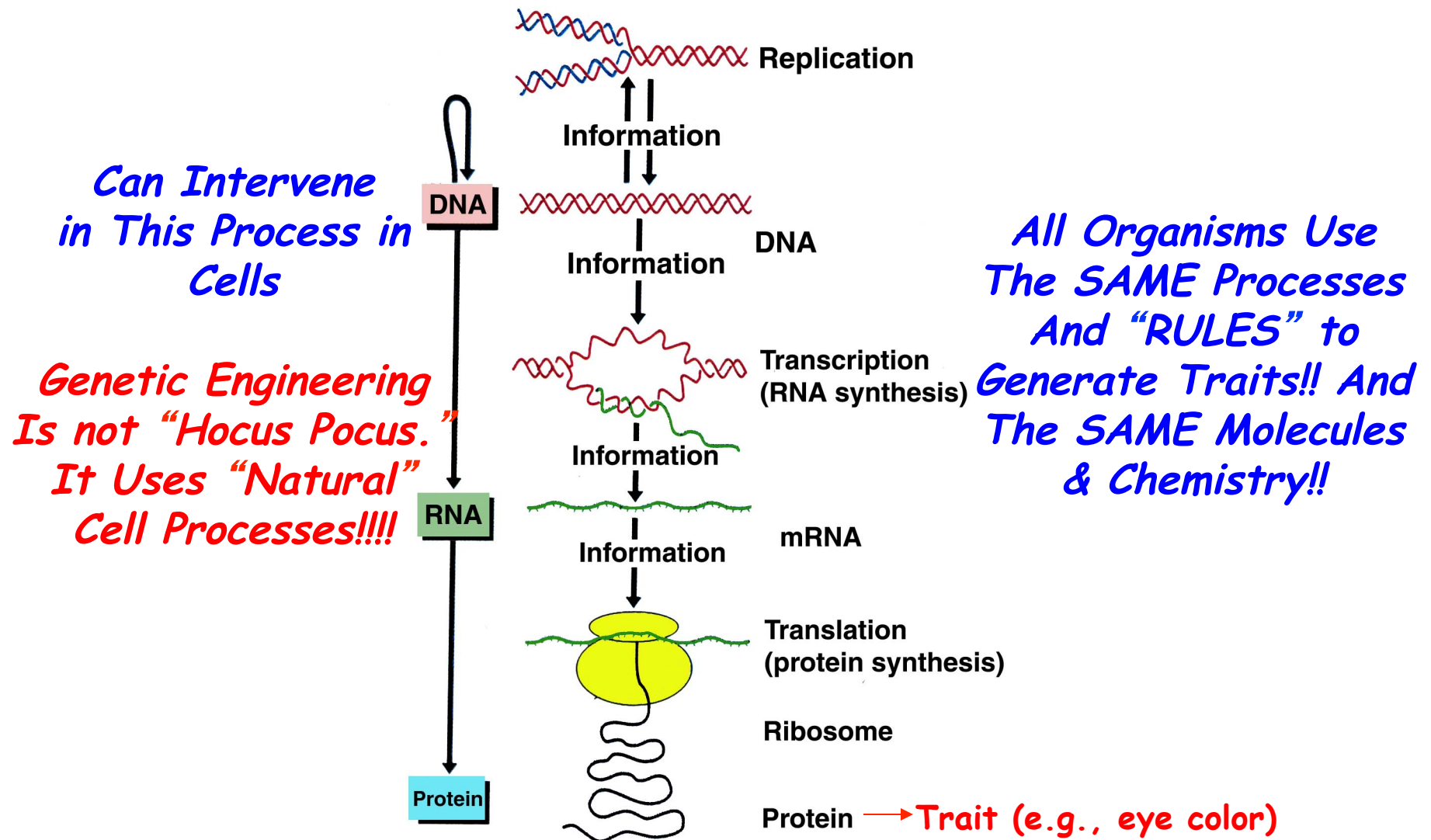


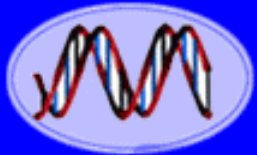
Observations and Inferences From Genetic Engineering Experiments

- 1. Genes Can Work Independently of Each Other*
E.G. - The Jellyfish Fluorescence Gene Works Perfectly in a Variety of Organisms
- 2. Basic Genetic Processes Are Universal (Replication & DNA to RNA to Protein)*
E. G. - The Bt Gene Directs the Production of BT Protein in Crops.
- 3. Basic Genetic Processes Can Be Used to Engineer or Transfer Genes From One Organism to Another and Transfer Them Stably Generation After Generation*
E.G. - The Chimeric GloFish & Bt Genes Are Inherited Generation After Generation.



Translating The Genetic Code Into Proteins is a Conserved Process

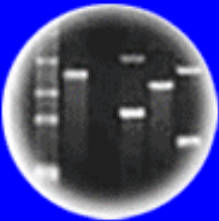




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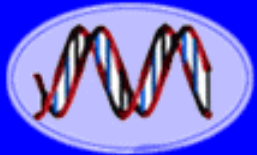
Plants of Tomorrow

Summary - Age of DNA - There Are NO Genetic Limitations to What Can Be Done Using Genetic Engineering

- Synthetic Chromosomes & Microbes (GE 2.0)
- Recombinant Plasmids & Bacteria
- GlowFish, GloMice, GloMonkey, GloPlant
- Mighty Mice and Giant Fish
- Insect Resistant Crops
- Novel Fly Body Plans (e.g., eye on leg)
- Engineered Humans

GE 1.0

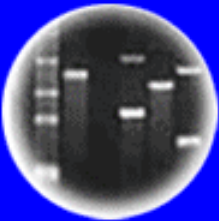




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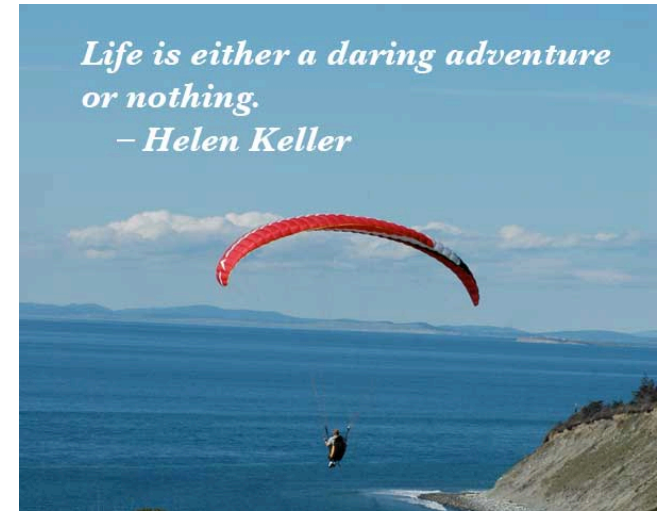
Plants of Tomorrow

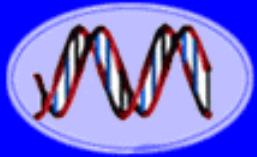


We Are Only Limited By Our
Ingenuity and Our “Fear”
of the Unknown

*Life is either a daring adventure
or nothing.*

– Helen Keller

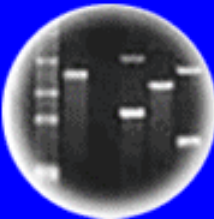




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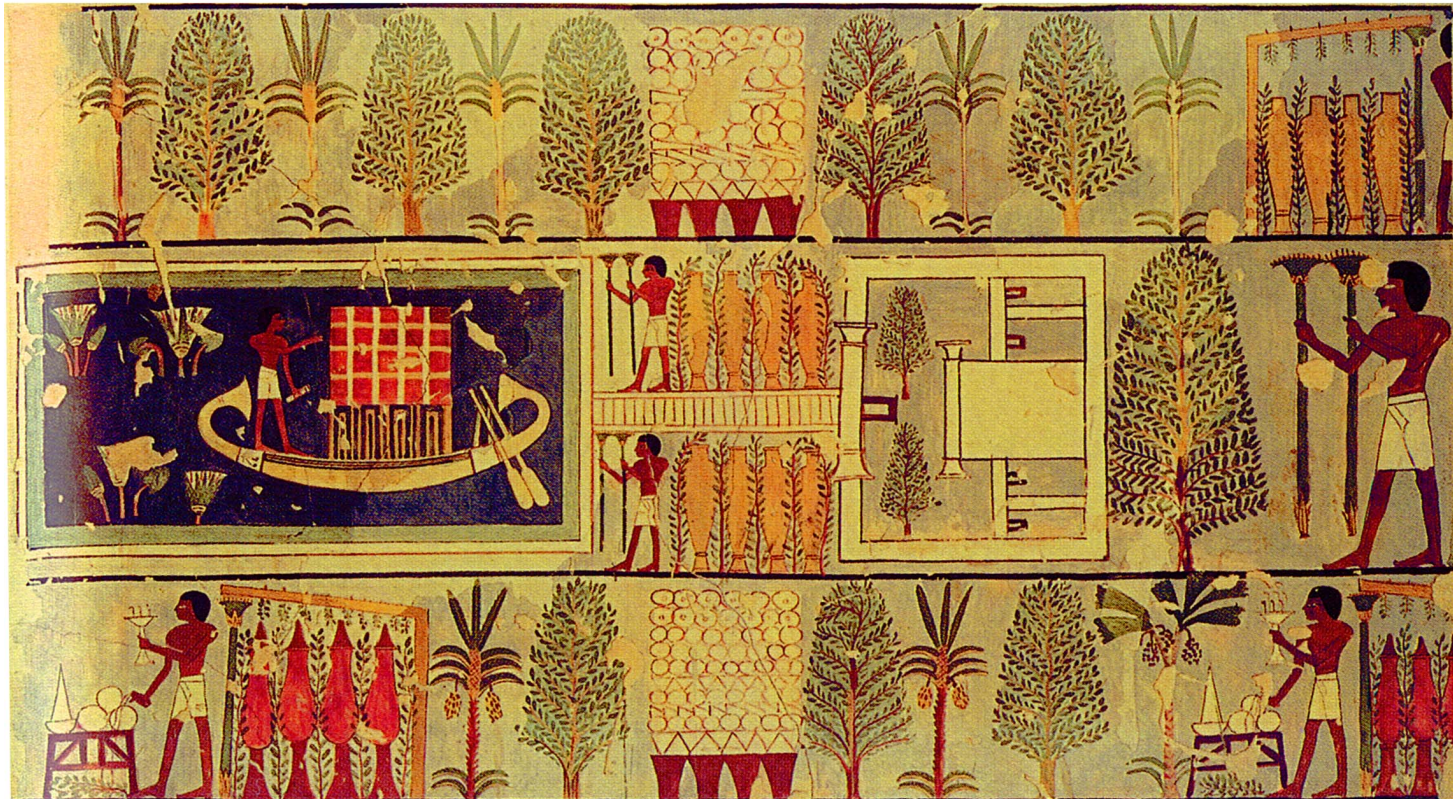
Plants of Tomorrow

There is Nothing New About Genetic Engineering!

**Manipulating Genes IS
Manipulating Genes No Matter
What Technology or Processes
Are Used!!**

This is Genetic Engineering 0.0!!

**Breeding And Cultivation Of Plants
Have Taken Place Over Thousand Of Years**

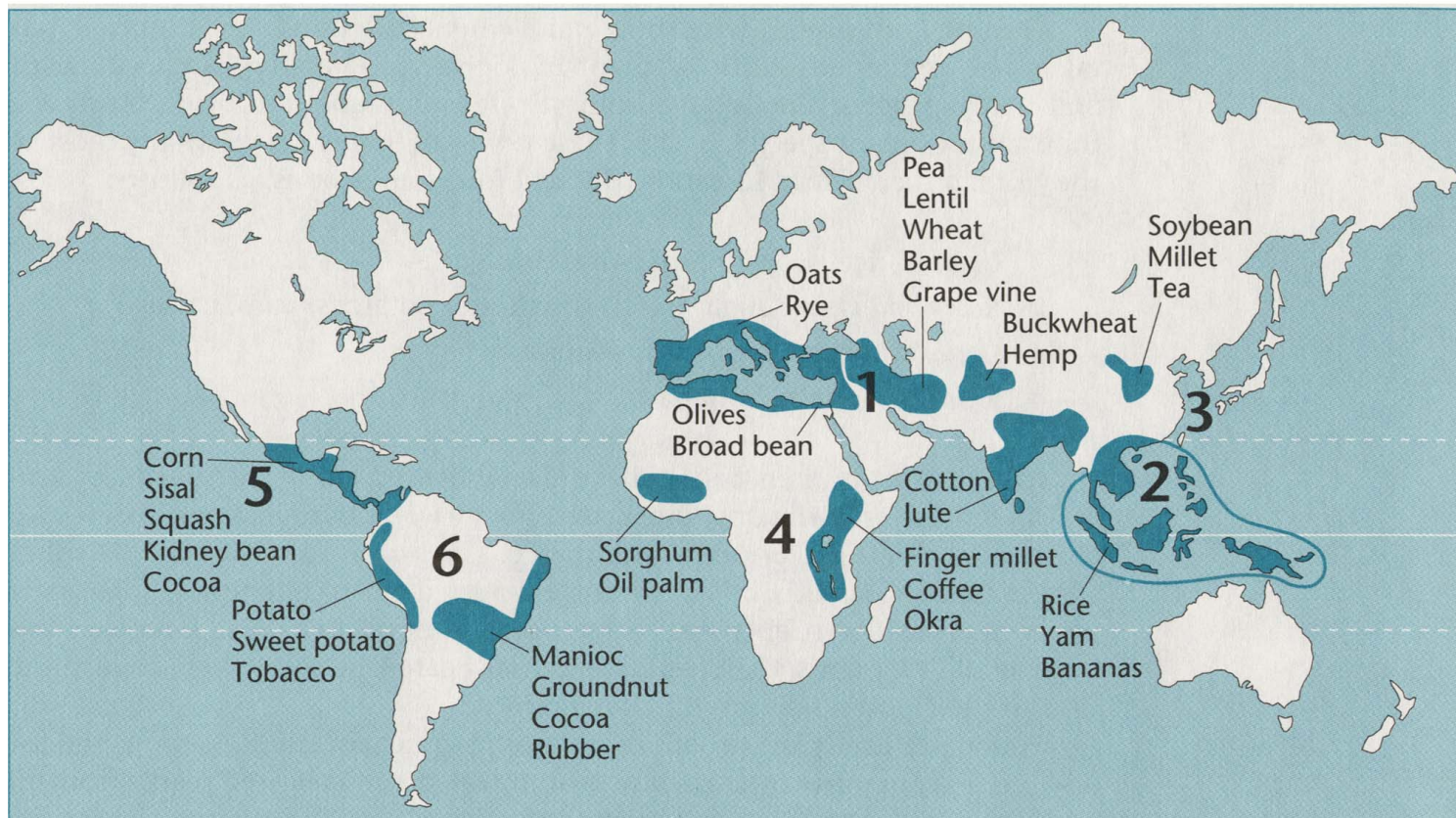


Genetic Engineering is Not New

Crops of Egypt 400 B.C.

Most Major Crops Were Engineered From Wild Relatives by Early “Bioengineers” Over 10,000 Years Ago!!

Regions Where Major Crops Were Established



Breeding Involves Gene Manipulation Using EXISTING Genetic Variability!

Breeding Uses Natural Genetic Variability of Genes As Raw Material - *Variability Generated by Mutations*



*Mutations in a Gene That Change Its Chemical Sequence
& Slightly Alters Its Function (e.g., fruit size, color)*

*Tomatoes Were Engineered From Small Wild Relatives
Because of Mutations in Fruit Size Genes!*



*The Early Tomato “Bioengineers” Selected For Large
Fruit Size Because it Provided More Food!*

What They Were Selecting Was a Different Form (Allele) of a Fruit Size Gene!

Engineering Teosinte Into Domesticated Corn



Teosinte

Domesticated corn

Teosinte

Early domesticated corn

Note: Architecture and Fruit (cob) Size

*Only Five Genes Cause These Plants to Differ
& We Now Know What They Are*

Engineering the Modern Banana

Wild Banana



Modern Banana

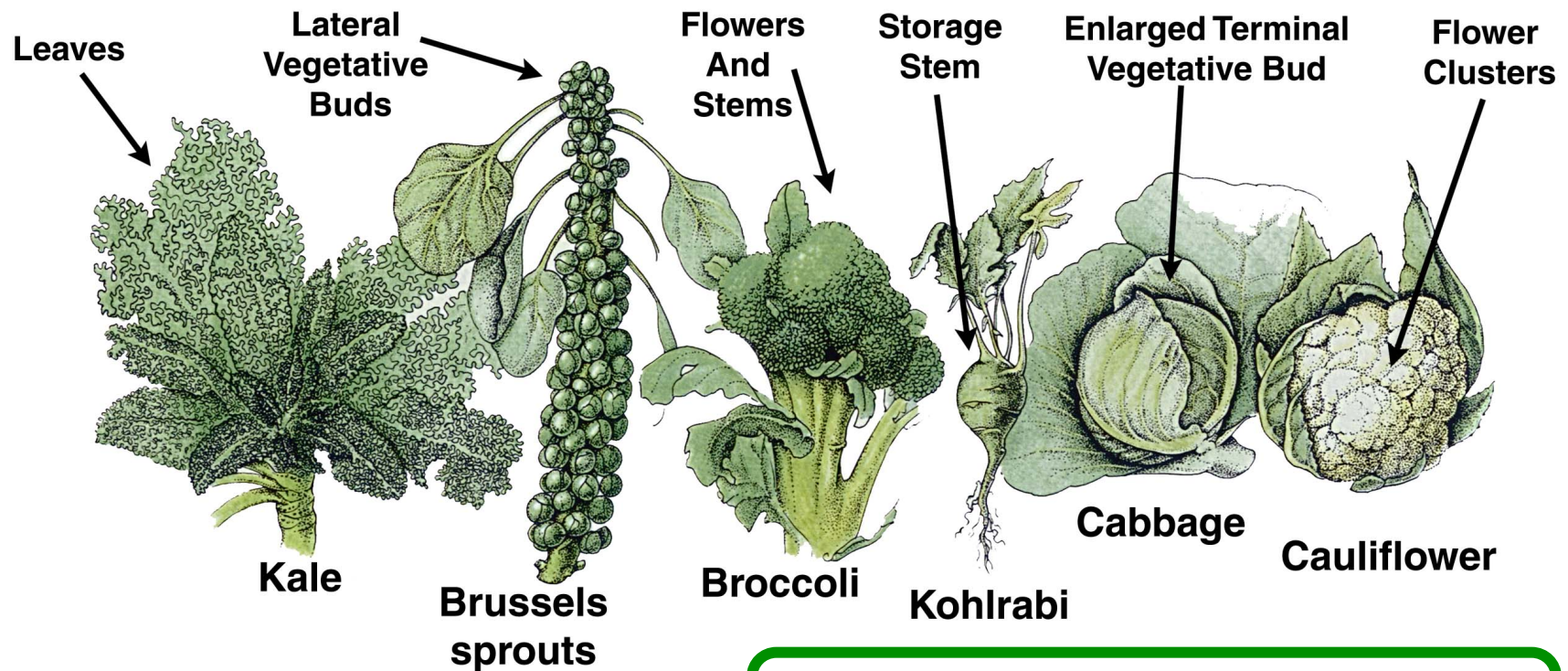


Origins of
Domesticated
Banana



Note: *Fruit Architecture
and Presence of Seeds*

Breeders Have Selected For Variability In Plant Control Genes To Generate Novel Crops



How Are These Plants Related?

Farm Animals Were Also “Engineered” By Breeding Wild Relatives Cattle Breeding in Egypt 4,000 Years Ago!



Manipulating Existing Genetic Variability
Brought About By Chance Mutations!

Even Domesticated Pets Were “Engineered” By Breeding Wild Relatives

Vol 438 | 8 December 2005

nature

Nature, December 2005

NEWS & VIEWS



GENOMICS

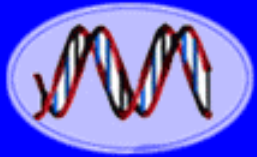
The dog has its day

Hans Ellegren

Domestication and selective breeding have transformed wolves into the diversity of dogs we see today. The sequence of the genome of one breed adds to our understanding of mammalian biology and genome evolution.

The Dog Genome Has Been Sequenced!

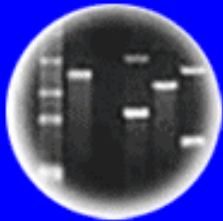
Canine DNA
Forensic Testing



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Plants of Tomorrow

The Problem With Breeding the “Old Fashioned Way”

Cannot Predict Results!

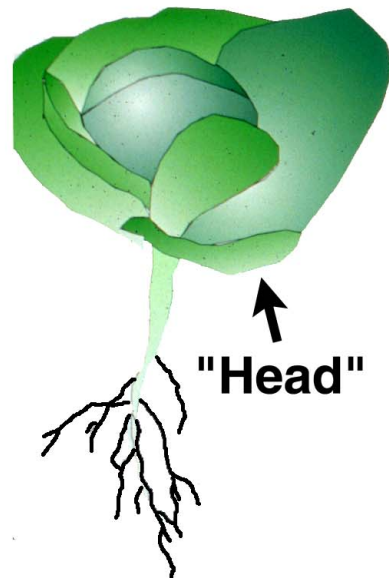


The Problem With Breeding the “Old Fashioned Way”

Engineering A Novel Crop By "Wide" Breeding

Cabbage (*Brassica*)

Radish (*Raphanus*)



X



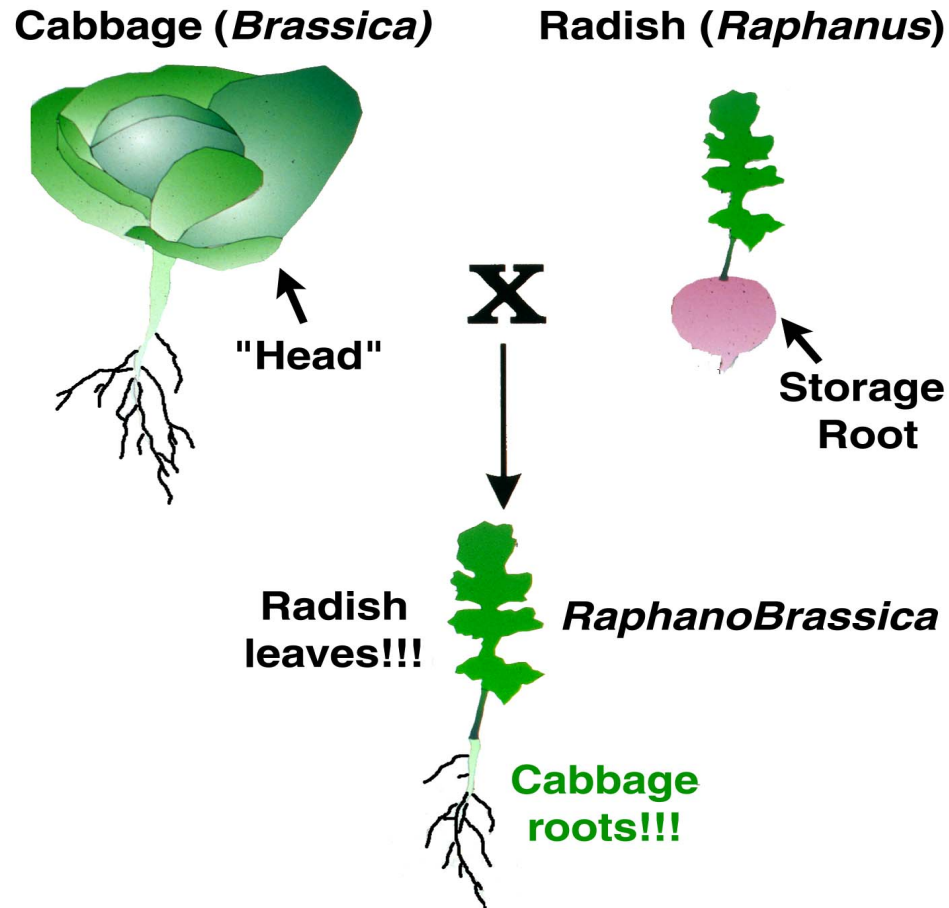
**Storage
Root**

???

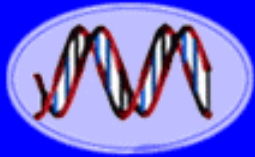
Karpechenko, G.D., 1928. *Polyploid hybrids of Raphanus sativus L. X Brassica oleracea L.*
Zeitschrift für induktive Abstammungs- und Vererbungslehre 48, 1-85.



Engineering A Novel Crop By "Wide" Breeding



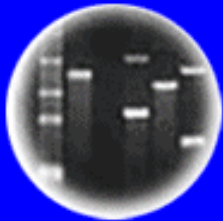
*Results Show the Unpredictability of Classical Breeding Approaches!!
Compare With the Modern Genetic Engineering Examples Shown Previously*



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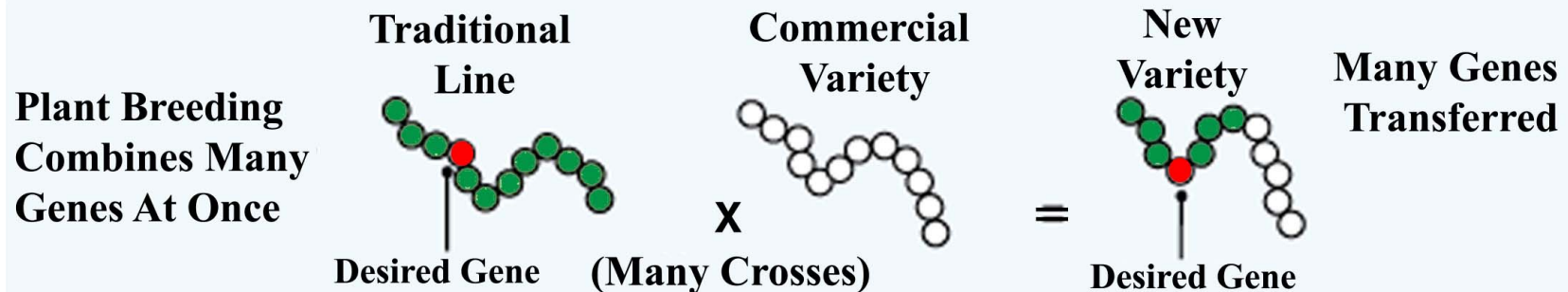
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Genetic Engineering is a TECHNIQUE!

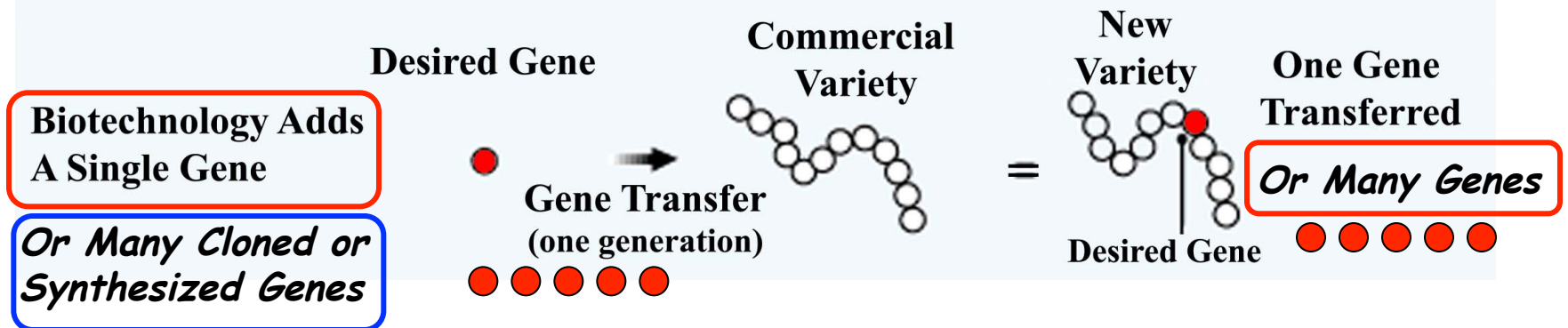
*How Do Classical Genetic Engineering
Methods Differ From Those Using
DNA and 21st Century Technologies?*

Classical vs. Molecular Genetic Engineering Techniques

TRADITIONAL PLANT BREEDING

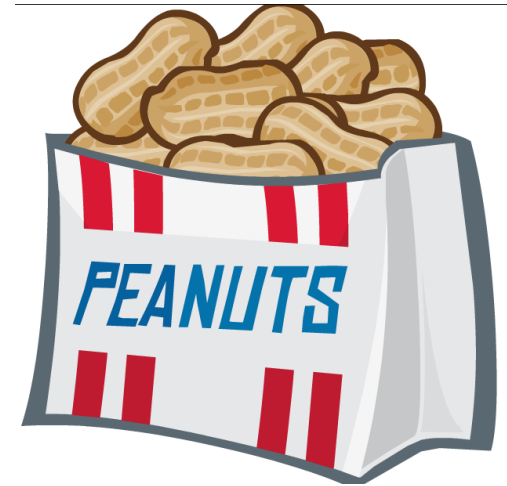


PLANT BIOTECHNOLOGY

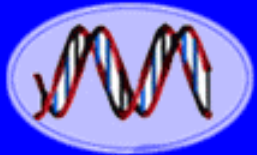


Both Manipulate Genes - But in Different Ways!!

Focus on the Product NOT the Process!!



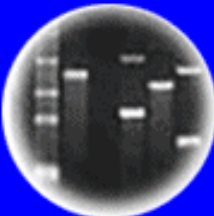
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What Is a GMO? | GMOs are the product of a specific type of plant breeding where precise changes are made to a plant's DNA to give it characteristics that cannot be achieved through traditional plant breeding methods.

SELECTIVE BREEDING

Plant breeders look for, select and cross-breed the best performing plants in the field, similar to how farmers have naturally improved the crops they grow since farming began.




ADVANCED BREEDING

Breeders identify and tag desirable characteristics (traits) within a plant genome. They use this information to pick which plants to cross-breed and create better performing crops.


DROUGHT TOLERANCE

STRONG STALKS AND ROOTS



GM PLANT BREEDING

If a plant needs a trait that can't be achieved through advanced breeding, a gene can be turned off or moved, or a gene from another source can be inserted.



GMOs can help farmers ...

- prevent crop disease
- control insects
- manage weeds
- change nutritional profile

There are eight GMO crops available in the U.S. today:

- Corn (field and sweet)
- Soybeans
- Cotton
- Canola
- Alfalfa
- Sugar Beets
- Papaya
- Squash

For more information, visit www.GMOAnswers.com

**Breeding or DNA - It's the Same
& Called *Gene Manipulation*
WHAT IS A GMO!!!!**

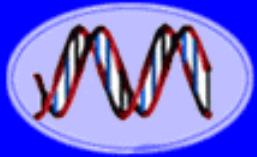
What Are The Limitations of Classical Breeding/Genetic Engineering?

1. Limited To Genes of Interbreeding Organisms and, Clearly, Severe Ethical Issues With Humans (Eugenics)
2. Only Can Make New Combinations of EXISTING Genes - Genes Created By “Natural” Mutations
3. Can't Make Existing Genes “Better” - Just Better or More Useful Combinations of Existing Genes and/or Alleles
4. Takes Time - Limited To Generation Time of Organism - Decades For Some Crop Plants
5. Only Useful For “Obvious” Traits - One's That Can Be Observed or Followed
6. Unpredictable Outcomes (Bringing in Thousands of Genes at Once - Some With Deleterious Consequences)

What Are The Advantages of Using 21st Century Genetic Engineering Methods?

1. Any Gene From Any Organism Can Be Used In Any Organism - There Are No Breeding Barriers (e.g., genes of all sequenced genomes)
2. New Genes Can Be Engineered - Genes That Work Better and/or Produce New Proteins (i.e., create new genetic variability and/or alleles)
3. Existing Genes Can Be Engineered to be Switched On in “Places” That They Are Normally Off - Gene Control or Regulation Altered (e.g., fly eye on leg)
4. Speed - Can Engineer a New Organism in a Generation
5. Can Change, Alter, Manipulate, Synthesize and/or Control the Genetic Blueprint of Any Organism
6. Very Precise (Working With Known Genes & Proteins)

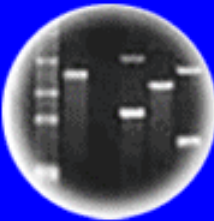




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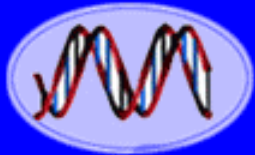
Plants of Tomorrow

WHAT IS SCIENCE?

WEBSTER: Knowledge about, or study of, the natural world based on facts learned through experiments and observation.

Technology, like Genetic Engineering, is the application of science knowledge

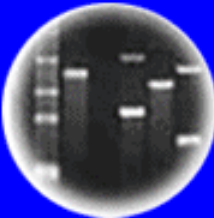




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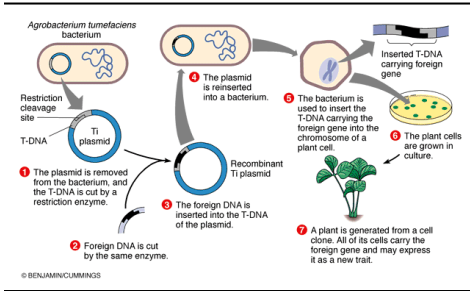
HOW IS SCIENCE CARRIED OUT?



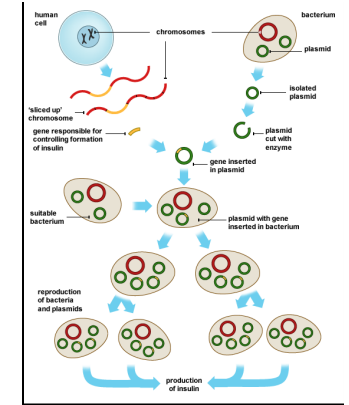
Scientific Knowledge is Based on
Observation, Hypothesis Testing,
Rigorous Experimentation,
Results, Facts, and Verification

What Are the Data!!!!

Science is **NOT** “Hocus Pocus” or
Based on Opinions and Beliefs

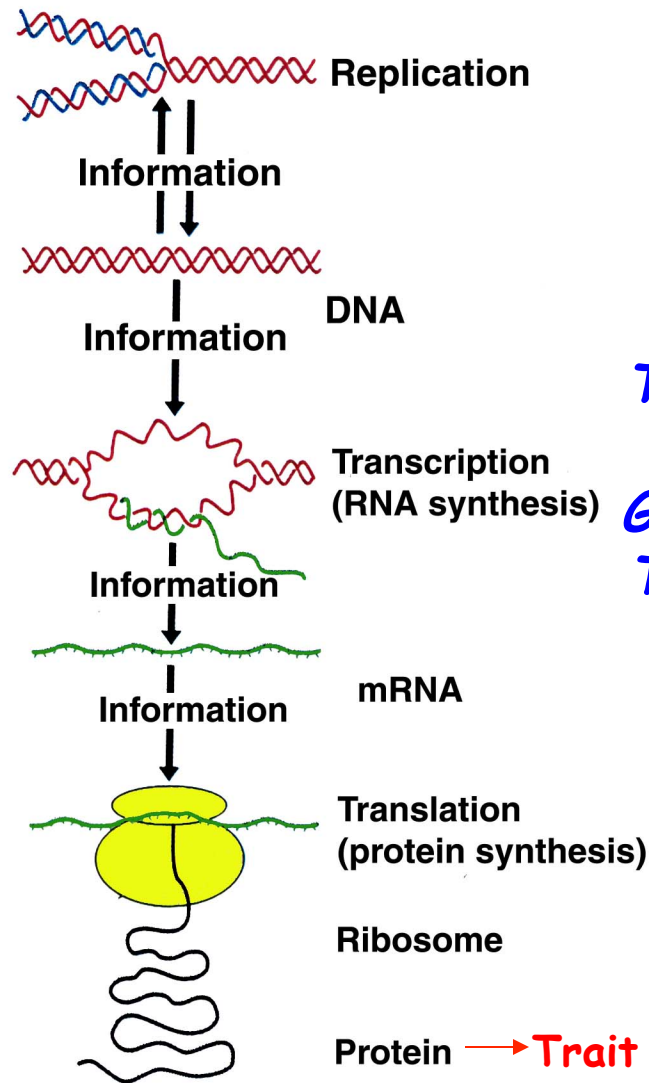


THE FACTS ARE:

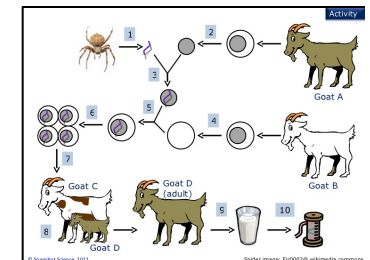
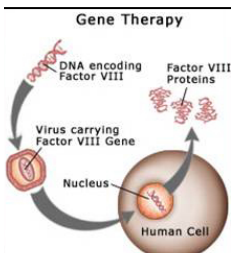


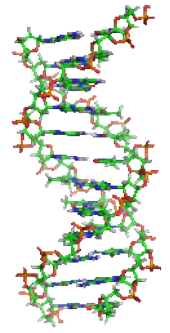
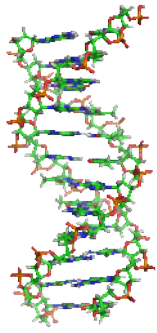
*Can Intervene
in This Process in
Cells*

*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!!*





We Live in The Age of DNA & Genetic Engineering!

**Understanding Genetic Engineering
*Requires a Basic Understanding of Genes
And How They Work***

